Designing for Playfulness: Investigating the Therapeutic Potential of Technology Interfaces for Children on the Autism Spectrum

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By: Wendy Keay-Bright

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Advisors: Dr. Clive Cazeaux and Dr Cathy Treadaway

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Declaration

This work has not previously been accepted in substance for any degree and is not being currently submitted in candidature for any degree.

Signed (candidate) Date

Statement 1

This work is the result of my own investigations, except where otherwise stated.
Other sources are acknowledged through explicit references. A full list of such references is appended.

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Statement 2

I hereby give consent for my work, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

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Preface

As a student of design and animation in the early 1980s I discovered a passion for the abstract, expressionistic work of filmmakers Len Lye, Norman McClaren and Oskar Fischinger. Whilst my colleagues sought skills in character design I animated dance notation to musical scores and experimented with materials other than the pencil. Twenty-five years later, programming in Director on a Mac I found myself drawn to create simple interactive screens that tried to match mouse or keyboard input with a corresponding movement, colour, shape and sound. The aesthetics of the expressionistic form captured my imagination once more. However, the potential for user interaction offered a more dynamic and varied output.

My career by this time had moved away from commercial animation into academia. As a lecturer at Cardiff School of Art and Design, I taught animation and moving image design, and as technology became part of my everyday practice I was increasingly faced with the challenge of introducing students to software applications. Reflecting back on this period I remember demonstrating how to programme a shape that could respond to mouse movement. This playful exercise appeared to be far more motivating for students than learning how to create a button that 'beeped' when pressed, an exercise that offered some extrinsic reward but also created annoyance and frustration.

Around the same time, John Maeda, heralded reactive media through the Aesthetics and Computation Group and Physical Language Workshop at MIT. His playful experiments triggered my imagination and my interest in interaction with everyday technologies deepened.

With Maeda's work as inspiration, I designed my own interfaces and encouraged my own children to explore. Their delight at seeing their
actions copied by the computer monitor led me to investigate further the concept of reactive interaction as a powerful learning and teaching tool.

Observations of the natural curiosity that emerged during play with the interfaces led me to conclude that there could be huge potential in using this functional object (the computer) in a more playful and intrinsically rewarding manner. Without the need to follow instructions children were relaxed, experimental and unconcerned about the operational features of the computer. Both the hand-eye coordination required for using computer hardware and levels of concentration increased. I conducted a feasibility study, funded by the local authority that enabled academics to conduct a field research with an external organisation. Findings from this study suggested that young children on the autism spectrum may benefit from using a software application that did not make unnecessary demands. This is where I discovered an application for my ideas and my research question. The study and early concept ideas were presented in two conference papers, not included in this submission. The first was Broadening the Band, Association of Internet Researchers (AOIR) Conference in Toronto, Canada, October, 2003, and the second: FutureGround, Design Research Society, Monash University, Melbourne, Australia, November, 2004.

I am still concerned that learning is highly structured and neglects the joyfulfulness of natural curiosity as we discover what things do, how they work and what might we want to do with them. We are overloaded with information and instruction, we are afraid of failure and bombarded with reminders of how we could do better.

This work represents my response to this, and offers simplicity as inspiration for design. My research has included children and adults on the
autism spectrum; it has been the most demanding, creative, and joyful experience of my career. I have discovered a mindful approach to design. Mindful in that it aims not to prejudge, not to assume, not to expect that I will find a solution to a problem. The work represented in this PhD by Published Works offers ideas, experiments and optimism. It does not attempt to overcome deficits. The studies have been designed with the assistance of an enthusiastic team of teachers and therapists who have observed something creative in the behaviour of their children. I have learnt so much from them. They have shaped this work more than any single methodology and provided a continuous source of motivation.

As an academic I strive to imbue my teaching and research with mindfulness, valuing experience as it arises in the here and now, rather than relying on statistical analysis or the tendency to try to overcome problems. This is embodied in my most recent work and has resulted from the depth of investigation represented in this PhD.

Wendy Keay-Bright

June 2011
Acknowledgements

This work would not have been possible without the children, teachers, therapists, support assistants and technical staff from the many schools and centres that took part in the studies. Enduring thanks go to Glynis Thomas, Chris Matthews, Dyfi Allen, Sheila Mullet, Kath Keely, Wendy Templeton and many others who I did not meet in person but I know made a big contribution to exploring prototypes in the classroom.

