

Enhancing Social Communication in High-Functioning Children with Autism through a Co-located Interface

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Abstract

In this paper we describe a pilot study for an intervention aimed at enhancing social skills in high functioning children with autism. We found initial evidences that the use of a co-located interface may have a positive effect on the quality of social interaction and may lessen the repetitive behaviors typical of autism. These positive effects also appear to be transferred to other tasks following the intervention. We hypothesize that the effect is due to some unique characteristics of the interfaces used, in particular enforcing some tasks to be done together through the use of multiple-user GUI actions.

Keywords: Multiple-user GUI, computer-assisted instruction, social interaction, autism.

1 INTRODUCTION

Autism is a complex developmental disability with symptoms that usually emerge during the first years of life. Children with autism often have difficulties in verbal and non-verbal communication, social interactions, and leisure or play activities [1-3]. 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. That is, a child with HFA may function well in literal contexts but have difficulty using language in a social context. Social impairments, abnormalities in reciprocal social interaction and difficulties in emotional expression and recognition are considered to be among the core deficits associated with the autistic syndrome [1]. Children with autism 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 relationships in comparison to low functioning children with autism. However, in comparison to typical children, the social participation of all children with autism in peer interaction is low in frequency and poor in quality, comprising, for example, more ritualistic behaviors and poor social behaviors such as only maintaining close proximity, rather than performing prosocial behaviors such as sharing feelings and experiences [13].

Researchers and clinicians have noted the value of technology, in general, and computer-based activities, specifically, as therapeutic and educational tools for people with autistic spectrum disorders (ASD) [7]. Studies have suggested a few reasons for the special interest that people with ASD have in computerized learning, and have identified several advantages that computers provide with respect to its core deficits. These include, for example, the predictability of software, the safety of a clearly defined task, and the usually specific focus of attention [8]. While these attributes have been promoted in recent years, very few studies have investigated this potential via a systematic intervention with children with autism. 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 [10, 14].

Although various Computer Assisted Instruction (CAI) tools have been studied (see among others [9]), responses from both professionals and parents have been mixed due to the fear of increased social withdrawal [4] and the encouragement of compulsive behaviors [11]. In order to teach social skills, the use of Virtual Environments (VEs) has also been proposed (see among others [10]). The tendency for people with autism to interpret situations literally, however, could impede their understanding of VEs as representations of reality therefore making ineffective the use of this type of technology [10].

In a previous study [15], we experimented with a co-located interface where pairs of children (not affected by developmental disorders) interacted to construct a common story. The interface was explicitly designed to “enforce collaboration” by requiring that some activities be performed together by the children. The design hypothesis, partially confirmed, was that forcing joint behavior on the interface promoted mutual recognition and fostered collaboration. Robins et al. [12] have used a similar concept wherein a game was introduced where the rules “enforce collaboration” among children with autism.

In this paper, we discuss the use of that interface in the context of a therapeutic intervention aimed at enhancing the ability of children with HFA to interact in social situations. The results of the pilot study suggest that this technology appears to have a positive effect on improving the quality of social interaction as well as on decreasing the repetitive behaviors that are typical of autism; these positive effects appear to also transfer to other tasks. We hypothesize that this is due to the fact that the setting requires that, at crucial points during the story construction, the subjects agree on relevant steps to be taken and make this physically explicit by joint actions. In other words, the very nature of the scenario requires HFA children to engage in a number of social behaviors they most often refrain from, this being one of their major and more difficult to overcome problems.

2 THE STORY TABLE INTERFACE

The Story Table interface goal was to support pairs of typically developed children in the activity of storytelling within the context of a museum visit that causes them to reflect about their experience [15]. The system is based on DiamondTouch [6], a multi-user, touch-and-gesture-activated device designed to support small-group collaboration. A standard projector is used to display a top-projection of a computer screen. This technology supports multiple touches by a single user and distinguishes between simultaneous inputs from multiple users.

