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ORIGINAL ARTICLE

Enhancing social communication of children with high-functioning autism through a co-located interface

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Abstract This study evaluated the effectiveness of a 3-week intervention in which a co-located cooperation enforcing interface, called StoryTable, was used to facilitate collaboration and positive social interaction for six children, aged 8–10 years, with autistic spectrum disorder (ASD). The intervention focused on exposing pairs of children to an enforced collaboration paradigm while they narrated a story. Pre- and post-intervention tasks included a "low technology" version of the storytelling device and a non storytelling play situation using a free construction game. The outcome measure was a structured observation scale of social interaction. Results demonstrated progress in three areas of social behaviors. First, the participants were more likely to initiate positive social interaction with peers after the intervention. Second, the level of shared play of the children increased from the pre-test to the post-test and they all increased the level of collaboration following the intervention. Third, the children with ASD demonstrated lower frequencies of autistic behaviors while using the StoryTable in comparison to the free construction game activity. The implications of these findings are discussed in terms of the effectiveness of this intervention for higher functioning children with ASD.

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1 Introduction

Autistic spectrum disorder (ASD) is a complex neurobiological disorder with symptoms that seriously affect the child's social interaction capabilities: his verbal and non-verbal communication and repertoire of activities and interests (Diagnostic and Statistical Manual of Mental Disorders, DSM-IV-TR; American Psychiatric Association 2000). Those with high-functioning autism (HFA) have a close to normal IQ, and some even exhibit exceptional skill or talent in specific areas. Language development often appears to be normal, but individuals with HFA frequently have deficits in pragmatics and prosody, the intonation and rhythm of one's speech (Landa 2000; Peppe et al. 2007; Rubin and Lennon 2004). That is, a child with HFA may function well in literal contexts, but have difficulty using language in a social context, as well as using of language pragmatics and functional communication (Beukelman and Mirenda 1998; Tager-Flusberg 1997).

Social impairments, abnormalities in social interaction, and difficulties in emotional expression and recognition are indeed considered to be among the core deficits associated with the autistic syndrome (American Psychiatric Association 2000) and characterize also children with HFA. The social impairments of children with ASD are reflected in difficulties in understanding social conventions, interpreting body language, reading facial expressions and understanding social protocols (Hadwin et al. 1996; Hobson 2005). These social deficits limit the learning of effective individual and group interaction skills such as sharing, turn taking, empathy and verbal initiations (Spradlin and Brady 1999). Children with ASD who have normal intelligence can compensate for some of their social deficits by utilizing their relatively high cognitive abilities, and therefore can engage in a higher level of social interaction in comparison to low functioning children with autism. However, in comparison to typical children, the social participation of all children with ASD in peer interaction is low in frequency and poor in quality (e.g., Bauminger et al. 2003). They often express ritualistic behaviors and poor social behaviors such as maintaining close proximity without sharing feelings and experiences (e.g., Sigman and Ruskin 1999). Maintaining interactions, in particular, requires the performance of complex, cooperative, prosocial behaviors that pose difficulty for these children, such as sharing feelings and experiences, collaborating, and comforting (Stone and Caro-Martinez 1990; Lord and Magill-Evans 1995; Bauminger et al. 2003).

Repetitive behaviors and circumscribed interests are considered to negatively affect social interactions because they increase social isolation (White-Kress 2003; Jensen et al. 2001). Circumscribed interests (CI) are conceptualized as the interests or preoccupations of individuals with ASD that become unusual in their intensity and/or focus (e.g., Boyd et al. 2007; South et al. 2005); they may interfere with the development of peer relationships given that they may not naturally develop into functional hobbies or adaptive skills.