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Dinah also introduced me to Karen Guldberg, Programme Director of Web Autism and Director of the Autism Centre for Education Research. I am indebted to Karen, not only for the depth of input on the studies and pedagogy, but for her positive encouragement, common sense attitude and for listening to my frustrations and doubts. Geoff Fitzpatrick and Helen Joy worked with Karen to ensure that ReacTickles could be integrated into curriculum frameworks. Thank you both for your belief in this work and for driving it forward in such a realistic, usable manner.
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Imogen Howarth, a specialist in assistive technologies, has contributed a depth of analysis that has been completely sensitive to experimentation. Thank you for your vision, for seeing potential before it had been proven, for giving me guidance and an outlet for dissemination through SENIT and Communication Works.

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So many people in the autism community have shown encouragement for my research. Hugh Morgan and Maggie Bowen of Autism Cymru made me welcome right from the start. I made my first presentation of the Reactive Colours research at the inaugural Autism Cymru conference in 2004 and have presented at all the subsequent conferences. In turn, I am committed to supporting Autism Cymru as Wales national charity for autism and have been a Trustee since 2009.

Other international charities have also been very encouraging. I am grateful to Wojeck Nadowski, Altogether Autism, Victoria, and Mandy Williams, Scope Victoria, in Australia; Tanya Breen, Alpha Autism, New Zealand; Fuyong Yiao, Xian Provincial People’s Hospital, China; Manjit Kochar, Winds O’Change Therapy Centre, Bangalore. Apologies to those I may have missed.
Caille Golding deserves a special mention. Caille has extensive experience in working with children with severe learning difficulties and specialises in ICT, she has trusted my vision from the earliest concept. She has evaluated prototypes and celebrated in the achievements of some of the most hard to engage children. Caille introduced Reactive Colours in schools and centres in Scotland and to speech and language therapists in the Wirral before moving to Melbourne, Australia. Here she introduced ReacTickles to Alpha Autism, Gateways School Services and SCOPE, where ReacTickles has been included in the support services for adults and children with disabilities including Cerebral Palsy and Autism. Caille is a dear friend; her warmth has kept me going in some of the difficult times. Thank you, Caille.

The strategic and financial support of NESTA cannot be underestimated. Thank you to Will Pearson for putting Reactive Colours forward for the NESTA Learning Programme Award and for remaining loyal to my work, even to this day as it moves into new territories.

I acknowledge Derek Freeman for pushing me to “think big”, and to Ben Norris for teaching me to programme the earliest prototypes. Ben, together with Alun Owen, continued to work on programming ReacTickles with funding from NESTA, thanks are extended to both of them for taking away the burden of coding and allowing me time for research.

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Thank you to John Galloway for letting people know about by work, for seeing a market and leading me to Tag Learning. These thanks are extended to Pete Johnson, Brand Director at BLI/Tag for respecting the values that underpinned the ideas and extending the network of users worldwide.

I am indebted to my friends and colleagues at Cardiff School of Art and Design, particularly Ruth Dineen and Steve Gill, who gave me a push when I needed it.

Of course, a PhD is not possible without advisors. I am grateful to Dr. Cathy Treadaway and Dr. Clive Cazeaux for their careful reading and advising, and to Professor Tim Coward for encouraging me to undertake a PhD by Publication. Debbie Savage has taken the stress away from some of my other duties to allow me to finally bring all the works together, she has managed the administration seamlessly, always with a smile.

Thank you to my parents, especially Malcolm, for diligently proof reading every page of every paper.

Finally, but most emphatically, I want to thank my husband Simon and children, Rosie and Joe, for their inspiration and patience.

Dedicated to Simon, Rosie and Joseph

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List of Papers


Critical Overview

Abstract

Exploration and discovery are core components of play. For children with autism, whose needs are complex and diverse, the potential that technology affords for developmentally appropriate play is under researched. Many software programmes focus on operational routines and fail to maximise on the capricious, idiosyncratic and emergent fun that can evolve when children are relaxed and able to freely discover their interests. There are very few studies that reveal how children with autism benefit, in terms of their confidence and self esteem, when technology is utilised simply as a trigger for play and how this particularly influences emotional regulation, social communication and learning.