Exploiting this functionality, we extended the event system of standard touchable interfaces allowing multiple-user events such as the multiple-user touch, the multiple-user double touch and the multiple-user drag-and-drop. For example, a multiple-user touch is an event that is triggered when two or more users click together on a button (see Fig. 1). Indeed, a chain of events is generated: the system first triggers a standard touch event when the first user touches the button; when the second user touches the same button, a new multiple-user touch event is triggered. When one of the two users releases the touch, a multiple-user release event is triggered. Finally, when the other user releases the button the standard release event is triggered. The other multiple-users events were defined in a similar, albeit more complex, manner. GUI widgets can therefore be programmed to react differently when a single-user or a multiple-user touch is received.

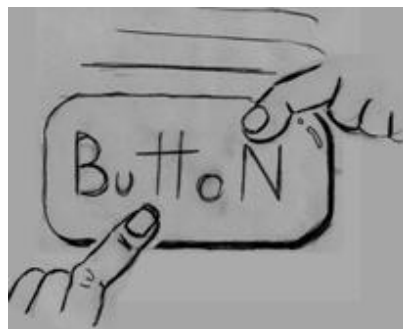


Figure 1. Conceptualization of a multi-user touch gesture

The design rationale of StoryTable is based on a methodology known as Family Bears (e.g., Bornstein [5]) where a child is invited to play with puppets representing a family of bears and their living environments (e.g., the house, the school) and then to invent stories about what happens to the family. This approach is used in both educational and therapeutic settings to measure the linguistic capabilities of the children and their relations with the world. Story Table provides many different scenarios (i.e., backgrounds) in addition to the Family Bears; each one has different characters for which children can invent stories.

The interface was designed according to the concept of ladybugs wandering around the table surface (see Fig. 2). Ladybugs were chosen as a familiar, friendly object to children; the users had no difficulty in understanding the function of the ladybugs that differed in size and color in accordance with their functions. A mixture of standard touch events and the new multiple-user events were used as a means to control the objects. One ladybug carries the backgrounds, the context within which the story will be set — e.g., a forest, a medieval castle, etc. This ladybug can be opened to access the backgrounds by double touching on it. Since the selection of the background is crucial for determining the story, the system forces previous agreement by requiring that selection of the background setting be done jointly by the children — i.e., through a multiple-user touch event. Another ladybug carries the various story elements (e.g., the Princess, the Knight,) that can be dragged onto the current background. Again, this ladybug can be opened by a single-user double touch event. In this case, however, the elements can be dragged autonomously by each child. A third type of ladybug of a different size and shape (the blue ones shown in Fig. 2) contain the audio snippets that will form the story. In order to load an audio snippet into one of these ladybugs, a child has to drag it into the recorder and then keep the button pressed while speaking. The audio snippets are recorded independently by each of child. Once loaded with audio the ladybug displays a colored aura that represents the child who recorded it. An audio ladybug can be modified by the child who recorded it, but the system refuses modifications attempted by the other child. Therefore, a ladybug is “owned” by the child who recorded it. Yet, the two children may agree to release ownership of a ladybug by a multiple-user drag-and-drop action: if they jointly drag the ladybug onto the recording tool, the system removes the content and the aura. The resulting story is the sequence of the audio snippets recorded in the ladybugs placed in the sequence of holes at the bottom edge of the interface; while each audio ladybug may be listened to individually, the story as a connected sequence of snippets, can be listened only if both the children touch the first ladybug in the sequence.



Figure 2. The StoryTable interface projected on a DiamondTouch device

An experimental study on 35 dyads provided evidence that this settings facilitates 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 Story Table than in the control condition [15].

3 A PILOT STUDY FOR AN INTERVENTION METHODOLOGY

Based on the literature and our clinical experience, we suggest that HFA children would benefit from an intervention based on the Story Table setting, for two main reasons. The first refers to the well-known fact that HFA children like using and engaging with computerized technologies (e.g., [7]). The second, and more important, reason is that the

Story Table setting requires that, at crucial points during the story construction, the subjects agree on relevant steps to be taken (release the property of an audio lady bug, choose the scenario, listen to the whole story, etc.) and make this physically explicit by joint actions. In other words, the very nature of the scenario requires HFA children to engage in a number of social behaviors they most often refrain from, this being one of their major and more difficult to overcome problems.

