Usability of a Multi-Touch Tabletop Surface to Enhance Social Competence Training for Children with Autism Spectrum Disorder

Patrice L. (Tamar) Weiss
University of Haifa

Eynat Gal
University of Haifa

Sigal Eden
Bar Ilan University;
The Open University

Massimo Zancanaro
University of Trento

Francesco Telch
University of Trento

Abstract

We present the results of a usability study of a co-located suite of games (the Join-In suite) run on a multi-user tabletop surface to support social competence training for children with Autism Spectrum Disorder (ASD). This suite has been designed to implement different patterns of collaboration to support teachers and therapists in their use of Cognitive-Behavioral Therapy. Following a participatory design process that included three focus groups of occupational therapists, teachers and children with ASD, a field study was conducted where two occupational therapists used the system for social competence training during a single one hour session with four pairs of boys with high functioning ASD, aged 9-13 years. Outcome measures included two usability questionnaires, the Intrinsic Motivation Inventory and interviews with the boys who participated in the study. Responses of the therapists to the System Usability Scale were also recorded. Results showed great enjoyment of the games as well as clear preferences amongst them. The participants demonstrated proficient use of the collaboration patterns embedded within each game, showing a range of abilities in social competence. The use of collaborative patterns embedded in the structure of the Join-In suite 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 Disorder, collaborative games, cognitive-behavioral therapy, Touch table.

Introduction

Autism Spectrum Disorder (ASD) is a neurological disorder that affects behavior and the ability to communicate and interact socially (American Psychiatric Association, 2000). Social competence, a child's capacity to integrate behavioral, cognitive and affective skills to adapt flexibly to diverse social contexts is impaired in children with high functioning (HF) ASD. This diminishes their ability to learn and to interact appropriately with other children (Bauminger, 2007).

Diverse technologies have been used to train social competence of children with ASD (Nikopoulos & Keenan, 2004; Parsons & Cobb, in press; Dautenhahn & Werry, 2004). To date, well-established practices for the design of technology to support interventions are lacking (Davis et al., 2010). In recent years multi-user or multi-touch tabletop surface technologies have become available (Cappelletti et al., 2004). These are large touch-screens placed horizontally to be operated simultaneously by more than one user. They afford new modalities of interaction: multi-user "cooperative gestures", co-located interactions where the system interprets gestures

of more than one user as contributing to a single, combined command (Morris et al., 2006). Piper et al. (2006) used a four-player cooperative tabletop game to teach group work skills to children with Asperger's Syndrome. Gal et al. (2009) evaluated the effectiveness of a short intervention where a multi-touch tabletop led to significant improvements in positive social skills for children with HFASD.

The Join-In Suite is a new application designed to implement social competence training based on Cognitive-Behavioral Therapy (CBT) which views social competence as a multidimensional concept and assumes reciprocity between the ways an individual thinks, feels, and behaves in social situations (Hart & Morgan, 1993). Bauminger (2007) has provided good preliminary evidence of its potential for teaching social skills to children with ASD but its use via technology has not yet been explored.

The Join-In Suite was developed using Participatory Design (Bødker, 1996), a methodology that posits active involvement of users in the design process as a way of producing socially valid and sensitive systems. Participatory Design involves end-users directly as design partners (Binder, 1996) and has been used successfully for development of new technology for children who are typically developing (Druin, 2002) as well as for those with ASD (Francis et al., 2009). One of its features is that frequent design-review sessions be held between technology developers and users to enable rapid idea generation and selection of priorities for the next iteration of development. The objective of this paper is to present the results of one iteration of the design process.

Methods

Participants

Focus Groups. Two focus groups were held at an elementary school that has special education classes for children with ASD. The first focus group consisted of a meeting with the school principal, three occupational therapists and four special education teachers. The second focus group consisted of five boys with HFASD. The third focus group was attended by eight special education teachers specializing in teaching children with ASD.

Usability Study. Eight boys with high functioning ASD, aged 9-13 years, participated. All were enrolled in special education classes (Grades 2-5) within a mainstream elementary school. They were moderate to frequent users of video games. The intervention sessions were provided by two experienced occupational therapists.

