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Usability of Technology Supported Social Competence Training for Children on the Autism Spectrum

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***Abstract*—We present the results of two usability studies evaluating the use of collaborative technologies designed to facilitate children with Autism Spectrum Conditions (ASC) learning social competence skills through technology-delivered Cognitive-Behavioral Therapy (CBT). The first study examined a co-located games (Join-In Suite) run on a multi-user tabletop shared active surface (SAS). The second study collaborative virtual environment (CVE) designed to support understanding and practice of social conversation skills. Both prototypes were developed following a participatory design process that included focus groups of occupational therapists and teachers as well as children with ASC. Usability studies were then conducted where occupational therapists used the systems for social competence training during a single one hour session with pairs of children with high functioning ASC, aged 9-13 years. Outcome measures included two usability questionnaires, the Intrinsic Motivation Inventory and interviews with the children. Therapists' responses to the System Usability Scale were also recorded. Results for SAS and CVE prototypes showed great enjoyment of the games, preferences amongst them and proficient use of the technology. For both technologies, the collaborative nature of the activities appeared to be effective in leveraging the engaging power of computer games as well as capturing a level of ecological validity which is often not sufficiently present in computer games alone.**

Keywords-Autism Spectrum Condition (ASC), collaborative games, cognitive-behavioral therapy (CBT), Touch table, shared active surface (SAS), collaborative virtual environment (CVE)

I INTRODUCTION

Autism Spectrum Conditions (ASC) refers to a neurological disorder that affects behavior and the ability to communicate and interact socially [1]. Severity and range of deficits vary from one child to another, ranging from very low to very high functioning. Social competence, entailing a child's capacity to integrate behavioral, cognitive and affective skills in order to adapt flexibly to diverse social contexts and demands is one of the core skills that is impaired in children with high functioning ASC. Social incompetence adversely affects a child's ability to learn in formal and informal educational settings, and to interact appropriately with other children [2].

A variety of technologies have been used to train social competence of children with ASC. These include video modelling [3], virtual reality [4] and socially assistive robots [5]. Virtual Environments (VEs) are essentially 3-D pictorially-based scenarios or contexts, presented on standard computer hardware (such as a PC or, especially in schools, interactive white boards) that can realistically depict particular contexts or environments (e.g., a school building and / or classroom). These technologies have demonstrated the potential to be both feasible and effective for supporting learning about social skills [6, 7-9]. Collaborative VEs (CVEs), by extension, allow several participants to simultaneously share the same VE. This provides a facility for participants to engage in collaborative interaction within the VE.

In recent years, multi-user or multi-touch table top surfaces have become available [10]. These are large touch-screens placed horizontally that can be operated by more than one user at the

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same time. This technology affords new modalities of interaction including the use of multi-user "cooperative gestures", i.e., co-located interactions via a multi-user device where the system interprets the gestures of more than one user as contributing to a single, combined command [11, 12]. Several studies have examined the use of cooperative gestures for children with ASC. Piper et al. [13] used a four-player cooperative tabletop game to teach group work skills to middle school children with Asperger's Syndrome (a very high functioning form of autism). Gal et al. [14] evaluated the effectiveness of a three-week intervention in which a co-located tabletop interface was used to facilitate collaboration and positive social interaction for children with ASC. Significant improvements in key positive social skills were achieved. Similarly, Battocchi et al. [15] studied the ability of a digital puzzle game to foster collaboration among children with ASC; in order to be moved, puzzle pieces had to be touched and dragged simultaneously by the two players.

We have recently developed two new applications designed to implement social competence and social conversation training based on the Cognitive-Behavioral Therapy (CBT) model which describes social competence as a multidimensional concept and assumes reciprocity between the ways an individual thinks, feels, and behaves in social situations [16]. Bauminger [17] has provided good preliminary evidence of its potential for teaching social skills to children with ASC. However, although using technology for children with ASC has been shown to have great potential, and although CBT-based interventions appear to be beneficial for children with high functioning ASC, there have, thus far, been no attempts to explore the ways in which CBT can be implemented via technology. This work is part of a European Commission project, COSPATIAL (http://cospatial.fbk.eu/).