A pilot intervention A-B-A study was conducted where the Story Table was used with three dyads of children aged 9 to 11 years. All had a prior diagnosis of HFA but no physical disabilities and capabilities for only basic interaction (e.g., listening to others, turn-taking) and the capability of verbalizing simple sentences. The children knew each other before taking part in the study.

Three intervention targets are reinforced throughout the Story Table sessions. First, “shared activities” are encouraged because their lack is one of these children's core deficits in collaboration and cooperation. Second, “help and encouragement” is provided since these children have considerable difficulties in pro-social behaviors. Third, “persuasion and negotiation” is supported to help these children overcome their core deficit in language conversation and pragmatics.

The children were tested prior to (pre-A) and following (post-A) the intervention with a low-tech version of the Story Table interface (Fig. 3, right) and with a lego-like assembly game, MarbleWorks, where children were instructed to build a shared marble maze using ramps, connectors, funnels, and tunnels (Fig. 3, left). The structured intervention consisted of ten 20 minute sessions which took place at their school 3-4 times per week for 3 weeks. During the intervention, the dyads of children were instructed to create and narrate stories using the backgrounds and the associated characters that they jointly selected (as described above). The children were provided with opportunities to become familiar with the Story Table during a “free play” session (Session 1). They then received intervention based on principles of supporting social interaction while using the Story Table. Sessions 2-4 focused on support for “shared activities”, Sessions 5-6 focused on “help and encouragement” and Sessions 7-8 focused on “persuasion and negotiation”.

Prior to each of the sessions the children were presented with a few minutes instruction, aimed at familiarizing them to the various constructs of collaboration. These “rules” that were learnt at this session were clearly displayed on the wall in front of the children while playing the Story Table, so they could be visually reminded of them while playing. The constructs of collaboration that were presented to the children included:

Session 1: free play, no intervention

Sessions 2-4: shared activities: 1. shared choice, 2. shared planning, 3. shared implementation

Sessions 5-6: help and encouragement

Sessions 7-8: persuasion and negotiation



Figure 3. Tools used for pre- and post-testing: MarbleWorks game and “low tech” version of the StoryTable

The outcome measures were coded from videotapes of each session by three trained research assistants. Following training, an inter-rater reliability of .85-.96 was achieved. The outcome measures included (i) a behavioral checklist of positive (e.g., non-verbal expression of affection, use of “small talk”) and negative (e.g., avoidance) social interactions as well as autistic behaviors (e.g., topic perseveration) based on [1] and (ii) an analysis of language usage in the interactions and in the narrations. Our specific research questions included items

related to changes in behavior while using the StoryTable: Does it (1) enhance positive social interaction?, (2) help users make progressively better stories? and (3) lessen stereotypical, repetitive (autistic) behaviors? We also asked whether use of the StoryTable had an impact on (1) children's ability to transfer to collaboration in other tasks? and (2) the level of play?

4 RESULTS

All the children enjoyed using Story Table and appeared motivated to create and tell stories. They were readily able to learn and execute the various functions within one or two teaching sessions. Due to the small sample sizes, non-parametric statistics were used to compare the means scores for the three pairs of children. Only trends were obtained as reported below.

With regard to the behavioral measures, there was a clear trend towards supporting the development of important social behaviors as shown in Fig. 4. A comparison of the behavioral scores between the first (light histograms) and the last session (dark histograms) of use of the Story Table showed a considerable increment of the positive social behaviors. In particular they had a substantial increment in eye contact and emotion sharing as well as demonstrating an interest toward the partner. A concomitant reduction of stereotypic, repetitive behaviors was observed while the children were interacting with Story Table compared with the pre-intervention low-tech activities.