The aim of this PhD is two-fold: to contribute to knowledge on the challenges of designing for play for children with autism and to make a contribution to research in the autism field by demonstrating the expressive communication abilities revealed by children through playful interaction with a software interface.

The PhD overview critiques eight published works, which analyse and discuss the design methods, the nature of discovery-led interaction and the impact on children's play and communication.

The early publications are cohered around participatory design, and how the relationships with end user populations influenced early prototypes and shaped initial evaluation. These studies paved the way for deeper investigations into the multi sensory capacities of technology in relation to the characteristics of autism. These studies furthered the contextualisation
of the work by locating design in and with affordable everyday environments. The emphasis on situated-ness is understood from a philosophical perspective in the most recent and concluding studies, which draw on phenomenology for the meta-analysis of action and reaction. The final paper provides a confident argument for play as a means of exploiting the physical directness of tactile and auditory input. The studies reveal how even the most hard to engage child demonstrated creative and communicative ability beyond the expectation of his carers.

The papers contribute towards an understanding of playfulness as an emergent, unpredictable and ultimately rewarding experience for children severely affected by autism. In the design field, the work represents a contribution to new knowledge in participatory and collaborative methods for developing responsive sensory interfaces for marginalised groups.

**Key words:** Autism, interaction, tangible interaction, play, playfulness, sensory, prototypes, generative, therapeutic, repetition, inspiration, participatory design, collaboration, embodiment, colour.
1. Introduction

The goal of this critical overview is reflect on where the body of work undertaken since early 2006, documented in this selection of papers, has made a contribution to new knowledge in the design field. The papers aim to reveal how the interpretive qualities of design research can impact on the lives of those we design for, giving them a voice, empowering them to be the innovators of design in use (Ehn, 2008).

*The machine itself makes no demands and holds out no promises: it is the human spirit that makes demands and keeps promises. In order to reconquer the machine and subdue it to human purposes, one must first understand it and assimilate it. So far we have embraced the machine without fully understanding it.*

Lewis Mumford, (1934) Technics and Civilization, p6

For children with autism, the potential that technology affords for relaxation and autotelic play is under researched. Opportunities for controlling the confusing, multi-sensory everyday world are few and far between and whilst computers have the potential to adapt to user needs, the rhythm of computer interaction is typically set at a pace that offers no pause, reflection or repetition that can be controlled by child with developmental and cognitive delays and sensory dysfunction. Whilst sensory play is an area of interest to researchers, no research has investigated this in a digital environment with a specific focus on design. Most research focusses on technological development.

This critical overview addresses this issue and situates my research in the context of:
← a contribution to new knowledge in the design discipline, specifically in originating pragmatic and democratic approaches to the challenges of designing with children on the autism spectrum;

← a critique of eight peer-reviewed papers, published between 2006 and 2010, which represent a sustained investigation into the therapeutic benefits of technologies for autistic children.

Paper I, *Reactivities: Autism and Play* provides background theory and experiments that investigate the experiential capacity of computers. Evidence is provided of the potential of a simple interface to activate and transform ways in which autistic children communicate and play.

Paper II, “The Reactive Colours Project: Demonstrating Participatory and Collaborative Design Methods for the Creation of Software for Autistic Children” identifies the need to situate research in contexts that maximise on participation, acceptance and impact. A case is made for conceiving Information Communication Technologies (ICT) as triggers for embodied play; a concept which characterises the development of the research.

Embodiment is further examined in Paper III, “Can Computers Create Relaxation? Designing ReacTickles Software With Children On The Autistic Spectrum”, for its specific role in fostering relaxation. This paper maps out the territory for participatory research, and reveals how cooperative methods were especially significant in identifying therapeutic experiences.

The significance of locating the studies in traditional learning environments is developed in the fourth paper IV, “Designing Playful Sensory...”
Experiences with Interactive Whiteboard Technology: the Implications for Children On The Autistic Spectrum”, as findings revealed greater bodily awareness in autistic children who experience proprioceptive and vestibular sensory disorders. The use of interactive whiteboards (IWB) in this study represented a significant breakthrough for the research, and has had widespread impact on use of ICT in the classroom for expressive communication.