Instruments

JOIN-IN Suite

The Join-In Suite is a 3-user, touch-based application implemented via the DiamondTouch (DT) (Dietz and Leigh, 2001). DTs multi-user capabilities were used to foster collaboration between pairs of children and to provide ways for a practitioner to control the interaction's pace and process. The design of the application explored different types of collaborative interaction patterns that supported a CBT session for social competence training. This is usually organized into distinct but interleaved phases in which children learn the concept of socializing, experience social tasks that address the learned concept and reflect upon learning and experience phases. Each of Join-In Suite's three applications includes 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, social problems and five alternate solutions are presented; the children and

practitioner scan and discuss the alternatives and select one that is appropriate. During the experience part, the children play a game directly related to the social problem.

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 formulation and performance of a joint plan. *Apple Orchard* focuses on joint performance, *Bridge* on sharing, and *Save the Alien* on mutual planning (Fig. 1). These functions are possible due to the DiamondTouch's multi-touch capability of distinguishing who is touching where that enables the programming of constraints on interface objects including:

Constraints on objects (to achieve joint performance), realized by having objects that are operated on or selected by all users. In *Apple Orchard*, the children move a basket to collect falling apples; it moves very slowly when operated by a single child but faster and smoother when both children simultaneously move it.

Constraints on ownership (to achieve sharing), realized by having some objects assigned to each child; operations can be performed only by the owner. In *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 are located on their side of the river; when a child needs a piece on the other side, he has to ask for it because the system does not allow him to just take it.
Constraints on roles (to achieve mutual planning) impose different roles on the children; the system does not allow one child to play a role not assigned to him. In *Save the Alien*, the children have to collect shooting stars to refuel a starship; one child taps on the stars making them fall toward the sea while the other moves a boat to catch the stars.
These dimensions exemplify patterns of collaboration that children should learn to recognize and use in real life while the constraints are specific examples used in the multi-user games.

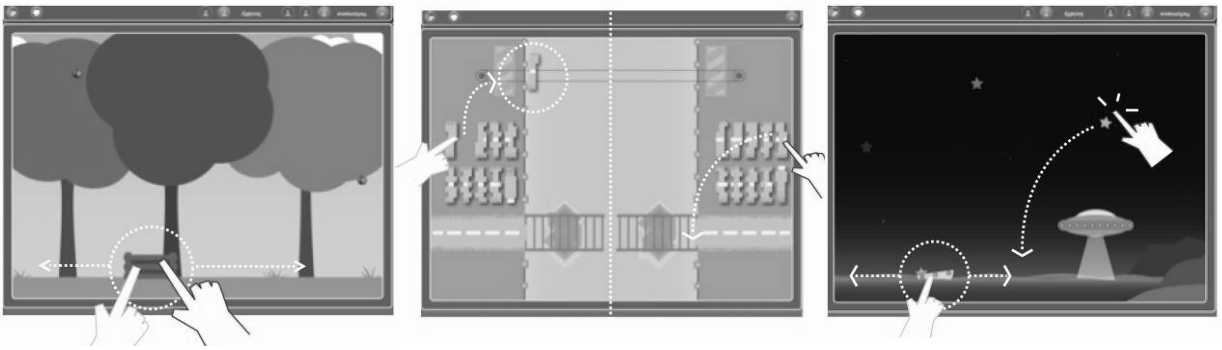

Figure 1. Join-In Suite: left, Apple Orchard, middle, Bridge, right, Save the Alien

Questionnaires

The **Scenario Experience Feedback Questionnaire** (SEFQ) consists of 14 items, rated on a 5 point scale, to query the children's enjoyment, understanding, ease of use, and other usability issues while playing the games. The **Scenario Learning Feedback Questionnaire** (SLFQ) consists of 5 items to query how well the children understood the problem and solution part that precedes each game.

