Collaborative Benefits of a Tangible Interface for Autistic Children

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ABSTRACT
We analyze the collaborative benefits of a tangible interface for Autistic children. Topobo, a constructive assembly system with kinetic memory [12], was presented to children with Autism to see if more co-operative and collaborative play occurred when using Topobo compared to play with passive building blocks (LEGOs). This note presents the first quantitative study to address collaboration with Topobo, and results show that far more cooperative play occurred when autistic children used Topobo compared to passive blocks. Parallel and observational behaviour among users of Topobo was also noted.

Author Keywords
Autism, Tangible Interface, Collaboration, Children

ACM Classification Keywords
K.3.1 Collaborative learning; K.4.2 Assistive technologies for persons with disabilities

INTRODUCTION
In recent years, computer technologies have facilitated a growth of communication by those with Autistic Spectrum Conditions (ASC) and Asperger's. Websites such as YouTube.com are supporting a burgeoning community of ASC users who are expressing ideas and comments they were unable to communicate until the advent of computers and the internet in their present form. This freedom for autistic individuals to share values and opinions that were quite literally trapped must be an incredible step away from an insular life towards a more social existence. Murray [6,7,8] argues that children with Autism tend to find the computer a good way to work as the stress of a human face (and human interaction for that matter) is removed, and computers take advantage of autistic users' tendency to exhibit selective tunneled attention.

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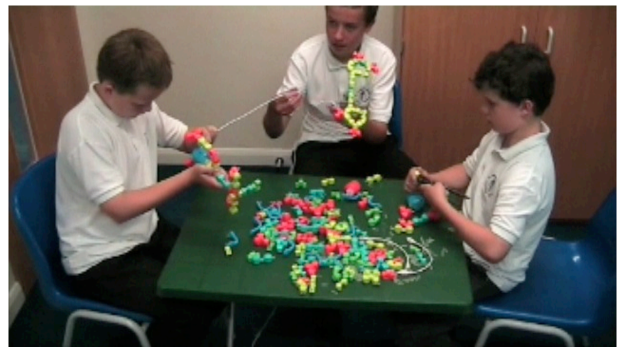

Figure 1. An example of Autistic children playing together with Topobo in a collaborative setting

But while GUI paradigms can support autistic users' remote expression of ideas, efforts are also being made to support autistic users' *co-located* collaboration via emerging computer interface paradigms. Piper et al [11] used a Mitsubishi diamond-touch surface to show that table-top interactions, created with the Autistic Spectrum in mind, can enable children to have greater awareness of those around them, and work for longer periods of time while reducing behaviour typical for those with ASC.

Tangible technologies, which have also been shown to support collaboration [18], may support ASD children to collaborate and communicate in new ways. Foundational evidence from "Lego Therapy" [4] suggests that interaction with physical manipulatives may support autistic children to collaborate for extended periods of time by helping channel children's attention and provide a common context for sharing of objects and ideas [3]. Tangibles may be particularly well suited to autistic children because they take advantage of children as active learners, whose experience is grounded in the body and improved through sensory awareness. The kinesthetic learning experience may be ideal for the development of social skills. Topobo offers expressive activity [5], programmability, and construction of moving objects with structural integrity.

This paper addresses the viability of using tangibles to support the collocated communication and collaboration of autistic children. If computer technology is embedded within tangibles and presented in a shareable *environment*, especially if the tangible itself affords sharing, does this create more interaction? Topobo in particular has been found in qualitative studies to promote collaboration [9, 12]. This paper documents the first quantitative study of Topobo in use, assessing the system's collaborative affordances for autistic children in an interdependent task.

PARTICIPANTS

Individuals with a diagnosis of Autistic Spectrum Disorder from a special needs school in the West Sussex Area of England, were chosen for the study. Children were taken from Key Stage 2 (Upper Primary school) and Key Stage 3 (Lower Senior School) classes in the school age range of year 4 -7 (aged 9-13).

All individuals with ASC (N=6) were observed over a period of six weeks in the classroom, and all individuals showed an initial interest in construction toys such as Lego and Meccano. Educational practice for children with ASC recommend following individual interests and motivations [1,15,17], and Topobo filled this role for some children. Children were selected for our study by teacher assessment and parental agreement. The ASC group was assessed for English national curriculum speaking and listening (mean S&L score = 3C), and school Individual Education Plans (IEPs) were reviewed to establish severity of Autism.

METHOD

Code	Definition
Disengagement	Participant is not attending to the task or other individuals within the group.
Onlooker	Participant is watching what the other individuals within the group are doing but does not actively take part.
Solitary independent activity	Subject is taking part in the task but is working alone and individually rather than with others.
Parallel activity/play	Subject chooses to work alongside another participant but does not influence or modify other people's work, plays beside rather than with.
Associative activity/play	Borrowing and loaning of play material – no division of labour and no organization individual acts as he wishes, group play
Co-operative activity/play	Subject works with another person by turn-taking, or discussing play outcomes but where tasks are distributed Individual works together with somebody e.g. hands on something at same time or discussing outcome together.
Repetitive behaviour	Repetitive odd behaviour typical of children with ASCs.