Paper V, “Tangible Technologies as Interactive Play Spaces for Children with Learning Difficulties: the Reactive Colours Project” captures a deepening interest in phenomenology and perception as a philosophical framework for interrogating ideas and draws conclusions from an empirical study that documents the impact of physical directness on engagement.

Paper VI, “ReacTickles: Playful interaction with Information Communication Technologies” expands on previous studies by introducing new strategies for interpreting the dynamics of non verbal communication. The notion of repetition as a playful activity defines this work, as children’s actions perceived to be reflective and intentional.

The aforementioned studies have evolved around a responsive prototyping method and favoured the use of video observation for generating, documenting and evaluating experience. The studies included in papers VII, “ReacTickles Global: A Non-Textual Mobile and Networked Play Space” and VIII, “Designing Inclusive and Playful Technologies for Pre-School Children” are conducted on a robust prototype that followed two years of participatory design. These final papers reconsider the generative methodology, however, they transfer this to new contexts as a way of evidencing the importance of inclusivity and accessibility in
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interface design. Together the papers contribute towards an understanding of playfulness as an emergent, stimulating experience for children severely affected by their autism. In the design field, the work represents a contribution to new knowledge in participatory methods for developing responsive interfaces for marginalised groups.

A number of theoretical perspectives underpin the work. I have used these not only to deepen my understanding of key areas, but also to interrogate the ideas that have arisen intuitively through my practice as a designer. Engaging with theoretical discourse has thus provided the currency with which to introduce design research to other communities. This critical overview will revisit these theories in more depth than the scope of each individual paper allowed.

The earliest literature searches informed my position on the role of play in social interaction. Research indicates the importance of social communication as the basis of learning for all children (Bruner, 1975; Vygotsky, 1978; Piaget, 1971; Mercer and Littleton, 2007). This is reflected in curriculum frameworks and has influenced the use of technology in schools. Central to communication is interaction. For children with impairments in social interaction, who find contact with other people stressful or confusing, interaction with digital and electronic media has the potential to offer highly motivating and rewarding experiences. One of the most challenging communication disorders is autism.

The autism spectrum is diverse. Whilst the developmental trajectories of children differ widely, social interaction is typically stressful and intimidating. Young children with autism, particularly those on the severest end of the spectrum, are cut off from learning with and through other
people in ways that typically developing individuals are not (Schopler & Mesibov, 1995; Jordan & Jones, 1999).

Using computers in classroom environments has been proven to assist the inclusion of even the most anxious of individuals, whether they have autism or not. The computer environment offers a motivating, safe, and emotionally engaging experience where various multi-sensory stimuli of the real world can be reduced (Murray and Lesser, 1997). There is also evidence that computer assisted learning is effective for pupils with autism, as the predictability and operational mode of use suits the autistic preference for order and routine (Grandin, 1995; Murray, 1997; Murray & Lesser, 1997; Murray & Aspinall, 2006; Murray & Lawson, 2007).

Computer technology has been investigated both as a way of helping children with autistic spectrum conditions (ASC) develop social interaction skills (e.g. Robins et al., 2006), and diagnostic resource for exploring different socio-cognitive development theories of autism (e.g. Parsons et al., 2005; Herrera et al., 2006; Baron-Cohen, 1995). However, technologies are rarely conceived as exploratory environments where children can simply relax and feel playful without obvious purpose or extrinsic reward. Playfulness is emergent and unpredictable, it requires children to think "what does this do?" and "what can I do with this?" Finding a mode of interaction on the computer that does not rely on systematic, attention demanding operations might seem paradoxical, but could also offer a safe experience, if interaction can be controlled by the child and enjoyed simply for its intrinsic sensory properties. Could computers, therefore, have a more therapeutic role in supporting learning? Could the reduction of operational interactions reward children with experiences that can be shared with others and thus prompt the desire for social communication?
Purpose of Critical Overview

In undertaking this research I have attempted to address these questions and in writing this critical overview I reflect on the following:

1. How the research has been informed by a number of key theoretical perspectives and disciplines;
2. How contexts have emerged through end-user participation and expert collaboration;
3. How methods evolved and have been refined;
4. Where the findings have made a contribution to knowledge.