Researchers and clinicians have noted the value of technology, in general, and computer-based activities, specifically, as therapeutic and educational tools for people with ASD (Grynszpan et al. 2005). The literature on computer-based interventions reports that children with ASD seem to be highly motivated by such tasks (Chen and Bernard-Opitz 1993; Hart 2005) and have made significant gains in learning vocabulary (Heimann et al. 1995; Moore and Calvert 2000), emotional expressions and understanding (Silver and Oakes 2001; Golan and Baron-Cohen, 2006) and social problem solving (Bernard-Opitz et al. 2001) using different kinds of multimedia software. Studies have suggested a few reasons for the special interests that people with ASD have in computerized learning and have identified several advantages that computers provide with respect to their core deficits. These include the predictability of software, the consistency of a clearly defined task and the usually specific focus of attention due to reduce distractions from unnecessary sensory stimuli (Murray 1997). During the last decade, a number of experimental studies were carried out to assess the general utility of innovative technologies for people with ASD. These studies demonstrated the potential of a variety of different devices and interaction environments, including virtual reality (Sik Lányi and Tilinger 2004; Strickland et al. 1996), robotics (Dautenhahn and Weery 2004), and multimodal interfaces (Bernard-Opitz et al. 2001; Bosseler and Massaro 2003; Hagiwara and Myles 1999). A recently established research area aims at developing mobile technology based on social and emotional intelligence capabilities. For instance, el Kaliouby et al. (2007) have studied a wearable device with sensors (e.g., a small camera combined with machine vision algorithms) that helps analyze facial expressions and head movements of the person with whom the wearer is interacting. This provides people with ASD cues about the interaction.

While various computer-assisted instruction (CAI) tools have been studied, and suggested to have mainly positive effects on children with ASD, responses from both professionals and parents have been mixed; along with the obvious advantage of using such environments with children with ASD, there has also been expressions of fear of increased social withdrawal (Bernard-Opitz et al. 1990) and the encouragement of compulsive behaviors (Powel 1996). Moreover, despite the fact that specific attributes for improving social skills as well as decreasing autistic behaviors through technological oriented tools have been promoted in recent years, very few studies have investigated this potential via a systematic intervention in children with ASD. Those who did suggest that computer-based intervention and virtual environments appear to offer a useful tool for social skills training in children with ASD (Silver and Oakes 2001; Parsons et al. 2005; Herrera et al. 2004; Revel et al. 2002; Piper et al. 2006).

In the present study we investigated the use of a specific type of computer-assisted paradigm to improve the social interaction skills of children with ASD. Inspired by the methodology of Cooperative Learning (Johnson and Johnson 1999), our "enforced cooperation" paradigm aims to support and promote cooperation within small groups by requiring that designated actions and manipulations at the interface be physically performed together by the group participants (Zancanaro et al. 2007). The nature and distribution of those multi-user actions can be varied to affect the degree of cooperation among the group members.

In previous studies (Cappelletti et al. 2004; Zancanaro et al. 2007) we applied the paradigm in a co-located setting and developed the StoryTable (ST) application, whereby pairs of children could interact to construct a common story. The system was deployed through the Mitsubishi Electronic Research Laboratory's (MERL) Diamond Touch table (Dietz and Leigh 2001). An experimental study on 35 typically developed dyads provided evidence that this interface facilitated more complex and mature language (both in their recorded story segments and in their interactions with one another during the task) and that the contributions to the story and to interaction were more equally distributed between the children in the StoryTable than in a control condition. We found that the enforced cooperation paradigm, as realized through multi-user operations, is a powerful means by which cooperation could be stimulated (Zancanaro et al. 2007).

In the current study we investigated the potential of the enforced cooperation paradigm and the use of the StoryTable in the context of a therapeutic intervention aimed at enhancing the ability of children with HFA to interact in social situations. Specifically we aimed at investigating whether the enforced cooperation paradigm will enhance positive social interaction skills and play capabilities within pairs of children with high-functioning ASD.

2 Methods

2.1 Participants

Six Caucasian boys with HFA, aged 8–11 years, participated in the study. They had been diagnosed by a licensed psychologist and multidisciplinary team in an educational-based program using criteria stated in the Diagnostic and Statistical Manual of Mental Disorders, 4th edn (American Psychiatric Association 2000), confirmed by the Childhood Autism Rating Scale (Schopler et al. 1998) or the Autism Diagnostic Interview, revised (ADI-R; Lord et al. 1994), which were administered to the parents of the children. All of the children learned in a special education program within a typical elementary school, in two different classes. Thus all children in the sample had opportunities for both mixed interactions with typically developing children and for non-mixed interactions with other children with ASD. All children read and wrote at a minimum of a Grade 2 level. They all were independent in basic activities of daily living (ADL) and instrumental ADL, and were able to understand the routines of social interactions such as taking turns, listening to each other and relating to the others' words. They were able to use verbal language at the level of simple sentence construction. None of the children had physical disabilities and they were not receiving any specific social interventions in school at the time of the study.