All of the COSPATIAL technology prototypes have been developed using Participatory Design [17], a methodology in the field of User-Centered Design that posits an active involvement of users in the design process as a way of developing socially valid and sensitive systems. Participatory design involves end-users directly as design partners [18] and this approach has been used successfully for development of new technology for children who are typically developing [19] as well as for those with ASC [20]. One of the features of the co-operative inquiry method is that frequent design-review sessions are held between technology developers, researchers and users. These sessions enable rapid idea generation and selection of priorities for the next iteration of technology development.

To date, well-established practices for the design of technology to support therapeutic and educational interventions for these children are lacking [21, 22]. The objective of this paper is to present the results of how the design process led to improvements in SAS Join-In Suite and the CVE TalkAbout prototypes. We present the results of usability studies in which children with ASC tested each prototype.

II METHODS

A. Population

Usability Study 1: Eight boys with high functioning ASC, aged 9-13 years, participated in the study. All were enrolled in special education classes (Grades 2-5) within a mainstream elementary school. They were moderate to frequent users of video games and had used the DiamondTouch table previously during a study of social collaboration during story telling. The intervention sessions were provided by two experienced occupational therapists who work with these children at their school.

Usability Study 2: Twelve children (11 boys and 1 girl) with high functioning ASC, aged 9-13 years, participated in the study. All were enrolled in the same special education classes (Grades 2-5) within a mainstream elementary school as for Study 1; half of these children had participated in Study 1. None had any previous experience in using CVEs or virtual reality technology but they were adept at playing computer games and had some experience in using multiplayer online games). The study took place at the school and was facilitated by an experienced occupational therapist who works with these children at their school.

B. Cognitive Behavioral Therapy (CBT)

CBT was the theoretical and inspirational base for the initial concept design of both Join-In Suite and TalkAbout. A CBT session for social competence training is usually organized into distinct but interleaved phases in which the children can learn the concepts of socializing, experience a social task that addresses the learned concept and have the possibility of reflecting upon the learning and experience stages. Thus, each of the three Join-In Suite prototypes is composed of two tightly integrated parts: a learning part which realizes a structured version of the CBT social problem solving technique and an experience part based on the CBT behavioral reinforcement technique. During the learning part, a series of social problem vignettes and five alternate solutions are presented; the children scan and discuss together with the facilitator the various alternatives until they select the one that entails an appropriate social collaboration. During the experience part, the children play a game that allows them to directly experience a scenario based on the presented a problematic social situation. The key operations on the interfaces require cooperative gestures, for example the chosen alternative has to be selected by the two children and the facilitator by tapping together on a card.

In TalkAbout the objective social goal is to achieve effective conversation with another participant (involving initiation, turn-taking and reciprocal dialogue). The activity revolves around two or more players engaging in conversation within the CVE. In this case, two children and one facilitator share the CVE and are each represented by virtual avatars. They can each move their avatar around the virtual room and can thus demonstrate non-verbal behaviour related to social conversation (i.e. facing towards and moving closer to the character that they are speaking to). As with the Join-In Suite, TalkAbout interleaves CBT learning and experience techniques. In the learning part, the facilitator guides the children through the main stages of conversation and shows them the drop-down prompts listed for each stage. The facilitator discusses the prompts with the children and explains what would be expected in a social conversation (e.g. describing emotions and feelings rather than merely information sharing). In the experience part, the children select a topic of conversation and are required to work through the conversation stages together. During this part, the facilitator supports them by providing cue cards separately to each one to suggest what they should do (e.g. listen to the other participant, or ask them a question) and awards stars for successes during the task. CBT experience techniques implemented in TalkAbout include modelling, behavioural rehearsal through role play and feedback and reinforcement. The 'record and replay' feature of CVE technology is used to make a recording of the conversation This is shown to the children at the end of the task and the facilitator guides them through the reflection process.

C. Instruments

JOIN-IN Suite

This is a 3-user, touch-based application implemented via the DiamondTouch (DT) [23]. The Join-In Suite uses the multi-user capabilities of this device to foster collaboration between pairs of children and to provide ways for a teacher or a therapist, henceforth referred to as a facilitator, to control the pace and process of the educational or therapeutic interaction. The design of the application explored different types of collaborative interaction patterns in a multi-user context. Fig. 1 shows two children with ASC interacting with the DT surface.

Fig. 1: Two children with ASC interacting with the DT surface.