Structure of Thesis

This PhD by Publication is structured around two thematic concepts that serve to unify ideas and create a link between the theoretical components and design in use. The first theme is participatory design, whereby people who use the design and those who are affected by it are included throughout the process, gives the work its direction (Ehn, 1992). This second theme, embodied interaction, a term used by Dourish in 2001 to describe novel approaches to the design of interactive computational experiences, provides the technological and philosophical foundations from which to interrogate ideas.

In investigating the relationship between these themes, the research converges on the understanding that design methods which value intentional and emergent actions - however unusual and idiosyncratic - as evidence of engagement, can lead to novel uses of everyday technologies for children on the autism spectrum. Taking this point of view, innovation
arises when opportunities for interaction are discovered rather than planned through system specifications and user modelling.

The themes are explained and discussed by dividing the thesis into sections that aim to reaffirm where the research has had most impact. Each section will describe the findings in relation to key theories that informed the research, and will introduce additional material that may have been excluded or unavailable at the time of the original paper submission. The purpose of this is to present a cohesive and up-to-date argument for the work.

Following this introduction, Section 2 will review theoretical perspectives on autism. The purpose of the section is to reflect on studies undertaken in Papers I-V, which explain how I speculated on and interpreted the autistic condition whilst developing design ideas with children. Papers II and III, draw heavily on theories of joint attention, attention tunnelling, and sensory perception. Being conversant with these perceived areas of deficit assisted in the identification of gaps in education provision for children diagnosed as “low functioning”.

The section will conclude by discussing the impact of sensory motor play on social interaction. The predominance of sensory motor, physical forms of play, characterised by unusually obsessive interests in objects suggests that the play abilities of children on the autism spectrum are limited. Taking an alternative perspective, my research investigated sensory motor play as a trigger for engagement and to question whether this may lead to increased desire for social interaction. Papers I, II, III and IV examine the play patterns of autistic children, and later papers present novel forms of play evidenced in studies of interaction with ReacTickles prototypes.
Including autistic children and those who care for them throughout this research heavily influenced my understanding of autism and interpretation of behaviour. Rather than rely on theoretical models that have a tendency to focus on deficits, locating my research in natural settings, where children are well supported by adult carers and routines that reduce the likelihood of upset, provided an inspiring and creative opportunity for gaining insight into the richness and diversity of autistic experience. Beyond the potential to observe children and thus gain contextual knowledge of their specific behavioural profile and setting, it was essential that children could participate through action, rather than expecting them to verbally articulate an experience. Section 3 documents how the process of experience prototyping enabled children to have input into the design by acting on prototypes intuitively and thus avoided participatory design techniques that rely heavily on social communication and a degree of abstract thought.

Investigations in the previous sections led to the conclusion that should the experience of using computers be expressive and less reliant on functionality, there may be additional therapeutic benefits, not yet realised in other research. Section 4, describes how developments in tangible and embodied computing provided vital clues to envisioning interaction as a relaxing and expressive experience. The understanding that the computer can arouse playful and relaxing experiences when the cognitive burden of interface semiotic and instruction are removed was reinforced through the prototyping and observational methodologies. The section concludes by referencing forms of embodied play revealed through the variety of observational studies presented in papers I-VII.

The concluding section, 5, considers the impact of the participatory prototyping methodology, in particular how it led to certain design
specifications that distinguish the work as *inclusive, interpretive* and *experiential*. These methods have been transferred to other technology environments and have led to a robust, usable software product, ReacTickles.