The **Intrinsic Motivation Inventory** (IMI) task evaluation questionnaire (Plant & Ryan, 1985) consists of 22 items, rated on a 7 point scale, to assess a user's interest in and enjoyment of the task, perceived competence, perceived choice and feelings of pressure or tension. It was

administered at the end of all three scenarios to document the children's overall response of to the Suite.

Game Preference and Effort questions. The games were rated in order of preference and effort.

System Usability Scale (SUS). 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 (Brooke, 1995).

Procedures

Focus Groups. The focus groups started with a presentation of the project objectives and the scenarios. The Join-In prototype was demonstrated. The professionals were then asked to give feedback during an open discussion.

Usability Study. Each therapist was trained to use the system as a CBT tool for social collaboration. Demographic data about the children were collected after the parents gave permission to participate in the study. The therapist introduced the Join-In Suite to the children who then used each of the three scenarios. After each story, the SEFQ and SLFQ were administered. At the end of the session, the IMI and Game Preference questionnaires were administered. At the end of all sessions, the therapists completed the SUS.

Results

Focus Groups

The professionals 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 to enhance generalization, e.g., a story about children who have to choose one of two different toys to play with. Adding "authoring" functionality to the Suite was another recommendation, thereby enabling practitioners to create different social problems tailored to specific interests. Inclusion of more feedback options, e.g., voice and symbols, was suggested to denote a successful solution. They also recommended the provision of opportunities to reflect on the process by videotaping the children's view of the collaboration experience. In some instances, the collaborative skills required for Join-In were felt to be too simple; the inclusion of more complex problem solving interactions was strongly recommended.

The children appeared to greatly enjoy the opportunity to provide feedback. They strongly recommended improvements in the quality of the animation by making the games 3D, extending the range of difficulty levels, and incorporating stories with more "action" (e.g., about thieves). They noted several technical problems (e.g., insensitive touch action) and recommended making the games usable without the table (e.g., via multiple mice) to make it more widely available.

Usability Study

The level of engagement and perceived difficulty that emerged from analysis of the videotaped interactions (not presented here) were consistent with the children's responses to the questionnaires. Figure 2 displays the mean enjoyment and ease of use items.

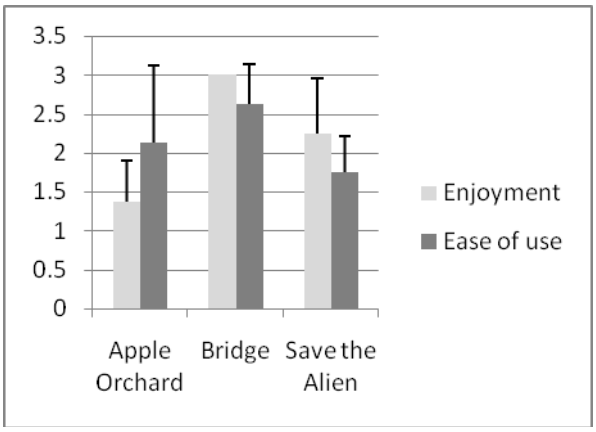

Figure 2. Mean plus 1 SD of children's Enjoyment and Ease of learning scores.

Figure 3 displays the combined results from the mean SEFQ and SLFQ administered after each story. The SEFQ was divided into four categories: Enjoyment/Comfort (5 items), Success (4 items), Control (3 items), and Cooperation (3 items). The ratings for *Apple Orchard* were lower in all the experience categories but all three scenarios were rated similarly for the learning part (very positive for all). *Bridge* and *Save the Alien* were rated similarly and were very positive for all experience categories. The cooperation components for *Bridge* and *Alien* were particularly high.