In the Join-In Suite we explored three collaboration dimensions including Joint Performance where collaboration is the performance of joint actions, Sharing where collaboration is the sharing of personal resources to achieve a common objective and Mutual Planning where collaboration requires the users to formulate and perform a joint plan. The Apple Orchard story focuses on joint performance (Fig. 2), the Bridge story focuses on sharing (Fig. 3), the Save the Alien story focuses on mutual planning (Fig. 4).

These collaboration functionalities are possible due to the DiamondTouch's multi-touch capability of distinguishing who is touching where. This enables the programming of constraints on interface objects that realize the three dimensions above. These include:

Constraints on objects (to achieve joint performance), realized by having some objects on the interface that can be operated or selected by all the users acting upon them. For example, in one of the games (Apple Orchard), the children have to move a basket to collect falling apples; the basket moves very slowly when it is operated by a single child while its movement is faster and smoother when both children simultaneously move it.

Constraints on ownership (to achieve sharing), realized by having some objects on the interface assigned to one or the other child and the system lets operations be performed only by the owner. For example, in another game (Bridge), the children have to repair a broken bridge in a puzzle-like game but they can only use the pieces that belong to them and that are located on their bank of the river; when a child needs a piece that is on the other bank, he has to ask for it from the other child because they system does not allow him to just take it.

Finally, the *Constraints on roles* (to achieve mutual planning) impose different game roles on the children such that the system does not allow one child to play a role which was not assigned to him. For example, in another game (Save the Alien), the children have to collect shooting stars to refuel an alien starship; one child has to tap on the stars and make them fall toward the sea while the other has move a boat to catch the stars. The system does not allow the child assigned to the stars to operate the boat and vice versa.

The collaboration dimensions exemplify the patterns of collaboration that children should learn to recognize and use in real life situations while the constraints are specific examples of these dimensions in the multi-user games. The learning objective of the Join-In Suite is to teach social dimensions by exposing the children to them in a playful environment and by giving the facilitator a structured way of discussing them.

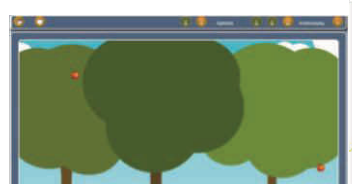

Fig. 2: SAS Apple Orchard Game   Fig. 3: SAS Bridge Game

Fig. 4: SAS Save the Alien Game

TalkAbout

This is a CVE computer program in which children are encouraged to learn about and practice the stages of social conversation. The program currently supports three players: two children and a facilitator who is usually a teacher or therapist that knows the children. Each user has accesses to the virtual environment from their laptop and has their own avatar. The users can then talk to each other using headsets with microphones. The role of the facilitator is to explain the concept of a social conversation to the children and to help them learn about and have successful social conversations with each other with the aid of the computer program. TalkAbout has been designed for both co-located and distributed use (i.e., users could be in different classrooms or the same classroom). Face-to-face interaction can be anxiety provoking for children on the autism spectrum so, importantly, the TalkAbout program provides a platform for children to practice their conversations in an environment that does not require this.

The TalkAbout session is divided into five phases:

1. **Introduction to the scenario:** Introduction to the concept of "social conversation".
2. **Training phase:** Introduction to and practice of the different stages of a social conversation: 'Initiate', 'Maintain', 'Switch' and 'Exit'.
3. **Introduction to cue cards:** Introduction and explanation of virtual cue cards.
4. **Main task:** Children choose a topic to talk about, and try having a full conversation with support from the facilitator where needed.
5. **Record and replay:** Play back of the recorded session to the children. Facilitator leads a discussion about what happened and how they could improve their conversational skills.

In some sections we provide example scripts to help illustrate the role of the facilitator however we feel that the facilitator will know best how to approach the session due to their pre-existing knowledge and experience with the child.

Before the children and facilitator enter the virtual environment, the facilitator spends time introducing the session and explains the concept of "social conversation". The length of this session is decided by the facilitator based upon the needs and abilities of the children. The facilitator is provided with a number of materials to help support the session. These include short storyboards or vignettes that demonstrate appropriate and inappropriate social conversations. An example is shown in Figure 5.