An important aspect of an intervention methodology is the extent to which the positive effects are transferred to other tasks. Comparison of pre and post MarbleWorks games showed a trend towards similar progress was observed for what concerned positive social interaction behaviors: respond and propose action, sharing emotion, express interest in the partner, comfort and encourage the partner, look and positive affect, as shown in Fig. 5. The light histograms show the behaviors during the pre MarbleWorks game and the dark histograms show them during the post MarbleWorks game.

Moreover, comparison of pre and post MarbleWorks games showed a trend towards progress in the level of play. Typically developed children as infants first begin in simple play in that they play by and with themselves through their sensorimotor experiences. For example, they play with their feet, pull off their socks or stack blocks. The next phase of play is parallel play where toddlers play near by each other, but not cooperatively or with each other. Complex play involves cooperative play, but usually including more imaginary themes and longer time. The results of this study showed that "parallel play" increased to parallel play with looking at the partner and "simple play" increased to "complex play". For example, as shown in Fig 6, more time spent on less complex play (parallel play without looking) during the pre-intervention MarbleWorks game (light histograms) to more complex play (complex coordinated game) during the post- intervention MarbleWorks game (dark histograms).

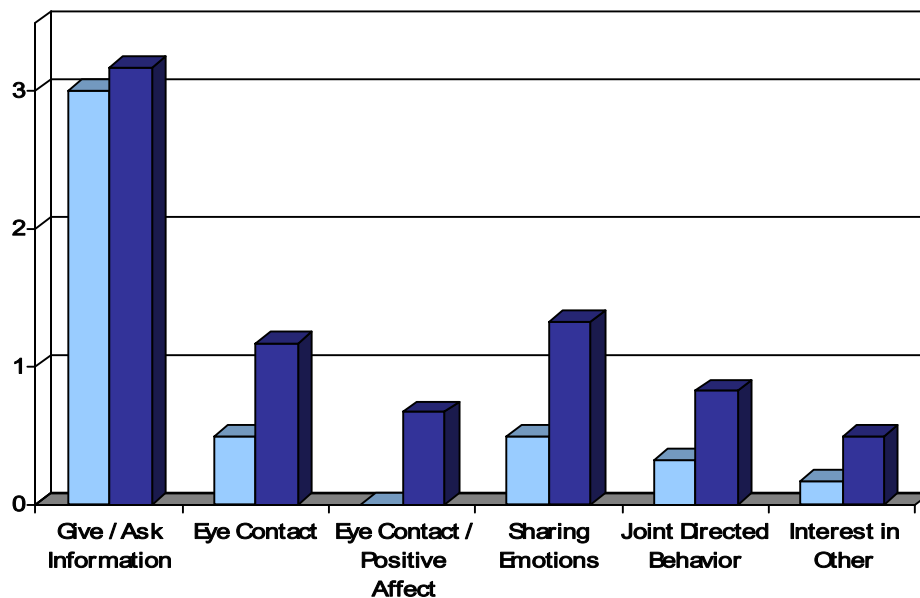


Figure 4. Comparison of the mean behavioral scores between first (light) and last (dark) Story Table sessions.