Throughout this work, I use the term “autism spectrum” to broadly describe the conditions, difficulties and experiences that affect a diverse population. There are other terms I use when I refer to children, such as child *with autism*, and *autistic* child. Opinions are divided on these terms; therefore, I have chosen to use both interchangeably. Within the papers I use the terms *Autism Spectrum Disorders*, *Autism Spectrum Differences* and most recently, *Autism Spectrum Conditions*. In my earliest work, I used the term *Autism Spectrum Disorders*, as it was consistently used in literature to describe the range of impairments that constitute a diagnosis of autism (Wing, 1996). However, as I started to include people on the spectrum as participants, I moved to a position of autistic *difference*, rather than *disorder*. The idea of a disorder suggests a disease needing a cure, and as my aim was not take a behaviourist or interventionist approach, I decided the term *Autism Spectrum Differences* would better position my work as representing the experiences of the person. Wendy Lawson, advocates the idea of autistic difference when she champions the *different* abilities of autistic people (Lawson, 2001). In later papers, as a result of my involvement with the Autism Centre of Education Research (ACER) I adopted the term Autism Spectrum Conditions. This term is now being more widely accepted to describe a ‘condition’ that is researched and understood (Jordan, 2007).

The research described in this PhD investigated opportunities to move away from the regimes and complexities of interventions that predetermine how children might perform, create and play. Rather than offer an
unambiguous solution, the work focused on determining an interpretive space for speculating on and communicating about alternative approaches, in which users are designers of their own experiences. Interpretive, in that any semiotic details that may denote function, or imply developmental and cognitive ability, or that situates the interfaces within a specific cultural framework. The design, in seeking to include children with autism, their non-autistic peers, parents and carers, does not reduce surface detail in order to compensate for disability, rather, it takes the sensation and perception of colour and movement, space and tactility, as triggers for interest, meaning that any person, autistic or otherwise, can interact from the same starting point – curiosity and the desire to make an impression on the world. The participatory methods describe how the research successfully avoided the tensions that arise between top-down, theoretically motivated design for ‘disability’ that focuses on impairment, and bottom-up, participatory design that seeks to promote a positive image through a focus on ‘ability’.
2. Designing for Autistic Experience

Designing for experience requires an understanding of people as capricious beings, continuously changing and adapting to the world around them. The challenge for the interface designer is to speculate on how people may adapt and adopt systems as requirements and knowledge changes. Attempts to understand people using logical models of users and the tasks they perform tend to focus on interaction as a purely cognitive process. Empirical approaches and user modelling are methods typically adopted in the design of technologies for children with autism as many interventions are formulated to maintain routines and to teach skills. However, the emphasis on operational interaction neglects the opportunities children need to make their own discoveries and to cope with a changing environment, as they would need to in the real world.

Playfulness and having fun are experiences associated with discovery, they are also known to elicit positive emotions, and to enable us to gain control of situations by removing the fear of failure. The Papers included in this Critical Overview aim to capture the subtleties of experience as the research evolved, however, they are underpinned by a rigorous review of the core theories of autism. This Chapter aims to present these theories with particular reference to play and its role in social communication and emotional growth.

Autistic Playfulness

The earliest papers describe my understanding of play from the psychological viewpoints of both Vygotsky (1962 & 1978) and Piaget (1951 & 1971). This theoretical knowledge assisted me in making connections with teachers, as I was able to demonstrate an understanding of the differences between the play patterns of autistic and typically
developing children. As I began to introduce my own studies in school-based settings, it was clear that social communication was the primary goal of teachers and play was mainly of interest as an objective for gaining social skills.

Paper I, addresses social communication in the contest of how I use digital media to assist young children on the autism spectrum in discovering playfulness. What is significant about this first paper is that it draws heavily on literature that documents practical examples on how to maximise on the abilities of autistic children rather than overcome cognitive impairments (Leslie 1987; Libby et al, 1998; Boucher, 1999; Sherratt 2002; Beyer and Gammeltoft 2000; Moor 2002; Jordan 2003). The paper sets out to provide an overview of the delays in the development of functional and symbolic play and draws certain conclusions to support the notion of interaction as a key motivational factor child-led communication. The unusual and obsessive patterns of sensory motor interest in objects that prevail in autistic development provided vital clues for interpreting autistic interests.

