DESIGNING PLAYFUL SENSORY EXPERIENCES WITH INTERACTIVE WHITEBOARD TECHNOLOGY: THE IMPLICATIONS FOR CHILDREN ON THE AUTISTIC SPECTRUM

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Abstract

By definition, individuals on the autistic spectrum have difficulties with social interaction and communication; their different cognitive and sensory processing occurs in every modality and can result in a perception of the physical world that is fragmented, alarming and very different from non-autistic people. This can lead to high levels of fear and anxiety and a lack of understanding of the intentions of others.
This paper will document part of the Reactive Colours design research project, which has been developing customisable software, called ReacTickles, to engage the unique sensory interests of children on the autistic spectrum and will focus on how the ReacTickles software is being used on interactive whiteboards with young autistic children in a number of UK schools. Whereas the conventional view maintains that educational technology should be interactive, Reactive Colours offers tangible interfaces as an embodied play activity. The benefit of this approach is, I argue, that it elicits outward expression of inner sensation and, as such, encourages greater bodily awareness in autistic children who experience distorted or even disconnected relationship with their body due to proprioceptive and vestibular sensory disorders. The interactive whiteboard removes the necessity to manage control in a confined space and, in so doing, reduces the impediment to bodily expression created by the limited spaces of traditional interfaces.

1. Introduction

"Play allows children to learn and practice new skills in safe and supportive environments" (Boucher, 1999)

Social interaction, communication and imagination are attributes most commonly associated with the play patterns of young children (Piaget, 1971;Vygotsky, 1978; Bruner, 1972). Children on the autistic spectrum, however, are understood to experience difficulties with these areas, which are often referred to as the triad of impairments (Wing, 1975), and as a result, they may express limited interest in the social, symbolic and pretend forms of play that are known to provide the foundation for how we understand and experience the world (Beyer and Gammeltoft, 2000; Jordan, 2003; Leslie, 1987; Sherratt, 1999).
Play is considered to be a reflection of a child's ability to interact with his or her environment, therefore the spatial and physical attributes of the play activity will have a direct influence on the mode of play; for example, some toys lend themselves naturally to pretence and imagination, such as cars and dolls, whilst others encourage exploration and repetition, such as spinning tops (Dominguez et al, 2006). These environmental factors are of equal significance in the design of digital play activities. The concerns expressed by other researchers whose work implies that computers can exhaust cognitive resources and are thus detrimental to health and learning, (Healy, 1998), and that open-ended opportunities for play are inhibited by the limited and repetitive operational actions of the technological experience (Levin and Rosequest, 2001), are based on the assumption that most activities will be located on a small screen and thus cannot be manipulated and explored in the same way as objects in the physical world, which would be more developmentally appropriate for young children

(Plowman, 2003). Most children with autism have a limited number of preferred play activities, but in their play they tend have a fascination for detail and the physical properties of objects and less interest in attaching symbolic meaning to the objects and involving others (Beyer and Gammeltoft, 2000; Jordan, 2003; Leslie, 1987; Sherratt, 1999).

This preponderance of sensorimotor play in autistic children has underpinned the development of the Reactive Colours project and the subsequent design of the ReacTickles interactive play experience. The designers, through working very closely with autistic children, realised that when perceptual and physical skills were engaged, in an appropriate environment, children were more likely to express themselves comfortably, and thus the opportunities for creativity and imagination were greatly expanded.

"If improving the play skills of children with autism gives them a sense mastery, and increases their pleasure and their motivation to play, then that is a justifiable aim in itself" (Boucher, 1999)

2. Understanding the autism condition

There are many complex theories which provide explanations for the apparent lack of social functioning described above, however, for the purpose of this paper I summarise the research which has been helpful in determining the context for the design of the Reactive Colours project, but do not aim to present a standpoint or bias towards any particular theoretical perspective.

2.1 Monotropic Interest Systems

Murray, Lawson and Lesser (2005), explain that one of the most significant differences between autistic and non-autistic is in the strategies employed in the distribution of scarce attention. Autistic people are understood to have *monotropic* interest systems, meaning that they are able to focus their attention intensely on a limited range of interests. In contrast, most non-autistic people have *polytropic* interest systems, meaning that they are able to divide their attention across many areas of interest and the focus of this attention is thus less intense, or 'tunnelled'. A consequence of this is that autistic people tend to be very good at tasks where attention to detail is required but may miss global meanings (Mottron et al, 2006; Frith, 1989). This is evident from a very early age, as suggested in the reference to play described earlier. Mottron et al (2006) find that higher-level processes are mandatory for typical people but not for people on the autism spectrum. These autistic atypicalities go hand in hand with sensory processing differences, which can have a disabling impact.