2.2 Instruments

The StoryTable was implemented using the capabilities of the MERL's DiamondTouch (DT) Table (http://www.merl.com/projects/DiamondTouch/), a multi-user touchable interface that allows detecting multiple simultaneous touches by two to four users (Dietz and Leigh 2001). The DT is multimodal in character, providing visual stimuli, responding to touch commands and supporting single or multiple users, including successive or in-tandem actions such as simultaneous touch commands and multi-user drag-and-drop acts. Each user sits or stands on a receiver (a thin pad) such that touching the table surface activates an array of antennas embedded within its surface (capacitive touch detection). When a user touches the surface, antennas near the touch point couple an extremely small signal via the user's body to the receiver. In this way, the DT supports both multiple touches and distinguishes between simultaneous inputs from multiple users.

The StoryTable application enables the production and recording of joint narratives. It provides virtual environments where users can manipulate objects and characters within the context of a specific story background setting. Many different scenarios (i.e., backgrounds) are made available, each having different characters, which children can use to create and narrate stories. The interface was designed according to the concept of ladybugs wandering around the table surface. One of the large ladybugs, shown in Fig. 1, contains a variety of backgrounds, settings for storytelling (e.g., a forest, a medieval castle). This object can be opened to access the backgrounds by double touching it (Fig. 1, right). Since the selection of the background is crucial for determining the story, the ST forces agreement by requiring that the double touch be done jointly by the children, i.e., via a multi-user touch event.

Fig. 1 The interface of the StoryTable on the MERL's DiamondTouch

A second large ladybug allows the selection of characters appropriate to a given background that has been selected previously; both its opening and the selection of characters can be performed by means of single-user operations.

Smaller ladybugs contain storage space for the audio snippets that will form the story. In order to load an audio snippet into one of these ladybugs, a child drags it to the recorder and then presses a button while speaking. The audio snippets are recorded independently by each of the children and, in accordance with the criterion of individual accountability, once loaded with an audio snippet, the ladybug displays a colored shape meant to represent the child who recorded it. The loaded ladybug can then be dragged to the bottom of the table and aligned with other audio-snippet carrying ladybugs to successively create the story. In order to listen to recorded snippets, the ST requires joint touch on the relevant ladybug.

An 11-item checklist of the abilities required to operate the StoryTable (called the StoryTable Skill Rubric) was developed to administer to the children prior to their selection for the study. Based on a task analysis of the basic skills needed to operate the Diamond Touch table, the skill rubric includes activities such as selecting a background graphic, selecting and placing story characters and recording segments of a story in one's own voice. Each task was operationally defined and broken down into its components. Four levels of competence for each task, starting from "unable to perform" up to "performs independently", were established. Skill level thresholds for each item, as well as a general threshold score were set. Children who achieved scores beyond the threshold were included in the study.

2.3 Outcome measures

The Social Interaction Observation (SIO) scale was adapted from the Friendship Observation Scale (FOS, Bauminger et al. 2005) and used to assess the level of social interaction, conversation, play, cooperative skill and autistic behaviors. The FOS is an interactional coding system designed to assess minute-by-minute changes in the frequency and quality of interaction in a given child when interacting with a peer, including behaviors, conversation and affect. The SIO scale included four categories: positive social interactions, negative social interactions, stereotypical behaviors typical of ASD and play. The positive social interactions included pro-social behaviors (e.g., comforting, helping, sharing), conversation (e.g., small talk, negotiation) and non-verbal interaction (e.g., a combination of eye gaze and a smile, and positive affect). The play scale coded play complexity including parallel play, simple social play and complementary play. Negative social interactions included behaviors such as avoidance and aggression. "Autistic" behaviors included repetitive stereotypical movements, verbal repetitiveness, imitation of movements and removal of self from activity.

Two coders who were blind to the intervention protocol were trained to code the social interaction behaviors. The presence of each behavior in each category was assessed once per minute throughout a 20 min observation period by a trained coder who viewed videotapes of the pre-test, post-test and intervention sessions. The coders observed the child's behaviors for 50 s out of each minute and then tallied the observed behaviors during the remaining 10 s. The observations of each behavior were summed separately for each of the categories. Thus, a higher score in a particular category indicated a higher frequency of social interactions for that category. Inter-rater reliability ranged between 0.85 and 0.96 for the different items on the final scale.