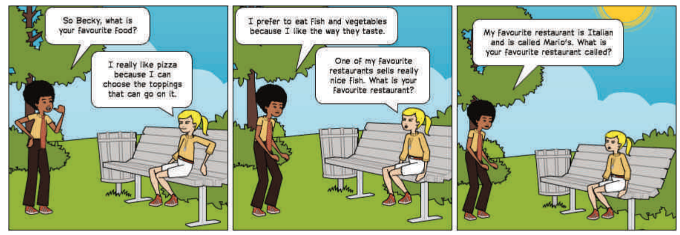

Fig. 5. Example of a social conversation created using Pixton ® http://www.pixton.com

The facilitator then explains that they will be practicing social conversations with their partner using a computer program. After completing the introductory session, the students and facilitator are seated at their own laptops where they are able to see the virtual TalkAbout room through their avatar's eyes. The children sit at opposite ends of a table either side of the facilitator; a divider is used to simulate a distributed scenario and to ensure that the facilitator and children communicate through the virtual environment rather than face-to-face. The facilitator interface is different as it provides tools for facilitating the conversation.

The five stages of a social conversation, 'Greet', 'Initiate', 'Maintain', 'Switch' and 'Exit' [2] are displayed across the top of the screen on both interfaces. The facilitator is able control which stage is highlighted on all users' screens by clicking on the appropriate tab. When the users hover over a highlighted conversation tab a drop-down box appears containing suggested phrases that the children could use (Fig 6). Table 1 shows the prompts listed under each tab. The facilitator explains each social conversation stage and suggested prompts to the children and encourages them to practice talking to each other. When the facilitator is happy that the children have an understanding of the five stages they move on to cue card training.

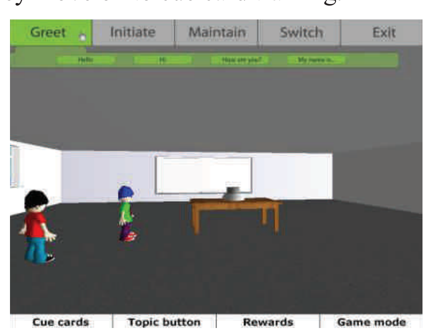

Fig. 6. CVE TalkAbout screen shot showing drop down prompts

TABLE 1: SOCIAL CONVERSATION PROMPTS

Social Conversation Stage	Suggested Prompts
Greet	Hello ● Hi ● My name is... ● How are you?
Initiate	What have you been doing today? ● What are you doing after school today? ● Did you do anything fun yesterday? ● Are you looking forward to the weekend? ● What's your favourite (animal / lesson / food)?
Maintain	What...? ● Who...? ● How...? ● How...? ● When...? ● I like... ● I don't like... ● This makes me think that... ● This makes me feel...
Switch	That reminds me of... ● Talking about ... makes me think of ... ● Another thing I like is... ● What else do you like?
Exit	Okay, I need to get to my next lesson, see you later! ● I have to get on with some work now, nice talking to you, goodbye! ● I have to meet ... now but let's meet up after the next break, see you soon! ● I have to go home now, goodbye!

Virtual cue cards are used within the CVE by the facilitator as a tool to prompt or remind the children of how to conduct their conversations appropriately. For example, if there is a period of silence during the conversation, the facilitator may send one child an 'Ask a Question' cue card by click on the card under either 'Player 1 which would appear on the child's toolbar. Figure 7 shows the facilitator interface. The participants are currently in the 'maintain conversation' stage in the main part of the activity. The facilitator can see the two players facing each other and is listening to their conversation. She uses the cue cards to prompt the players and has sent the prompt 'ask your partner a question' to player 1 and 'listen to your partner' to player 2. She awards stars to each participant to reward them for good conversational skills.

Children choose a topic (collaborative selection using the traffic light system on the selection button). Topics are: music, sport, television, pets, theme parks, cafe, computer games, holidays, family and own choice. When they have chosen the topic, the facilitator selects the 'greet' tab to indicate that children must start their conversation. The facilitator monitors the conversation and uses cue cards when necessary to prompt the student (e.g. showing the 'ear icon' to remind one player to listen to their partner or the question mark icon to prompt them to ask their partner a question.