2.2 Sensory Issues

The focus of this paper is on how tangible technologies can foster an embodied play experience for young autistic children; in order to explain how the design of the project was influenced by the young children and those who most closely care for them, I will describe the research in the context of three sensory experiences: tactile, vestibular and proprioceptive. These senses are central to how we experience, respond

to and interpret the variety of stimuli in the world around us. Characteristic behaviours of an over or under-stimulated sensory system are biting, spinning, rocking and hand-flapping, and dysfunctions in any of these areas can lead to high levels of anxiety and a lack of understanding of the intentions of others.

The tactile sensory system enables us to respond to light touch, temperature and pressure; those whose tactile senses are dysfunctional may experience pain when being touched or when eating foods that have a particular texture, they may also have an aversion to clothing, water, or using their fingers. This mis-perception of pain may manifest itself in an individual becoming isolated, distracted, hyperactive and generally ill at ease (Bogdashina, 2003).

The vestibular system refers to the inner-ear structures, which assist in the detection of movement and changes in the position of the head. Children who are hypersensitive to vestibular stimulation may become upset by movement activities such as swinging, sliding, climbing and descending stairs or they may be apprehensive in activities which require spatial control; generally they appear to be clumsy. Continuous intense activities such as spinning and jumping are ways in which children try to stimulate their vestibular system (Bogdashina, 2003).

Proprioceptive sensory systems are those which provide a person with a subconscious awareness of body position though muscles, joints and tendons. The proprioceptive system enables us to adjust our body positions in response to different situations, for example, sitting on a chair or walking down a step. Fine motor movements, such as using a knife and fork or writing with a pen are also manipulated though the proprioceptive system. A child with a dysfunctional propioceptive system may display unusual behaviours such as leaning on people or walls in order to feel pressure and for spatial orientation and will often appear clumsy or incompetent (Ayres & Tickle, 1980).

Autistic children may suffer from sensory dysfunctions in any or all of these areas and may be over or under responsive to sensory input; they may also fluctuate between extremes. Thus the behavioural characteristics most commonly associated with the autistic condition are directly correlated to issues of the sensory system (Ayres & Tickle, 1980).

3. Tangible Interaction

Computers make an important contribution in assisting people in their daily lives. For individuals on the autistic spectrum the ability to manage, control, organise, learn, communicate and be creative is accentuated through the use of computer systems. There has been a significant amount of valuable research to show why computers are so important, (Murray, 1997; Murray & Lesser, 1997; Murray & Aspinall, A 2006), and there are many highly imaginative and informative websites, created and maintained by autistic people which are valid testimonials to this research (http://www.gettingthetruthout.org/; http://www.isn.net/~jypsy/).

"Computers offer rich opportunities for taking control and making a mark on the environment which, in turn, strengthens the sense of agency, personal achievement and self-esteem. The neutrality of the interface may also assist in encouraging shared activity whereby all participants are inherently equal, thus the capacity for joining attention tunnels is accelerated." (Murray, Powell and Jordan, 1997)

The Reactive Colours project extends this research by taking an alternative approach to computation. Rather than considering computer systems in the conventional manner as a means to control and manipulate digital information, our research uses computers to afford a tangible experience capable of assisting relaxation and encouraging expression and creativity through improvisation and experimentation.

The emergence of new types of computer technology encourages multi-modal interaction and renders archaic the notion that the role of the computer is purely to handle textual information. Tangible interaction includes a broad range of systems that rely on the creative use of physical and spatial manipulation to control objects or interfaces (Dourish, 2001; Ishii & Ullmer, 1997). As computation becomes more embedded in everyday objects and experiences, the role of tangible computing has the potential to extend far beyond the functional and is increasingly becoming adopted by artists and designers who identify with the expressive and aesthetic qualities of tangibles and the way these new technologies involve the use of more human skills than cognitive (Overbeeke, 1999). The perceived value of tangible interaction, in an educational context, is that it is driven by action rather than cognition (Heidegger, 1996, Norman, 1988; 1999)