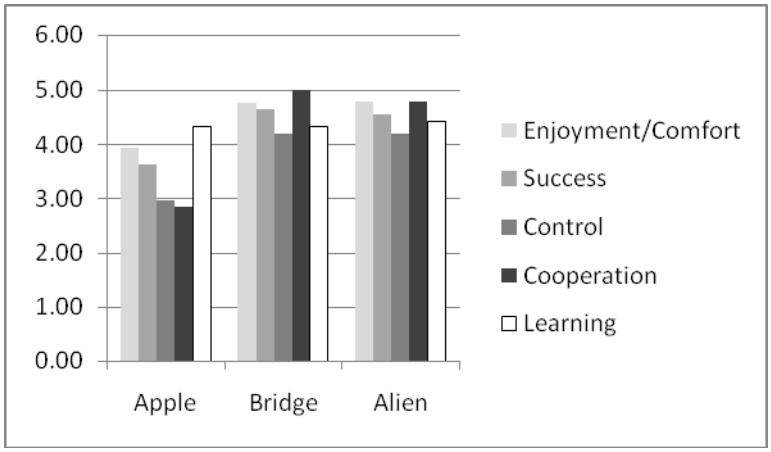

Figure 3. Mean scores from SLFQ and SEFQ questionnaires.

Figure 4 displays the results of the Intrinsic Motivation Inventory. The children were very interested in the task, felt very competent doing it, perceived that they could make choices, and felt minimal pressure and tension.

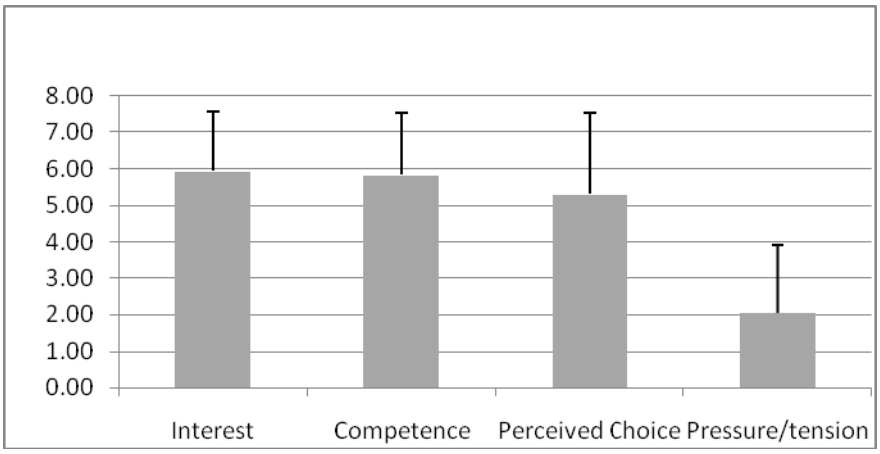

Figure 4. Mean plus 1 SD of children's IMI scores.

The results of the SUS questionnaire showed that the two 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.

Discussion

A key aspect of Join-In Suite prototype development process is that, in keeping with Participatory Design guidelines, it entails 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, and that meet the needs of the CBT teaching/therapy requirements (Bodker, 1996; Binder, 1996).

Our results attest to the richness of information that may be obtained by the two methods used here (focus groups and usability studies). The focus group is a relatively informal method that provides insight into user needs (Nielsen, 1997). It was important, in our case, to obtain this feedback from both types of users - the therapists as practitioners and the children with HFASD as end users - since they clearly had differing but complementary perceptions of what needs the software should address (Francis et al., 2009).

The second source of feedback included responses to usability and motivation questionnaires which were essential in identifying weak points in the software and catering, when possible, to user preferences and sensibilities. For example, the children with HFASD enjoyed the different parts of the scenarios (learning and experience), responded appropriately to the different collaboration strategies, and showed clear preferences for two of the three 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 (Dautenhahn, 2000). We have used both sources of 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.

In conclusion, the results of the current study have helped to ensure that the Join-In Suite is suitable to achieve its therapeutic goals, namely using a CBT-based strategy to train social competence skills in children with HFASD. We are now poised to run a formal evaluation study in which the effectiveness of the Join-In Suite to will be tested.

Acknowledgements

This work is part of a European Union FP7 ICT project, COSPATIAL (Communication and Social Participation Collaborative Technologies for Interaction and Learning, http://cospatial.fbk.eu/).

References

American Psychiatric Association. (2000). Diagnostic and statistical manual of mental disorders, (4th ed., text revision). Washington, DC: American Psychiatric Association.