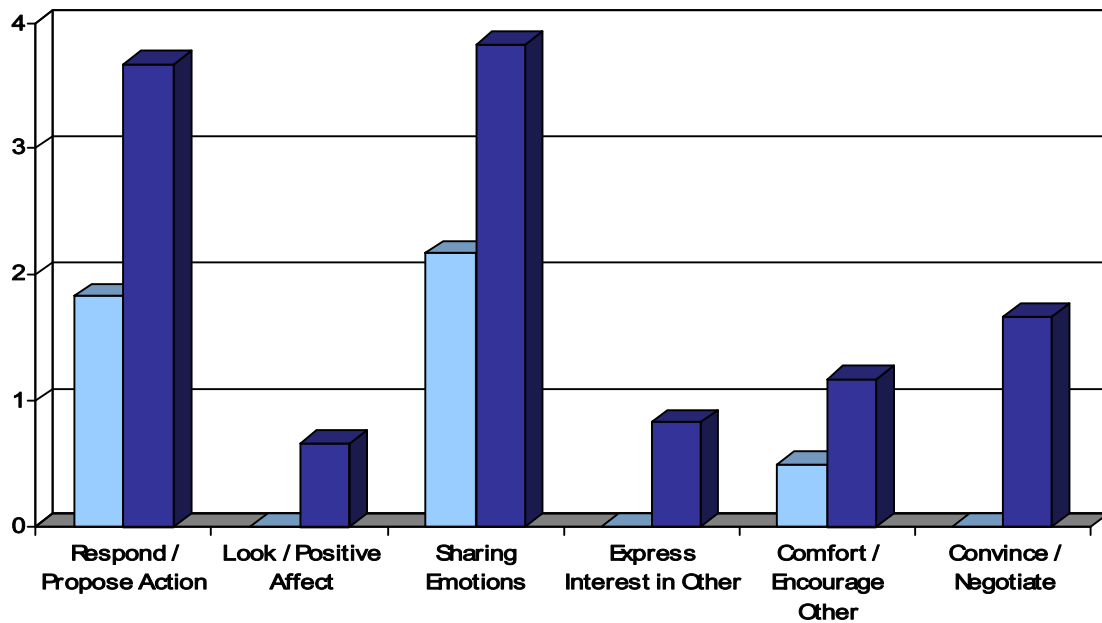


Figure 5. A comparison of the mean behavioral scores between the pre- (light) and post (dark) MarbleWorks game.

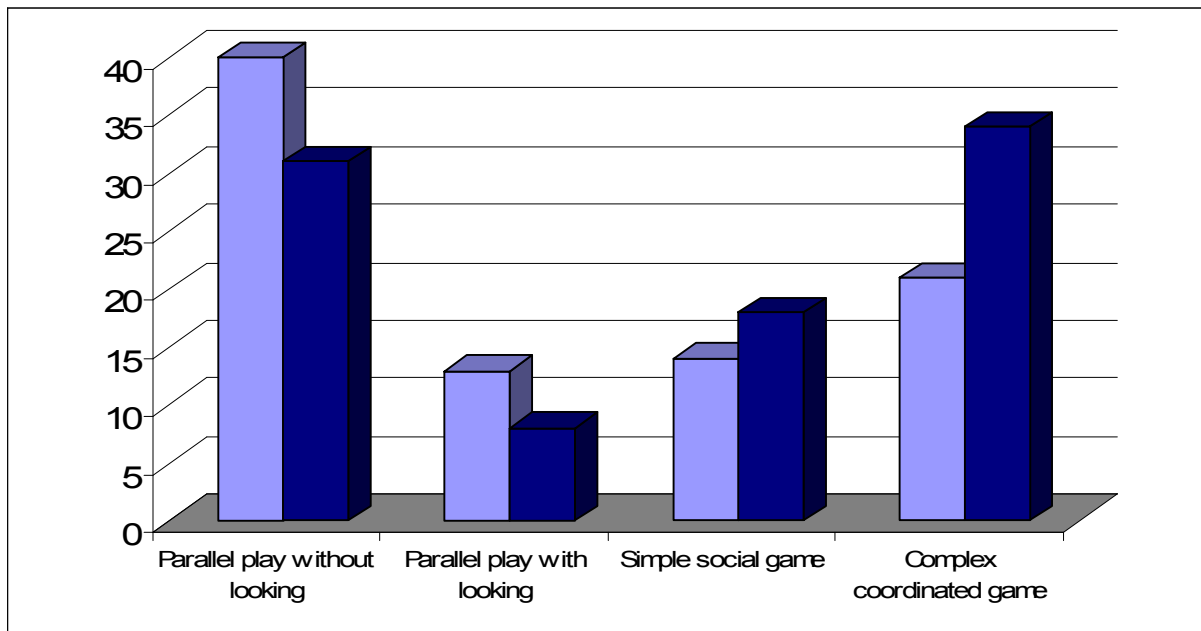


Figure 6. Transition from more time spent on less complex play (parallel play without looking) during the pre-intervention MarbleWorks game (light) to more complex play (complex coordinated game) during the post-intervention MarbleWorks game (dark).