Table 1. Coding scheme

Autistic children were exposed to Topobo for approximately two hours before the experiment, and then for up to thirty minutes under experimental condition. A direct comparison was made with Lego to see if there was any difference in behavioral patterns. During experimental conditions, children sat in three's around a small table (see figure 1) and children were set a task to create creatures, or objects from Topobo and Lego and then play with their creations. The experimental condition lasted for approximately 25 minutes.

The experimental condition restricted equipment. This was to see whether Lego or Topobo when reduced to a bare minimum would provoke collaboration. During the task children were presented with plans of what to make. Both plans used a similar layout with an overview of the final product, plus an expanded plan view showing how the parts fitted together.

All experiment was filmed and analyzed using a video coding system with Mangold Interact™ software. The coding system (see table 1) was based on Parten [10] and subjected to a reliability test where a second coder looked at a random sample of 10% of all video. A statistical kappa of 78% compatibility was achieved.

RESULTS

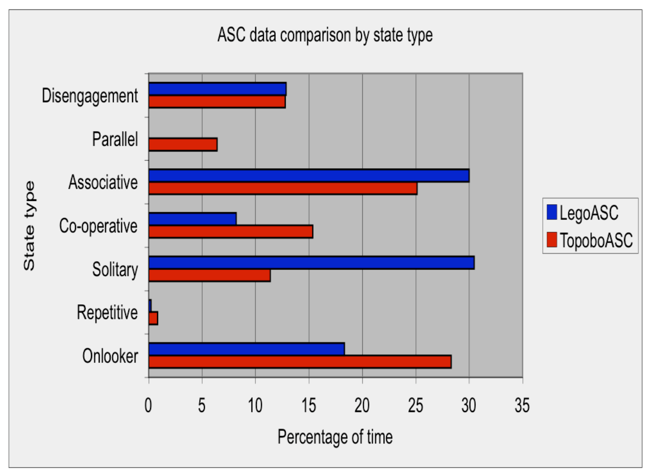

Figure 2. Results of ASC states of play with Topobo

Figure 2 shows percentages of time that children spent within a particular state type. A Wilcoxon two related samples analysis of state showed that Topobo reduces solitary play patterns ($Z=-2.201$, $p<0.03$). More parallel ($Z=-2.023$ $p<0.04$), and co-operative play ($Z= -1.782$, $p=0.07$) occurred with Topobo than Lego. More watching of other children's play occurs with Topobo, but this was not significant ($Z=-0.943 p=0.345$).

DISCUSSION

Topobo provides an opportunity for expressive and collective activity, reduces solitary behaviour, whilst increasing cooperation and play in parallel. More specifically Topobo may aid in:

Representation of Motion Perception
Motion perception is a recorded complication for those with ASC [2, 13]. Topobo provides a way of experimenting with biologically inspired structures. A movable object repeats your exact programming in a tangible. Objects can become imbibed with almost realistic, movable qualities. Creatures look alive, repeat movement, encourage improvement and self-reflection [5].

Restricting Opportunities for Isolation
Topobo restricts opportunities to 'go it alone'. It is a medium within which parallel and co-operative interaction are more likely to occur. Tangible technologies, which have been shown to support collaboration [18], may also support ASC children to collaborate and communicate in new ways. Why? Topobo enables extended objects to be created which supports longer task focus. The tangible programming model requires children to cooperate in order to program creations that incorporate multiple degrees of freedom [12]. We hypothesize that it also allows new kinds of contingent expression that children could not share without the tools [e.g. 16].

Fluid and kinaesthetic experimentation
The affordances of Topobo allow for fluid experimentation, where children tend to lean toward mastery as opposed to goal orientation. Topobo is based on the natural Fibonacci number series and so creates ‘organic loops and branched objects’ [12]. This creates a more stable creation that can be added to without weakening the structure. Also, the interaction paradigm is kinaesthetic in nature, allowing for physical, rather than verbal, expression of ideas.

CONCLUSION
We have shown how Topobo can increase fluid and kinaesthetic experimentation, restrict opportunities for isolation and reflect back movement at a user. Topobo then becomes an assistive technology, enabling users to take part in ‘computational offloading’ [14], by facilitating an external representation of an internal cognitive process. External representations via tangibles can (1) help autistic children to learn to read other people’s actions and intentions and (2) provide time and space for children’s internal cognition to advance. As explained by Hornecker and Buur [3], externalization of expressive representation through tangibility provides a focus for activities, allows for work to be recorded, and may give users a chance to think and talk through objects that are being used.

Quantitative analysis suggests that further analysis with tangible systems is best achieved when resources are limited in a co-located setting prompting interaction between participants.

For parents and teachers of Autistic children, tangible and assistive technological devices such as Topobo push internal cognition through external representation and provide a contingent forum for interactive communication and play [16]. Topobo will prove to be a useful addition to Special Educational Needs practitioner toolkits. Our evidence that tangible tools can support autistic children’s collaboration should prompt further design investigations into tangible technologies for autistic children to leverage new models of human computer interaction.

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