Paper II includes an additional literature review on play, social communication with regard to determining a methodology for formative evaluation. This required establishing a relationship with teachers that would enable me to observe and involve children with autism throughout my research. Consequently I created an iterative participatory model of research, inspire, listen and build, which was adapted from Druin’s model of Cooperative Enquiry (1999). This model will be presented in more detail in Section 3. Teaching staff and experts in ICT, special needs education, adaptive and assistive technologies, and psychology all played an important role in advising on evaluation strategies. Many of the scales used by other researchers did not place emphasis on individual
experience. Working with teachers in particular, helped to understand how evaluation could be beneficial to them, as well as to the research, in identifying how joint attention: waiting, attending, pointing and choosing, could be promoted in the classroom. Furthermore it enabled teachers to explore children's interaction in line with behavioural milestones and individual learning goals.

Paper VI develops the idea of repetition triggered by explorations of cause and effect as core to discovery led play. Design that exploits cause and effect is conceived through embodiment theories, phenomenology and perception. Of particular interest is how children interpret the environment and the physicality of objects through touch and gesture. Importantly, Paper VI makes a connection between play and the flow of concentration afforded when children make their own discoveries through repetition and pointing. The Paper concluded that play in the digital environment can lead to imaginative experiences and a desire to share when the child discovers a sense of control through repetition.

Paper VIII revisits sensorimotor play in a study undertaken with pre-school children aged 24-30 months, who, prior to the study, had no access to technology. The aim of the study was to understand the conditions of the play-school environment through observation and to use prototypes to consider whether technology could enhance these existing conditions. This study is included for the purpose of demonstrating how observations of sensorimotor play and imitation provide important contextual information for introducing prototypes to the children.

**Engaging the senses**

My understanding of the autistic condition deepened as a result of the literature reviewed for Paper III, and further supported the hypothesis that
computers may have a specific therapeutic application when their sensory properties support repetitive play that was missing from other research.

The paper concentrates on how the design process is informed by the distinct needs and characteristics of end-users and develops the argument from earlier work by considering how autistic people experience the world in a different way than non-autistic people as a consequence of sensory abnormalities. These sensory differences can occur in any modality, which means that their perception of the world can be alarmingly different from non-autistic people, and are often the cause of confusion and anxiety. At this stage the research begins to investigate how sensory phenomena can be harnessed through cause and effect to create a relaxing, yet compelling play experience.

The 7th European Academy of Design Conference, Turkey, 2007 presented an ideal forum to discuss and disseminate these findings. The theme of the conference - Dancing with Disorder: Design, Discourse and Disaster - encompassed three interrelated but relatively autonomous fields that highlight challenges for designers.

The paradox I faced as a designer is that most design briefs require the specification of purpose, intention and function, implying that design embodies ordered and systematic thinking. Whilst design research necessitates a process of speculation, interpretation and communication, the outcomes are expected to bring order to the relationship between us, and the communication tools we use, see, and perceive. This being the case, the function of design could be understood to eliminate disorder, such as confusion, chaos, and unpredictability. Disaster on the other hand could be considered the antithesis of order. However, this viewpoint will be will dependent on context. Disaster for one particular culture, group or
society may be regarded as victory for another. These themes represent some of the challenges exemplified in my work: design must have order to clearly communicate values, but for these values to emerge through collaboration, some of the order that we rely on through early specification may need to be avoided. In practice, this meant having to shift away from cultural norms around communication in order to discover a new way of thinking about how we communicate. In line with the conference themes, Paper IV discussed this idea from the viewpoint that the coping mechanisms children adopt in order to manage sensory disorder could be harnessed as playful triggers for communication. The idea was illustrated through studies with the interactive whiteboard, which was explored as a mechanism for stretching, jumping, smoothing and repetitive physical action. This contrasted with other software experiences designed for the interactive whiteboard that were limited to point and click user interfaces, similar to the desktop but on a larger scale. From experiments with ReacTickles on the whiteboard, and observations of children using other software applications, it became clear that children were being appropriately stimulated and that the device was under used as a sensory environment.

Paper V employed a quantitative methodology in order to gather data on uses of technology that were sensorially rather than cognitively motivated. The children selected had poor receptive and expressive communication abilities and were highly anxious. Data was gathered during sessions that were timed, observed, recorded and annotated using the measurement scales of Aldred, Green and Adams (2004) and the observational checklist of Cumine, Leach and Stevenson (2000). A second study was included in the paper, which aimed for a much broader picture of interactive play. This study used a semi-structured questionnaire methodology conducted with teachers in a number of schools with specialist provision for autistic
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children. The format for the study was adapted from a social skills checklist familiar to the teachers (Quill, 2000).