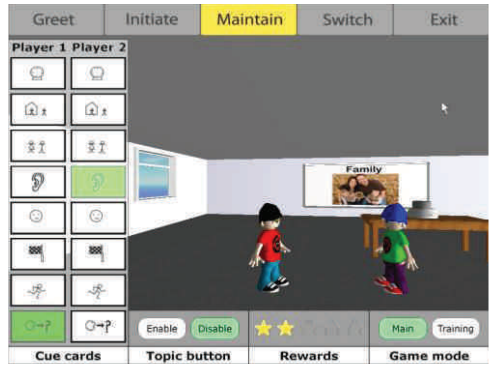

Fig. 7. CVE TalkAbout facilitator interface

Figure 8 shows the interface for player 2 during game play. They have received the cue card to prompt them to 'listen to their partner'.

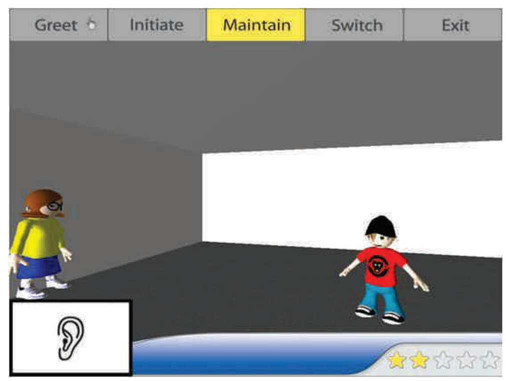

Fig. 8. CVE TalkAbout participant interface

Each session is recorded through the computer and at the end of the main activity the facilitator can replay parts of the session to the children to help them reflect on the conversation. This allows the facilitator to provide constructive feedback that they may not have had the opportunity to provide during the activity, and provides the child an opportunity to reflect on what happened.

Questionnaires

The Scenario Experience Feedback Questionnaire (SEFQ) consists of 16 items, rated with a 5 point scale, to query the children's enjoyment, understanding, ease of use, and other usability items while playing the games (maximum score = 80). The Scenario Learning Feedback Questionnaire (SLFQ) consists of 5 items to query how well the children understood and felt about the problem and solution part that precedes each game (maximum score = 25).

The Intrinsic Motivation Inventory (IMI) task evaluation questionnaire [24] consists of 22 items, rated on a 7 point scale, designed to assess a user's response to four components: interest in and enjoyment of the task, perceived competence, perceived choice and feelings of pressure or tension while doing the task. It was administered at the end of all three scenarios as a way of documenting the overall response of the children to the Join In suite. It was also administered after TalkAbout.

System Usability Scale (SUS). At the end of all sessions, each therapist was asked to rate the usability of the Join-In Suite using the SUS, a 10 item questionnaire rated on a 5 point scale [25].

D. Procedures

Before the beginning of the study, the therapist received a short training on the system and its intended use; in particular it was stressed that there were no constraints on the order of learning and experiential part for each story and the therapist was free to decide which part should come first and could mix the two. Demographic data about the children were collected after the parents gave their permission for their child to participate in the study. The therapist introduced the Join-In Suite to the children who then used each of the three scenarios in the following order: Apple Orchard, Bridge and Save the Alien. After each prototype, the SEFQ and SLFQ questionnaires were administered. At the end of the session, the IMI questionnaire was administered. At the end of all sessions, the therapists completed the SUS. The therapists and teachers who conducted the sessions were interviewed.

III. RESULTS

The level of engagement and the perceived difficulty of the four prototypes that emerged from the analysis of the videotaped interactions (not presented here) were consistent with the children's responses to the questionnaires. Figure 9 displays the distributions of the SEFQ (enjoyment, understanding, ease of use, sense of control) with 80 being the maximum score. The Apple Orchard prototype was clearly less enjoyed by the participants relative to the other two SAS prototypes and the CVE prototype.

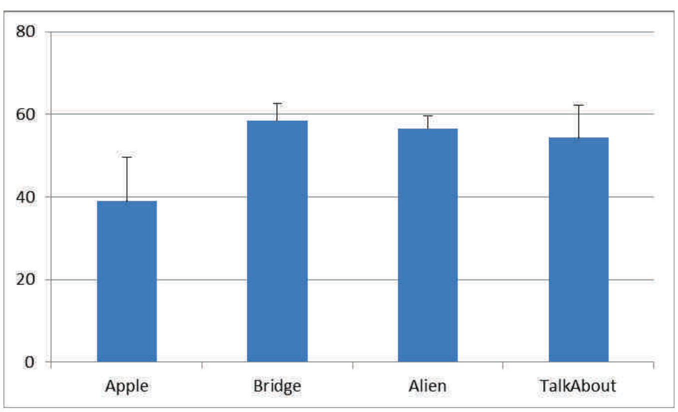

Fig 9: Mean plus 1 SD of children's feedback during experience part of prototypes (SEFQ).