In the earliest stages of development, young children prefer to play with objects because of their physical properties rather their abstract and imaginary qualities, (Piaget, 1971;Vygotsky, 1978; Bruner, 1972) for example, puzzles and building blocks and they are extremely attracted to sensory toys that engage them in self-directed, purposeful activity (Montessori, 1912). It has been well researched that children develop understanding through action, and the transformation of sensorimotor reflexes to more symbolic forms of manipulation (Piaget, 1971). Tangible technologies provide ways of interacting through exploration and manipulation; the focus is not on how things work or what they mean but on how they are used. This, I argue, is of enormous significance in the design of computational experiences for all young children, but particularly for autistic children, as this approach allows for improvisation and an opportunity to encounter experiences independently of skill, knowledge or task. For children whose complex sensory systems and difficulty with global meaning may result in exclusion from many play activities, tangible technologies have the potential to afford interaction during which meaning is created and understood through context and use rather than the necessity to understand a graphically mediated environment (Heidegger, 1996).

It is known that we encounter the world as a place in which we act and that through action, meanings are revealed, (Heidegger, 1996). However, for most of us, using traditional Graphical User Interfaces (GUIs) the logical process of interaction is to interpret a digitally represented task, and then to manipulate the environment with a physical object that has no specific behavioural or representational meaning (Fishkin, 2004). An example of this would be pressing a key or moving a mouse to perform many functions, all of which will have a different output, for example, menus, buttons, folders, and controllers (Ishii & Ullmer, 1997).

Tangible technologies enable a close relationship between manipulation through input and perception through output, and generally one function is assigned to an action. A more embodied experience results as the user can focus on the impact of their action

rather than the tools that control it.(Dourish, 2001; Fishkin, 2004)

4. The Reactive Colours Project

The aim of the Reactive Colours© project has been to define an expressive form of computation with a range of digital technologies in order to promote relaxation, encourage spontaneous play, and support learning for children on the autistic spectrum.

Many autistic children experience heightened feelings of anxiety and fear as a result of their highly focused interest systems and sensory differences (Grandin, 2000). By working directly with the target population, using methods briefly outlined below, the designers came to realise that the primary function of the software had to be to assist in creating a calm atmosphere, as without this, the positive aspects of play and learning available to children through the use of computers, could not be accessed. The context for use needed to be mobile and flexible to allow for changing technological and pedagogical processes and environments, and to encourage new contexts for creativity with computers that may arise as a direct result of using the software.

One of the outcomes of this process has been the creation of the ReacTickles software. ReacTickles experiences are completely directed by user input using a mouse, keyboard, microphone and other forms of adaptive devices. Significant to this research has been how ReacTickles are being used on Smart ™ interactive whiteboards creating opportunities for unmediated interaction where the whole body can freely move, and where embodiment is being used purposefully to help children interact with each other and to engender a calm, positive learning experience.

The use of interactive whiteboards in schools in the United Kingdom has become widespread in the past two years. A typical interactive whiteboard set up consists of a computer connected to a projector, which simultaneously projects onto a large-scale touch sensitive whiteboard. Whilst some boards are reliant on the use of a stylus pen for interaction, Smartboards™ enable users to control their experience through the touch of their fingers; when used in this way ReacTickles become interactive surfaces, which the user can directly manipulate (Ullmer & Ishii, 2000). When children use their fingers on the interactive surface, the outward response to being touched or stroked is a corresponding movement, shape morph or colour change. The primary interest is on the screen output and not the operational tools, thus a fully embodied experience is afforded (Fiskin, 2004)

4.1 Research Methods

As indicated throughout this paper, a flexible, ethnographic, participatory design process was required for this project in order to ensure that any proposed outcomes were driven by the specific needs of autistic children and those who are responsible for their care, this process has been well-documented in previous work (Keay-Bright, 2006), however I will provide a brief overview for the purposes of this paper.