2.4 Pre- and post-assessment procedures

The children were assessed prior to and following the intervention using two tasks. The first task was performed with a low-technology version of the StoryTable interface, which consisted of a poster board showing background graphics, cardboard figures relevant to the background and a small tape recorder for recording a story. Pairs of children were videotaped while taking turns narrating a story related to the background and characters. This assessed their ability to collaborate in the narration of a shared story that was not enforced by a computerized interface. A second task, the construction game, followed Siperstein et al.'s (1997) procedure for the assessment of children's social interaction, play and level of cooperation during the performance of a shared task. The pairs of children were provided with a noncompetitive construction game, Discovery Toys' Super MarbleWorks® Raceway Construction Set. Children were instructed to construct a shared design (a marble maze) while using ramps, connectors, funnels and tunnels. After completion, children could roll the marbles down and through the maze. The children were also videotaped while performing this task with the aim of assessing their ability to collaborate during a non-narrative activity as well as their level of play.

2.5 Intervention: description

2.5.1 Pre-intervention

The first meeting with the children focused on learning to operate the StoryTable. The StoryTable Skill Rubric was administered to confirm the participants' ability to perform the required tasks. A written list of StoryTable functions and rules was placed near the children to serve as a reminder when needed. All of the children were able to use successfully the StoryTable after this short training.

2.5.2 Intervention

The six children were divided into three pairs according to their teacher's recommendations based on their level of language as the major criterion. The intervention consisted of eight sessions given during 3 weeks. At the beginning of each session, the children were instructed in different aspects of collaboration and cooperative skills in accordance with specific intervention goals. The first goal, "sharing activities", was targeted during the second, third and forth sessions to help the children overcome their core deficit in collaboration and cooperation (e.g., Sigman and Ruskin 1999). The second goal, "providing help and encouragement", was targeted during the fifth and sixth sessions since these children have considerable difficulties in pro-social behaviors (Bacon et al. 1998; Charman et al. 1997; Corona et al. 1998; Dawson et al. 2004; Sigman et al. 1992). The third goal, "learning to persuade and negotiate", was targeted during the seventh and eighth sessions to help them overcome their core deficit in language conversation and pragmatics (e.g., Landa 2000). The goal-related guidelines that were targeted for each session were written and placed on the wall near the children to serve as a visual reminder of the session's focus.

During the eight intervention sessions, children worked in pairs to select together the background for the story they wanted to narrate and then to compose a narrative while taking turns recording it via the StoryTable audio recorder. The enforced collaboration was reflected through the need to perform specific simultaneous actions on the interface in order to operate some of its functions. For example, the children had to touch a ladybug containing story background graphics simultaneously in order to choose a specific background, or to touch a specific button simultaneously in order to listen to their taped voices. The sessions lasted until each child had three turns to narrate. However, in order to ensure uniformity of encoding, only the first 20 min of interaction were analyzed. The intervention was implemented by a third trained person, with experience in special education, who was instructed by the first author.

3 Results

All the children enjoyed using the StoryTable and were readily able to learn and execute the various storytelling functions within one or two teaching sessions. The results of an analysis of their storytelling ability will be reported in a separate paper, but a short example of a story composed by two of the participants during their third session is provided to illustrate the material that they generated (Table 1).

The example in Table 1 shows that at a pragmatic level, the children appeared to understand the conventions of storytelling, as seen by their use of narrative introductions and "turn taking". However, there was no real plot development, but rather alternating references to the behavioral states of the characters.

Due to the small sample size, descriptive statistics were used to compare the means scores for the three pairs of children. Since this is a pilot study with a small sample, we will present only the behavioral measures with the most notable changes. In the present paper, we will discuss the study results following study goals, first presenting results regarding changes in positive social interaction and play followed by a description of differences in "autistic behaviors".

3.1 Positive social interaction

A trend toward improvement of a number of important social behaviors was found on the measured positive social interactions, as shown in Fig. 2. Comparisons were made between the frequency of behaviors observed during the pre- and post-tests of the free-play construction task (MarbleWorks) and of the low technology StoryTable activity.