Bauminger, N. (2007). Group social-multimodal intervention for HFASD. *Journal of Autism and Developmental Disorders*, 37(8), 1605-1615.

Binder, T. (1996). Participation and reification in design of artifacts – an interview with Etienne Wenger, *AI and Society, 10*(1), 101-106.

Bødker, S. (1996). Creating conditions for participation: Conflicts and resources in systems design, *Human Computer Interaction, 11*, 215-236

Brooke, J. (1995). SUS - A quick and dirty usability scale. In: Jordan PW, Thomas B, Weerdmeester BA, McClelland IL, eds. Usability Evaluation in Industry. London: Taylor & Francis (189-194).

Cappelletti, A., Gelmini, G., Pianesi, F., Rossi, F., & Zancanaro, M. (2004). Enforcing co-operative storytelling: first studies. In: Proceedings of the IEEE International Conference on Advanced Learning Technologies (ICALT), August 30–September 01, 2004 (pp281–285). IEEE Computer Society, Washington, DC: USA.

Dautenhahn, K., & Werry, I. (2004). Towards interactive robots in autism therapy: background, motivation and challenges. *Pragmatics and Cognition, 12*(1), 1-35.

Dautenhahn, K. (2000). Design issues on interactive environments for children with autism. Procs of ICDVRAT 2000, the 3rd Int Conf on Disability, Virtual Reality and Associated Technologies pp.153-161.

Davis, M., Dautenhahn, K., Powel, S. D., & Nehaniv, C. L. (2010). Guidelines for researchers and practitioners designing software and software trials for children with autism. *Journal of Assistive Technologies, 4*, 38-48.

Dietz, P.H., & Leigh, D. L. (2001). DiamondTouch: A Multi-User Touch Technology. In Proceedings of User Interface Software and Technology (UIST), Orlando, FL. 2001.

Druin, A. (2002). The role of children in the design of new technology. *Behaviour and Information Technology, 21*, 1–25.

Francis, P., Balbo, S., & Firth, L. (2009). Towards co-design with users who have autism spectrum disorders. *Universal Access in the Information Society, 8*, 123-135.

Gal, E., Bauminger, N., Goren-Bar, D., Pianesi, F., Stock, O., Zancanaro, M., & Weiss, P.L. (2009). Enhancing social communication of children with high functioning autism through a co-located interface. *Artificial Intelligence & Society, 24*, 75–84.

Grynszpan, O., Martin, J.C., & Nadel, J. (2005). Designing educational software dedicated to people with autism. In Proceedings of AAATE 2005, Lille, France, 2005.

Hart, K. J., & Morgan, J. R. (1993). Cognitive behavioral therapy with children: Historical context and current status. In A. J. Finch, W. M. Nelson, & E. S. Ott (Eds) *Cognitive Behavior Procedures with Children and Adolescents: A Practical Guide*: Boston, Allyn Bacon.

Morris, R. M., Huang, A., Paepcke, A., & Winograd, T. (2006). Cooperative Gestures: Multi-User Gestural Interactions for Co-located Groupware. In Proceedings of CHI 2006. Montréal, Québec, Canada, 2006.

Nielsen, J. (1997). The use and misuse of focus groups. Software, IEEE, 14, 94-95, 1997

Nikopoulos, C. K., & Keenan, M. (2004). Effects of video modelling on training and generalisation of social initiation and reciprocal play by children with autism. *European Journal of Behaviour Analysis, 5*, 1-13.

Parsons, S., & Cobb, S. (in press) State-of-the-art of Virtual Reality technologies for children on the autism spectrum. *European Journal of Special Needs Education*.

Piper, A. M., O'Brien, E., Morris, M.R., & Winograd, T. (2006). SIDES: A Cooperative Tabletop Computer Game for Social Skills Development. In Proceedings of CSCW 2006, 1-10.

Plant, R. W., & Ryan, R. M. (1985). Intrinsic motivation and the effects of self-consciousness, self-awareness, and ego-involvement: An investigation of internally-controlling styles. *Journal of Personality, 53*, 435-449.