AutBlocks: Using Collaborative Learning to Develop Joint Attention Skills for Children with Autism Spectrum Disorder

Bryan Boyle, Trinity College Dublin, boyleb5@tcd.ie
Inmaculada Arnedillo-Sanchez, Trinity College Dublin, macu.arnedillo@tcd.ie
Aejaz Zahid, Mada Qatar Assistive Technology Center, azahid@mada.org.qa

Abstract: The development of Joint Attention skills for children with Autism Spectrum Disorder is an important pre-requisite to them achieving their full potential in terms of social and emotional interaction skills as they progress through childhood. This paper describes the development of a multiuser collaborative game using gestural interaction to provide autistic children with social interaction difficulties a means to build, practice and consolidate their joint attention skills. The feedback and experiences of a group of teachers of children with Autism are also presented for analysis and planning for future work.

Keywords: autism spectrum disorder, joint attention, gesture control, game design

Introduction

Social interaction and communication skills play a pivotal role in the development of a child's ability to form meaningful social and emotional relationships in later life. For typically developing children the development of social interaction skills follows a predictable developmental trajectory. For children with Austism Spectrum Disorder (ASD) the ability to correctly understand social behaviours is impaired such that they have difficulties identifying, interpreting and reproducing the general palette of behaviors that we use when interacting with others.

ASD is a neurodevelopmental disorder that is characterized by the presence of a triad of symptoms: communication disabilities, impairment of social interaction and the presence of repetitive, restricted and stereotyped patterns of behavior (Wing & Gould 1979). Difficulties in social interaction presents as one of the most significant problems faced by children with ASD, impacting upon their ability to communicate and cooperate with parents, siblings, peers and other adults. Children with ASD will often be unable to interpret verbal and non-verbal social cues such as speech, facial expressions or gestures and are less likely to initiate interactions with others or engage in cooperative play.   This leads to more limited opportunities social interaction or to practice social strategies restricting children to playing on their own or engaging in a narrow repertoire of behaviours and interests. *Joint attention* refers to a child's ability to "coordinate attention between interactive social partners with respect to objects or events in order to share an awareness of the objects or events" (Mundy et al 1986). It can include verbal and non-verbal behaviours such as visual attention, following the attention of others and directing the attention of others. Children develop joint attention in a developmental manner evolving through three types of joint attention: shared gaze, dyadic and triadic. Typically children with a diagnosis of Autism do not demonstrate joint attention on a consistent basis with care-givers, or other children. Joint attention has also been indicated as a predictor of future cognitive, socio-emotional, language development and verbal and communication skills (Sigman and Ruskin 1999).

Computers have been used widely as a tool to assist in learning and skill development for children with ASD in a range of different domains (Kagohara et al 2013). Some authors suggest that children with ASD demonstrate an affinity for using computers and technology (Ploog et al 2013).   To this end, there has been a variety of development projects reported exploiting the multi-media, interactive and flexible features of technology such as special input devices (touch screens and surfaces), interactive and virtual environments, eye tracking and social robotics (Boucenna et al 2007).

Related work

Computers assisted learning (CAL) approaches that support and facilitate the learning of children with ASD are well reported in the literature (Watson 2014). The value of educational games as a medium for collaborative learning for the general population of typically developing children is also documented (Wang et al., 2009). Moreover, recent work has examined the potential of newer technology interfaces to support collaboration and learning for children with ASD. Giusti & Zancanaro (2011) describe the development and use of a suite of games on a tabletop device to support the training of social competence skills for children with ASD. It has also been suggested that direct touch interfaces may be more effective than using multiple traditional input devices

such as mice or switches. Regardless of the technology being used, Battocchi and colleagues (2009) indicate that children with ASD required more support and encouragement from teachers or therapists during the initial phases of using collaborative or cooperative games.

Virtual reality or virtual worlds also present a viable alternative to more traditional ASD CAL approaches. People with ASD understand, or have the potential to understand, virtual worlds are a representation of reality (Parsons & Mitchell 2004, Moore et al 2004). To this end, such environments can be used to repeatedly practice and rehearse social skills while eliminating the stresses often experienced by children in face to face activities. For instance, Fabri (2006) suggests that using avatars, particularly emotionally expressive avatars, is a key element in enhancing the experience of the teacher-learner and learner-learner interaction. A further area of related research explores the use of motion or gesture based control to allow children with ASD to engage with a CAL game. Bartoli and colleagues (2014) point to the potential of using commercial solutions such as the Kinect™ by Microsoft as a tool for working on specific social interaction skills such as attention. Although her work offers some positive outcomes, it is made clear that to date, there is still a significant lack of empirical evidence demonstrating efficacy of such systems.