The project has four main stages and uses a *Research-Inspire-Listen-Develop* model

at each stage (Keay-Bright, 2007). The first stage of feasibility involved teachers and children helping the researcher define a positive playful environment that could be both relaxing and motivating for children and which could be seamlessly integrated into the school curriculum. This feasibility study led to a successful proposal for funding from the National Endowment for Science and Technology Awards (NESTA), which supported the addition of two programmers and consultant experts from psychology, linguistics and special educational needs, into the team. The design phase that followed funding focussed on the integration of ideas from the design team, consultants and teachers together with observations of children in free-play activities to arrive at a design concept. The implementation phase required the team to consider the goals of the project very carefully and to develop many of these ideas into a series of prototypes, each version accommodating more design ideas from participants and identifying both the parameters and possibilities of the technologies currently used in schools. Each prototype version was evaluated, using a variety of qualitative and quantitative methods, and the responses carefully analysed before the designs were refined. The final stage of the project has been to identify further possibilities and to invite contributions from a wider audience, deepening collaboration through the use of social media and making software prototypes publicly available on the Reactive Colours open source website, http://www.reactivecolours.org, (Stadler & Hirsh, 2002).

4.2 The role of autistic children in the development of the software

The ambition to undertake a participatory design process, whereby those who are most likely to benefit from the outcome are key informants in the most important aspects of development, (Friere, 1974; Druin, 1999), was realised through the commitment of a group of children aged between four and seven years, in full-time attendance at a school for special educational needs with a specific autism support unit, their teachers and teaching assistants.
Over a period of approximately two years, at the suggestion of teachers, these children, in small groups of up to five children aged between four and seven years, at varying stages of cognitive development, were invited to explore prototype ReacTickles on the Smartboard™. What became clear very early on was that the software needed to exploit the potential richness of bodily movement and to allow for the idiosyncratic, emergent needs of the children as many of them became upset by the sensory overload and potential for failure that is characteristic of many software programmes. Thus movement and perception became the prerequisites for interaction, rather than the need to manage the control of graphical information and ReacTickles were designed with a view to encouraging expressive full body actions. By utilizing velocity, gravity, inertia and elasticity in an advanced form of cause and effect, when the ReacTickles on the surface of the Smartboard™ are touched, a corresponding action is directly prompted on a different part of the screen. User action is expressed through location, direction and dynamics, rather than metaphorical or symbolic representations of objects, which is far more relevant for autistic children as, without the demands on cognitive and fine motor skills, they able to interact in a way that is positive and rewarding (Figure 1).

In this socially mediated environment the outward rendering of inner engagement has the potential to invite participation from others, as areas of mutual interest can be readily shared. In this context, embodiment denotes more than a synthesis of control

and response, it actually allows for actions to be mirrored in a positive, playful and improvisational manner. (Suchman, 1987)

4.3 Findings

What became evident from video analysis of the different groups using ReacTickles on the Smartboard™ was that children were using their physical and perceptual skills in a manner that was natural for them, and that they were able to use expressive forms of communication to demonstrate their interest and to invite the participation of others. Gross motor activities such as stretching, jumping, reaching and smoothing became part of the embodied experience, together with finer motor skills such as circling, tapping and pointing, all of which had a direct relationship to the digital response on the Smartboard™ surface. One child, aged seven years, evidenced a degree of discomfort at the start of the session, he was observed running backwards and forwards at the Smartboard™, flapping his hands violently, however, following encouragement from his teacher, he began to engage with ReacTickles, and within minutes started smoothing the Smartboard™ and became much calmer and in control of his actions. The child's teachers considered this to be a clear indication of intentionality and purpose.

For some of the children, the position of the Smartboard™ inhibited their ability to follow through their actions, for example, where the ReacTickles shapes ascend to the top of the screen having been released from a static position by the child's interaction, when the child attempted to chase the shape the height of the board meant that the shape moved out of reach. What was notable on these occasions was that children requested assistance using spontaneous language and gesture, and did not show any signs of distress. Although hand to eye co-ordination was generally very good, some children had difficulty gauging the amount of pressure needed to activate the ReacTickles on the Smartboard™ and needed assistance from a member of staff. (Figure 2)

Two classes using the software had no verbal language and had difficulties with concentration. Teachers noticed that when these children were playing with ReacTickles at the Smartboard™ the levels of concentration improved, as they were able to see their actions mirrored on the screen; it was also suggested that as the children were able to demonstrate their interest through their physical actions, their expressive communication also improved.