Figure 10 displays the distributions of the SLFQ (how well the children understood the functionality and objective of the presented situation (social collaboration for Join-In and social conversation for TalkAbout) (maximum score = 25). It is interesting to note that all prototypes were rated similarly for the learning part.

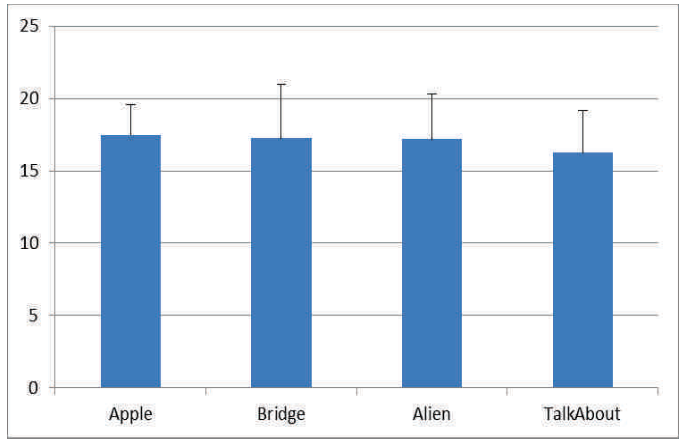

Fig 10: Mean plus 1 SD of children's feedback during learning part of prototypes.

Figure 11 displays the mean responses (plus 1 SD) to the four components of the Intrinsic Motivation Inventory (maximum response equals 7) administered to each child after he learned and experienced the prototypes. The blue bars show the responses for the SAS Join-In prototypes whereas the red bars show the response for the CVE TalkAbout prototype. The results show that the children were very interested in the task, felt very competent doing it, perceived that they could make choices during the task, and felt minimal pressure and tension while doing the task. Note that there was more variability (larger SDs) in these data relative to the experience and learning feedback.

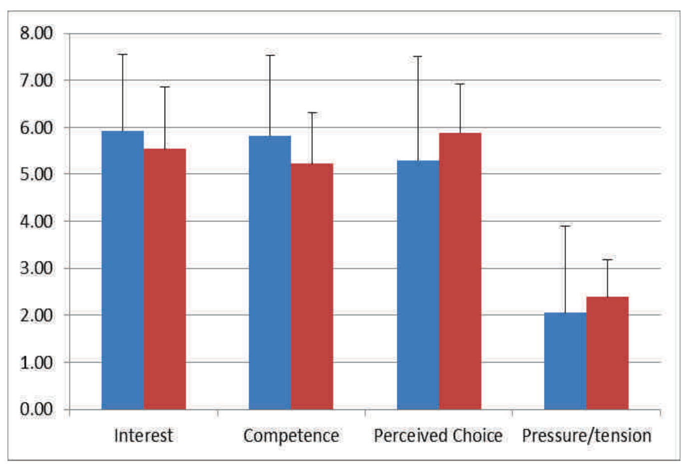

Fig 11 Mean plus 1 SD of children's IMI scores.

The results of the SUS questionnaire showed that the therapists found the Join-In Suite's functionality to be consistent, intuitive and easy to use. They expressed a strong interest in using it as an educational tool in the future. Similarly they found TalkAbout to be easy to use for both children and facilitator, and they consider it to be a strong tool to facilitate social conversation in those with ASC. They suggested the need to use alternate cues and instructions for different cultures.

IV. DISCUSSION

A key aspect of COSPATIAL prototype development process was that, in keeping with Participatory Design guidelines [18, 17] it entailed a complementary cycle of idea generation through participatory design sessions, with subsequent technology development thereby enabling rapid iterations of the software for users to evaluate. Rapid design review with the direct involvement of users should enable development of technical solutions that are usable and appealing to the users, and that meet the needs of the teaching/therapy requirements within the context of use [18, 17].