Game development

This section describes the development of a prototype collaborative game called "AutBlocks". The game itself is a simple, block building or tower game for two players requiring a range of behaviours from participants to foster collaboration and develop joint attention skills.
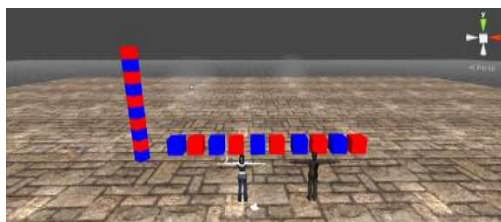

Figure 1. AutBlock Screenshot

The game environment was built using the Unity SDK (http://unity3d.com/) a popular cross platform game creation environment. The game interaction was designed using the Kinect for Windows SDK version 1.7 to control and utilize the four main data streams: Video, Skeletal, Color and Depth. In order to speed the development process a further development tool, ZDK for UNITY3D (http://zigfu.com/en/zdk/unity3d/) a development kit for developing motion controlled applications to provide a set of pre-defined C# scripts that initialize skeletal detection and Skeletal / player tracking. In terms of the user model around which this game was designed a constraint from the outset was the high variability of social interaction skills amongst the population of children with ASD as a whole. Unlike other similar projects targeting children and young adults with a diagnosis of High Functioning Autism or Asperger's Syndrome the target population for this particular application are those children with more significant impairment of social interaction skills. This suggested a more minimalist and simplified interface with a simple gameplay narrative involving a small number of core activities, such as moving, selecting, grasping and carrying.

Game based collaboration patterns

Related studies have applied a model defining four patterns of collaboration that encourage collaborative learning amongst users with ASD, although primarily for those with High Functioning Autism, these were used to guide the storyboarding of this game during development. The table below presents the collaborative patterns adapted for use in this project from the original with the required game tasks and the levels of joint attention demanded by the activity. In the proposed model, collaboration patterns are defined as follows: *Passive sharing pattern:* users engage with their own objects, using visual attention skills to identify their assigned block and follow patterns of play as demonstrated by the avatar. *Active sharing patters*: users begin to select from shared resources (blocks from a shared pile) moreover, users have to understand turn taking in order to select their own block for use. *Active sharing and joint performance pattern*: users must build on their turn taking skills to assist each other in building the tower, it is expected that they will shift attention from their own blocks to the other player's block either when prompted by the game narrative or by each other.

Table 1: Collaborative patters for game elements linked with joint attention

Collaborative Pattern	Game Element	Joint Attention
Passive Sharing Pattern	Identifying own avatar Identifying assigned bricks Selecting bricks from personal store Moving bricks to "Tower Building" area	Requires visual attention skills (individual) and shared gaze
Active Sharing Pattern	Selecting from shared resources Turn taking for selections and actions	Requires dyadic joint attention skills and turn taking
Active Sharing and Joint Performance Pattern	Sharing and giving blocks Requesting missing blocks Problem solving the building pattern for the tower	Requires active, triadic joint attention skills, including sharing and

Methodology

After the development of the game prototype, informed by the literature, related projects and the experiences of the authors working with children with ASD in a specialist Assistive Technology service, our objectives were to: 1) test the relevance of the overall concept with users/stakeholders; 2) get a firsthand perspective of teachers' requirements from games addressing social interaction, and specifically Joint Attention. Since case studies offer the possibility to study ideas and/or theories as they regard people in their real settings, and they enable researchers to establish cause and effect relationships as they occur in their authentic context (Cohen et al., 2000; Yin, 2003) we opted for this methodology. The case study took place at specialist school for children with ASD outside of school hours and comprised 6 teachers and 5 therapists (2 OT, 1 SLT, 2 ABA Therapists) working at the center. Both groups were facilitated by the same researcher, both groups felt uncomfortable with video as such data was gathered using the fieldnotes collected by a second researcher.

Findings

Generally both groups reported that they were positively inclined toward the use of a game to develop joint attention skills, although both groups reported concerns with the transferability of skills learnt outside of the game environment. Group 2, comprising mainly therapists (4 therapists, 2 teachers) were very interested in motion based games, particularly for children with difficulty sitting at desks for any functional time period. Furthermore, they expressed an interest in further developing the game to provide more simulation activities for real-life scenarios with the avatar developing a role demonstrating key behaviours in specific contexts. One issue that emerged for both groups independently was that for multiplayer games to be truly practical in a classroom setting they must be extendable beyond two players to include up to 6 children playing simultaneously. Group 1, comprising mainly teachers (4 teachers, 1 therapist) highlighted the role played by teachers, parents and others in facilitating gameplay for children suggesting that the role played by human assistance in the process is sometimes more important that the feedback or encouragement provided by the game itself. Group 1 continued in their elaboration to suggest that in until a child has developed a certain mastery of the procedural elements of any game that adult guidance is required. This issue in particular was the most valuable gained from this process and requires further analysis and consideration prior to embarking upon further work.

Conclusions and implications

Considering the fact that the game described here is at the earliest stage of development and that the use of Focus Groups for evaluation is far from robust as a methodology it was heartening to hear that most feedback has been generally positive. Future work should give consideration to the need to incorporate more than two players into games was also noted and may be possible as the Kinect™ technology matures further. Further work on the game should also incorporate the wider context within which the game is played. It was clear from the feedback on teachers in this study that a host of other people facilitate children with ASD playing games. This can range from verbal encouragement and reinforcement through to explanation of rules and sometimes physical facilitation. This should inform future development of games aimed at developing skills such as social interaction for children with ASD. Attention should be given to exploring the use of collaborative scripts as a

means of ensuring that the "players' involved in the overall game environment are utilized to the maximum (Dillenbourg 2002). One area that requires careful examination in any future work is the measurement of joint attention by children with ASD. A potential area for development however would be the integration of gaze tracking technology such as that used in marketing, usability and advertising research. More recently its potential is being recognized as a tool in computer supported collaborative learning (Jermann et al 2013).

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Acknowledgments