A different group, who were able to use verbal language demonstrated certain characteristics associated with symbolic play, as they attributed properties to actions in an imaginary way. For example, when filled circles ascend and wobble, a child enthusiastically says, "Pop the bubble!" As another child voluntarily joins the activity, instructional vocabulary is shared between the two and the pretence continues. A third child joins the group and extends the play, he imitates the actions of his peers and adds his own variations. In a different type of activity, where written words become the object of play, for example colour names form a wave and leave a trail, children voluntarily verbalised colour names, not simply as a descriptive label, but to draw attention to the action. Comments, such as, "I've made a circle!" clearly suggested that the child was inventing a context for the action and expressing a desire to share the experience with others. (Figure 3)

Experts analysing the video footage of the children suggested that as ReacTickles did not rely on understanding the representational significance of the visual elements, children were clearly responding in manner that was meaningful for them, rather than following the predetermined sequence of actions offered in most software programmes.

5. Further research

The spontaneous use of verbalisation, vocalisation and gesture form part of the pattern of activity with ReacTickles. Extensive research has been carried out which examines the gestural responses of children as a method of measuring learning and thinking (Goldin-Meadow, 2003). The results showed that gestural responses reflected a tacit knowledge which did not need to be expressed through verbal language. In the analysis of young autistic children's responses to ReacTickles, the non-verbal expressions of interest, engagement, and in some cases, anxiety, were used as an indicator of interest in ReacTickles and not to consider the skills of the child.

It was evident that the children directly related their use of language to their actions, (Bruner, 1972; Vgotsky, 1978) in a manner that was spontaneous and improvised (Suchman, 1987). This has far reaching implications for autistic children whose language use is often not directly related to intentionality and purpose, however this will be considered in further research.

6. Conclusion

The Reactive Colours project, through a gradually evolving, participatory design process, has identified the potential that young autistic children have to uncover, explore and develop meaningful play experiences in digital settings.
The small-scale study described it this paper has clearly identified the role of tactile interaction in affording comfortable sensory experiences, and its further potential to bring active playfulness into learning. The ReacTickles interface represents a deliberate move to provide a facility for children to interpret and understand their actions and the actions and intentions of others as it engages the tactile, vestibular and proprioceptive sensory systems to a higher degree than most other software programmes.

The design is not simply about the relevance of supporting sensory and physical skills, but how these skills can contribute to understanding the needs of others. The neutrality of the interface enables children to communicate expressively, using their personal choice of language and gesture in an improvisational manner, as they encounter experiences directly with the ReacTickles software or whilst interacting with others at the Smartboard™. Our study has shown that ReacTickles software can provide a completely embodied play experience as input and output are closely matched. In this way, children are supported in using a range of skills, including physical and perceptual, rather than purely cognitive skills, which can be highly demanding, particularly in social situations. For children whose sensory systems may exclude them from activities that require fine and gross motor skills, the combination of the responsive, non-representational ReacTickles and tangible technologies has the potential to create a positive learning environment in which meaning is created and

understood through context and use rather than the necessity to perform a task within a restricted set of physical and graphical boundaries.

7. Acknowledgements

Figure 1 Exploring the interactive surface

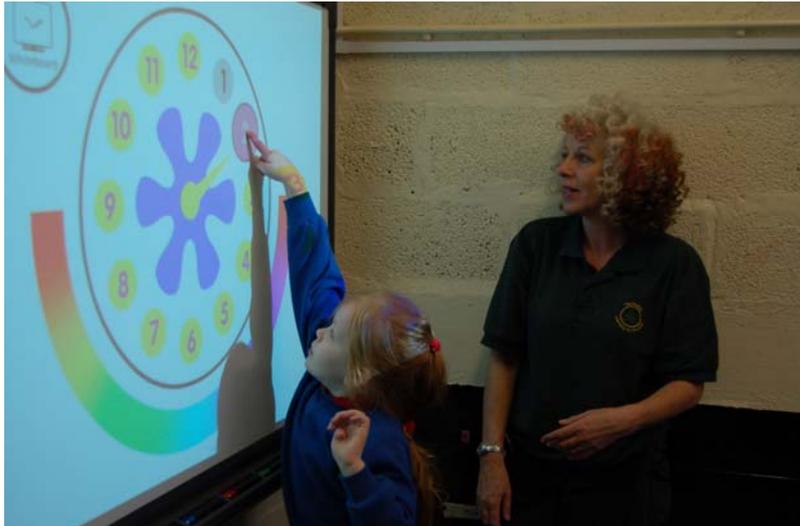**Figure 2 Getting help to reach the top**

Figure 3 Stretching at the SmartBoard

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