This initial formative evaluation of these prototypes provided valuable insight regarding the possibility of using collaborative games as a basis for teaching social competence (Join-In) and social conversation (TalkAbout) skills. Their strengths appear to derive from the motivational and engagement value of the interleaved learning and gaming tasks and also from the provision of new tools that intrinsically support a facilitator while conducting a session.

The ability of children to acquire skills when interacting independently with computer technology has been well documented [22, 26]. Educational software is able to reliably deliver stimuli, reinforce correct responses, and demonstrate errors under strict facilitator control. Much has been written about how to design software to help children with ASC improve in their academic, social and communication skills [22]. Davis et al. [21] and Jordan [27] recommend that specific factors should be taken into account when designing learning environments for children with ASC in order to enhance their strengths while reducing the need for abilities which are more difficult for them. These factors include task consistency and predictability as well as the gradual introduction of novel elements. Moreover, although computer-based learning activities should be challenging, children with ASC should not be explicitly penalized for mistakes; it is best when negative feedback is provided together with clear cues as to how to proceed. Finally, time is useful as a motivating factor but should not apply excessive pressure to the task.

Join-In has explicitly incorporated these design guidelines and, as demonstrated by both the focus groups and formative studies, they have proven to be appreciated by teachers, therapists and children with ASC. The facilitators strongly recommended that Join-In should encourage the children to create and insert their own alternative solutions, and not rely solely on those presented by the software, thereby increasing their active participation. They also indicated the importance of having stories that actually relate to the child's everyday life, at school and at home in order to enhance transfer and generalization. It was also recommended that the children be given an opportunity to reflect on the process by recording or videotaping how they viewed the collaboration experience (as if they tell someone else about their experience).

It is interesting to note that TalkAbout was specifically not designed as a game, rather it was designed to utilize features of CVE technology to focus attention on the required learning objectives and delivery of CBT strategies. However, it was noted that the use of game elements such as independent control of avatars and rewards for success were sufficient to motivate the children to use the prototype. The children really enjoyed exploring the CVE and having the freedom to move around. All children seemed excited about the replay of their session. The facilitator was able to reflect on the conversation with the children effectively. However, it was observed that the children did not always activate the drop down menus to reveal conversational prompts when the facilitator was talking about them. Moreover, the facilitators were usually unaware of this. It is important that facilitator should know what the children can see (either by seeing their screens or having a clear indication e.g. consistency between what the facilitator can see and what the child can see) in order to be able to facilitator effectively. Inevitably, cultural differences in the prompts (that had been translated from the English version) were noted by the Israeli team. It is recommended that the application should allow for individualisation by providing the ability for teachers and/or facilitators to edit in-game text.

The data presented in this paper derive primarily from response to questionnaires completed by both types of users, the children and the therapists. An additional source of data, reported only briefly here, was from a series of focus group which provided insight into user needs. These results have been presented elsewhere for the Join-In prototypes [28]. It was important to obtain this feedback from both types of users - the therapists and teachers as facilitators and the children with high functioning ASC since they clearly had differing but complementary perceptions of what needs the software should address [20]. Indeed, the initial scenarios were modified to the present prototypes prior to the usability study as a result of the Focus group feedback.

The results of the usability and motivation questionnaires were essential in identifying weak points in the software and catering, when possible, to user preferences and sensibilities. For example, the children with ASC enjoyed the different parts of the prototypes (learning and experience), responded appropriately to the different collaboration strategies, and showed clear preferences for two of the three Join-In games. We were gratified with their strongly stated preferences since this demonstrated their candor and conviction; indeed, verbalization of preferences is one indication of an empowered user [29]. We have also used interview and focus group feedback to refine the prototype and greatly improve the original software design. The next stage will include additional usability testing as well as more formal evaluation of the effectiveness of the Join-In Suite and TalkAbout prototype.

In conclusion, the results of the current study have helped to ensure that the Join-In Suite and TalkAbout are suitable to achieve their therapeutic goals, namely using a CBT-based strategy to train social competence skills (Join-In) and social conversation (TalkAbout) in children with high functioning ASC. We are now poised to run a formal evaluation study in which the effectiveness of these prototypes will be tested.

ACKNOWLEDGMENTS

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