The most noticeable changes were observed in the differences in prosocial behaviors between the pre- and

Table 1 A story composed by two of the participants during their third session using the "Jungle Book" story background and characters relevant to this story. "P1" and "P2" denote the two children who participated in this session and "A" denotes the session moderator

P1	One time Mogli walked, found the tiger, devoured him in the tree
P2	Out of the trees came a snake and…
P1	This is Balu (pointing)
P2	And (it) helped Mogli
P1	One time Balu and Mogli took three…a lot of monkeys, kidnapped them
A	Mogli disappeared (from screen). Pick someone else.
P1	Balu (picks character)
P2	The elephant roared, and enjoyed, and it had fun
P1	Monkeys (picks character). One time the monkeys kidnapped Mogli
P2	Balu climbed the tree close to Mogli and was angry at the monkeys

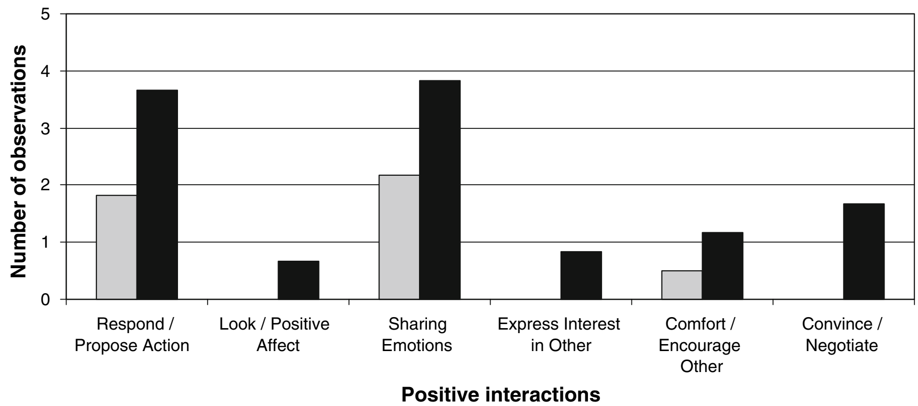

Fig. 2 Mean number of selected positive social behaviors observed during the pre-intervention free-play construction game (*gray histograms*) and during the post-intervention free-play construction game (*black histograms*)

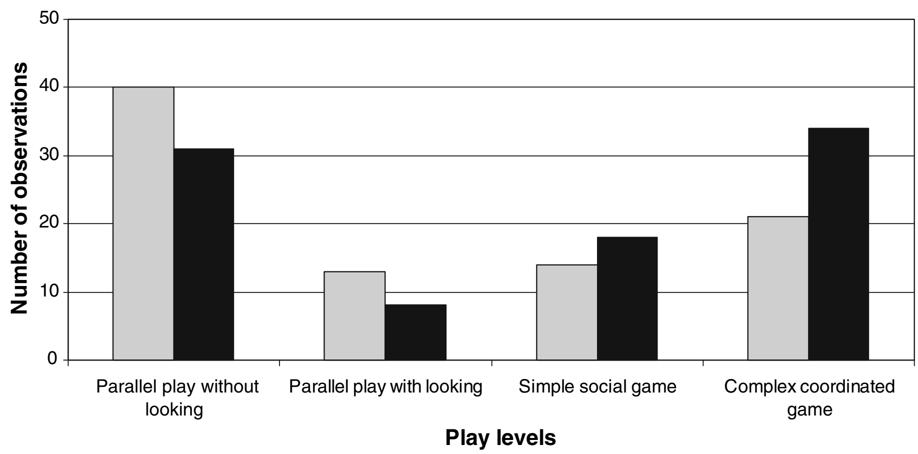

Fig. 3 Mean frequency of levels of play during the pre-intervention free-play construction task (*gray histograms*) and during the post-intervention free-play construction task (*black histograms*)

post-test free-play construction task. Therefore, we relate primarily to the changes observed in the comparison of the free-play construction game's pre- versus post-intervention tests. Comparison of the mean frequency of behaviors observed during the pre- and post-intervention free-play construction task (MarbleWorks) revealed an improvement in positive social interactions. For example, children increased the frequency of their responses to peers (pre-test mean = 1.83, SD = 2.85; post-test mean = 3.67, SD = 4.67). They expressed more positive affect (no occurrences during the pre-test; post-test mean = 0.17, SD = 0.40) They were more likely to share their emotions with their peer during the post-intervention free-play construction task (pre-test mean = 2.17, SD = 2.99; post-test mean = 3.83, SD = 2.99), and to request or to convince or negotiate with their partner (no occurrences during the pre-test; post-test mean = 1.61, SD = 2.65). These results are graphically displayed in Fig. 2.