In order to examine the interaction that leads to the production of narrative texts we analyzed the data at two different levels: Level 1 including conversational utterances as the verbal interaction that leads to the construction of the narrative text and Level 2 including narrative utterances as the narrative text itself, which takes place in a fictional (rather than real) world. The questions asked included (1) What are the type of conversational utterances that lead to story-construction? (2) How is child-child compared to adult-child verbal interaction? (3) Is it possible to reveal patterns of cooperation in story construction? Do these patterns change as a function of experience with the task? (4) How does technology (the communication board) affect the verbal interaction and the narrative as a product? and (5) How does experience with the task affect the production of narrative texts?

The analysis included transcription where the verbal interactions recorded during the joint activity were transcribed into turns and each turn was separated into utterances and coding where each utterance was coded according to a framework of analysis devised to capture indications of joint accomplishment.

The first type of Level 1 utterances that were examined were narrative conversational utterances. These included discourse strategies adopted while coping with the task, which were not directly related to the construction of the narrative. First, there were technical directions, questions and demands, that is, utterances that dealt with technical matters related to the task (e.g. "close it, close it"; "go on, press now"). Second, there were utterances aimed towards enhancing collaboration with the task (including turn taking), that is, utterances that enhance the children's cooperativeness with the task, calling attention to their involvement and commitment with the task, as well as reminding them about how to behave while participating in the task (e.g., "Jonathon, it's your turn now, I'm waiting"). Third, there were utterances related to agreeing and evaluating, that is, utterances that give support to the participants and encourage their participation (e.g., "nice", "they are an incredible couple!"). Forth, there were utterances related to getting organized with the narrative task, that is, utterances that deal with the narrative task properly, including description of rules, requesting collaboration with the narrative, etc. (e.g., "do you remember how we chose a background to the story?").

The second type of Level 1 utterances were narrative conversational utterances that included discourse strategies related to the text as a product, including utterances about: story structure (e.g., "we are now in the middle of the story"), story content (e.g., "is he telling the same thing as his neighbors did, about the cake?"), and story form (e.g., "speak nicely, Elad. It's a story it's not a song").

The Level 2 analyses involved a set of criteria meant to analyze the quality of the text in terms of degree of coherence, content and structure. The type of narrative utterances examined here included 1st person utterances (the characters speak) or 3rd person utterances (the child reports about the characters and their actions). The linguistic encoding of characters by means of (1) Nouns or noun phrases (e.g., 'the girl is preparing to go to bed'); (2) pronouns (e.g., 'and she says that she's doing her homework'); (3) zero (neither a noun or a pronoun are used before the verb). These categories allow for a functional analysis of 'reference tracking' along the texts, i.e. to see how the child succeeds in maintaining the reference to already presented characters and how he/she manages to introduce new characters.

Non-narrative conversational data was the most frequent discourse type during the Story Table sessions, especially utterances related to technical issues regarding the usage of device. However, this type of conversation became less frequent as the intervention advanced while the coherence of the stories produced increased with experience. In particular, there was an increasing ability to maintain the reference to the protagonists of the stories, either by grammatical or lexical means; and more occurrences of thematically connected utterances (e.g., successfully relating to the same topics and even expanding them) was observed. These data are shown in Figures 7 and 8.

Analysis of the child-adult interactions has not yet been completed.