3.2 Positive social interaction: play skills

Comparison of the pre- and post-intervention free-play construction task showed a trend toward greater complexity in the level of play. As shown in Fig. 3, children decreased the frequency of parallel play without looking at their partner from a mean of 13 observed instances during the pre-intervention free-play task to a mean of 8 observed instances during the post-intervention free-play task. Indeed, the frequency of parallel play with looking at the partner was reduced between pre- and post-assessment ($M = 40$ and $M = 31$, respectively), but the level of play complexity was increased. The children showed an increase in the observed instances of simple social play following intervention (pre-intervention mean = 14 versus post intervention mean = 18). Furthermore, they demonstrated a notable increase in the frequency of complex play (pre-intervention mean = 21 versus post intervention mean = 34). These results may suggest that the more primitive types of parallel play were reduced due to increase in the frequency of simple and complex social play.

3.3 Autistic behaviors

The mean number of "autistic behaviors" made by each of the children during the eight StoryTable intervention sessions was compared to the mean number of autistic behaviors of the children during the pre- and post-intervention free-play construction task. All children displayed such behaviors during the free play situation, ranging from very few (P1, mean = 0.5) to a moderate number (P2, P3 and P6, mean = 3.00–3.25). Five out of the six children showed a very low frequency of autistic behaviors (P5), or lack of them (P1–P4), during the StoryTable intervention (mean = 0 to 1.66). The child who presented more autistic behaviors during the ST interventions (P6) had considerable sweating on the palms of his hands. This meant that the response of the ST was less reliable for this child causing him to become frustrated and, in fact, more prone to "autistic behaviors" (mean = 9.0). These results are shown in Fig. 4.

4 Discussion

This pilot study examined the effectiveness of the enforced cooperation paradigm as realized through the StoryTable co-located system, in facilitating positive social interactions and play skills among high-functioning children with ASD, as well as in reducing their autistic behaviors, such as repetitive movements. The results presented in this paper are preliminary due to the limited number of subjects and to the relatively short duration of the intervention. Yet, the findings are highly encouraging. The results demonstrate considerable improvement in the frequency of pro-social behaviors. The participants were more likely to initiate positive social interactions with peers after the intervention, exhibiting better social interactive skills such as responding to the other's action or sharing emotions. Progress in certain skills in the post- versus pre-intervention free-play construction task may be a sign of generalization

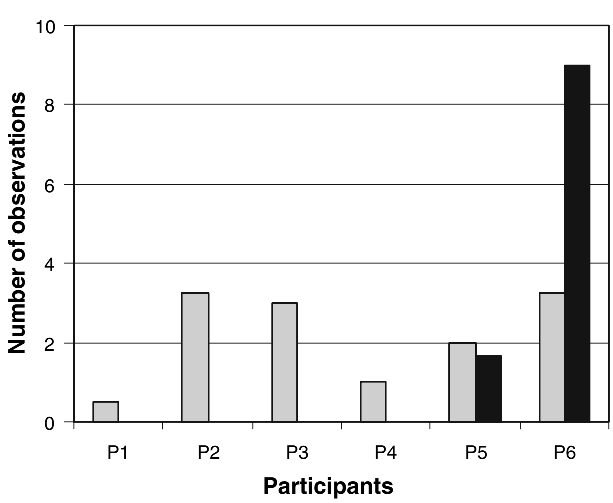

Fig. 4 Mean number of "autistic behaviors" observed per child during the free-play construction task (*gray histograms*) and during the StoryTable intervention sessions (*black histograms*)

of the skills learned in the structured StoryTable environment to a more spontaneous and less structured social scenario such as the free-play construction game.

In addition, results demonstrated also that children exhibited somewhat fewer autistic behaviors, specifically stereotyped movements, while using the StoryTable in comparison to the free-play construction task. Stereotyped movements have been suggested to serve as a coping response; the extent to which they are performed is influenced, in fact, by how much an individual is affected by sub-optimal stimuli in the environment, i.e., by an environmental setting that is perceived as either under-stimulating or over-stimulating (Odberg 1987; Gal et al. 2002). Repetitive behaviors including stereotyped movements have been attributed to excessive sensory stimuli and have also been shown to be less likely to occur during conditions involving social contact (Hall et al. 2003). Specifically, a reduction in repetitive behaviors was associated with an increase in positive social interaction after intervention (Bauminger 2002). The results of the current study, in which there was a lower frequency of autistic behaviors while engaged in the StoryTable activity in comparison to free-play construction task, support previous findings.