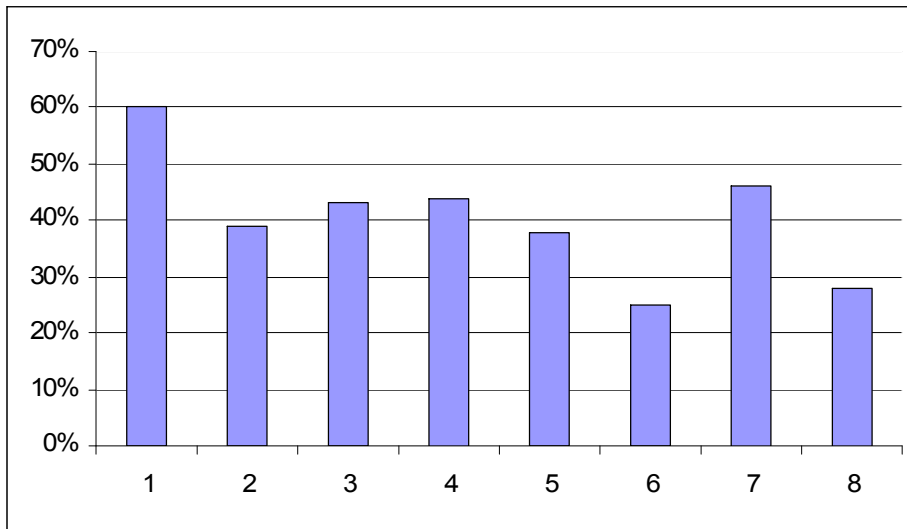


Figure 7. Non-narrative conversational utterances out of total turns in one interaction, by number of session.

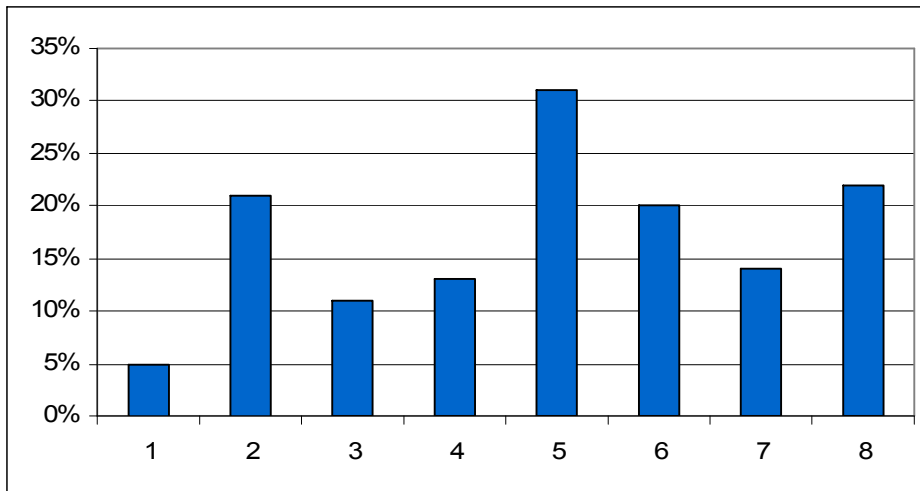


Figure 8. Narrative Conversational Utterances out of total turns in one interaction, by number of session.

5 CONCLUSION

The results presented in this paper are preliminary due to the limited number of subjects and because of the relatively limited duration of the intervention. Yet, the results appear to be highly encouraging; the use of the Story Table appeared not only to increment the level of involvement and to produce positive effects on some behavioral and communicative skills but these effects were, at least to some extent, transferred to other tasks.

Our hypothesis, which needs further study for confirmation, is that co-located interfaces like Story Table may be well suited to support these types of intervention for several reasons. First, the collaboration is carried out with a peer in a real situation rather than in a virtual environment yet technology is available to mediate the interaction making evaluation less stressful and more ecologically valid. Second, the possibility of forcing some tasks to be done together (as in the case of multiple-user GUI actions in Story Table) may foster the recognition of the presence of the partner and stimulate collaborative behavior.

Story Table was first used as an interface designed to support Cooperative Learning activities for typically developed children. The results of the pilot study reported in this paper provide evidence that the design of interfaces based on the notion of multiple-user GUI actions (what we call “enforced collaboration”) have

considerable potential for enhancing several key social behaviors and some core language skills of children with HFA.

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