The StoryTable environment includes a number of characteristics, which may provide optimal sensory stimuli to children with ASD, or the appropriate amount and kind of social interaction or both. The story backgrounds are sufficiently concrete, detailed and interesting to attract a child's attention. Yet, they are centered on a surface that is small enough to enable him to concentrate on the narrative task without being distracted by extraneous stimuli in the surrounding environment. Additionally, although collaboration with a peer is enforced during part of the storytelling activity, the child is able to limit the extent of collaboration during parts of the task (e.g., when creating his own story segments) or to engage in greater social interaction with his peer at other times (e.g., when listening to the final story). That is, the system presents an environment that is stimulating to the child, but also helps him block distractions; an environment that enforces collaboration, but also enables individual work. As such it may provide a dynamic balance that serves as a regulating environment in which there is less recourse to stereotyped movements.

Young children spend many hours participating in play activities because play is their way of interacting with themselves and with their environment (Mellon 1994). The joy of play is that it assists children in exploring and understanding various roles and interaction patterns, thereby supporting their understanding of their social world and facilitating their efforts to build a realistic sense of self (Spodek and Saracho 1998). Typically developed children first begin in sensory play, playing by themselves and enjoying their sensorimotor experiences, e.g., they play with their feet, pull off their socks or stack blocks. In the next phase, toddlers play near each other (parallel play), without cooperating. Then they move to simple social play, which includes the perception of the peer partner as a social playmate, reflected in activities such as turn taking, but does not necessitate full cooperation with the partner. The next stage in peer play is complex play. Complex play involves cooperative play and the coordination of activities; it includes more imaginative activity and lasts longer (Howes and Matheson 1992). Information on the play of children with ASD suggests that there are a number of typical patterns, including engagement in repetitive stereotyped activities and a decrease in the exploration of the characteristic of objects and in their use in a representational way (Wing et al. 1977). They rarely engage in symbolic play, and have difficulties in cooperative play and in any sort of social play. The latter is related in the literature to a deficit of the "theory of mind", i.e., to a failure to represent to oneself the mental states of others (Baron-Cohen et al. 1985).

The results of this study indicated that the participants increased their level of play during the post-intervention test. These results are important as they may suggest a generalization of the skills acquired while using the StoryTable, to the more eclectic abilities that are expressed within a functional situation of play.

The literature suggests that the dynamics of the physical and social aspects of the play environment signal to children what they can do and supports their natural play needs (Dempsey and Frost 1993). The nature and extent of children's play appear to depend heavily on the potential of an environment's attributes to meet children's needs, attitudes and interests (Frost et al. 1998). These attributes include its physical setup and the extent to which it provides structure for play.

Our initial results, which need further study for confirmation, suggest that co-located interfaces like the StoryTable may present an environment that provides support for both sensory and social needs of children with HFA, and therefore may be well suited to support social targeted interventions for this population. StoryTable enforces collaboration with a peer in a real situation and provides a technological mediation to the interaction. This makes evaluation less stressful and more ecologically valid. Moreover, the possibility of forcing some actions to be done together (as in the case of multiple-user actions in StoryTable) may foster the recognition of the presence of the partner and stimulate collaborative behavior. The fact that the setting requires the children to agree on relevant steps to be taken and to make this physically explicit by joint actions may assist in improving their collaboration. In other words, the very nature of the scenario requires children with HFA to engage in a number of social behaviors they most often refrain from, this being one of their major problems to overcome.

In summary, the results of the pilot study reported in this paper provide initial evidence that the paradigm of enforced cooperation, as realized through an interface allowing for multiple-user GUI actions, may: (1) serve as an environment that potentially meets the needs of children with HFA (2) have considerable potential for enhancing several key social behaviors, and (3) help control the need for autistic behaviors. More work is needed to verify whether these initial findings are reproducible and accurate, using bigger samples that will allow for statistics testing, and longer interventions. The expected output is a deeper understanding of the use of technology for the enhancement of social interaction among children with ASD.

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