Findings from both studies evidenced increases in levels of concentration and behaviours that could be considered creative as they moved beyond repetitive actions to more intentional ones. The children's curiosity was aroused by exploring cause and effect and was maintained without the use of prompts. Unsurprisingly, the scale and proximity of the interactive whiteboard enabled freedom for expressive and gestural communication. Importantly in both scenarios, teachers felt more inclined to experiment with using technologies to support free play rather than purely for task-based purposes, this in itself was considered to be an important benefit. It was notable that whilst empirical methods revealed that children were far more playful when their sensory interests were aroused through the technology, the data was inconclusive. The observational scales adapted for the studies did not account for idiosyncratic responses or a holistic overview of the impact on self-esteem for each child.

From theory into practice

Four key theories of child development have been reviewed for this research: theory of mind (Baron-Cohen, 1995) explores children's ability to empathize and reason about the mental states of others; executive functioning (Ozonoff, Pennington, & Rogers, 1991) investigates a child's ability to initiate, maintain and shift from particular subjects of interest; central coherence explores children's ability to integrate pieces of information into coherent wholes, for example making sense of their own mind's activities and their ability to extract overall meaning from larger pieces of information (Happe & Frith, 2006) and to generalise newly learned behaviours into other situations (Plaisted, 2001); inter-subjectivity
(Hobson, 2004) investigates problems associated with experiencing oneself in relation to others.

Together these theories offer an account of the myriad of symptoms that impact on social engagement. In terms of providing a theoretical underpinning for this work, the literature assisted in directing the work towards the role of imitation and joint attention on social communication. In addition to the theory, interviews with teachers highlighted the fact that most information communication technology (ICT) interventions in use within the curriculum were directed at joint attention. However, very few of these were deemed developmentally appropriate for children whose functional language was at a pre-verbal level. At this point in the critical overview it is relevant to draw attention to the main contribution to new knowledge in the autism field my research has encountered and to position the next three papers in the context of this finding.

Papers I-V, in seeking out a framework for designing for autistic experience, concluded that engaging children through sensory interest can unlock potential and lead to a situation where social communication is desirable.

Autistic self-report as well as a substantial body of theory has confirmed that social communication may be delayed in a child with autism due to a lack motivation to communicate. The literature review and the contextual studies described in Papers I-V provided an informed perspective on autism from which I was able to determine a design goal. This was that it would be most useful to create a relaxing environment in which children’s desire to communicate may be enhanced through having something to show, and through being able to control this environment through
harnessing existing skills and interests. Using an experience prototyping methodology, described in the next chapter, I was able to amass a body of evidence which concluded that children's desire to communicate increased as a direct result of using the body to draw attention to action and seeing this action mirrored on a monitor or interactive whiteboard. The most recent expansions of this idea have including mobile technologies and other projected spaces.

At this point I will provide a little more depth on the importance of drawing attention to action to explain why this is essential for social communication.

**Why attention is important feature of social communication?**

As human beings we pay attention to things that arouse our interest. Other people tend to stimulate interest, and certain features are more attention grabbing than others, for example, the eyes. Typically developing infants tend to pay attention to eyes, and from about four days they will gravitate towards people looking at them. Children with autism spend less time looking at the eyes. As they approach 24 months, they pay more attention to the mouth, the body and objects than their typically developing peers. As result of poor attention to the eyes, their ability to understand the emotions or expressive communication of others becomes most disabling factor of the autistic condition, and this understanding is critical to all aspects of learning (Klin, 2010).

Being able to follow and monitor the eye gaze of another person is key to many types of real world interaction. Furthermore, when this is combined with pointing there are clear indications of the ability to monitor and direct attention. If a child avoids the eye gaze of another person and cannot look to where someone else is directing attention, then they will not be able to
interpret intentions correctly and make an appropriate response. Conversely, if a child is unable, or lacks the motivation to direct someone else’s gaze, interests cannot be shared. I explored this concept in my research in the design of early prototypes, the rationale being that by keeping the interface simple, with only one event that immediately responds to interaction, attention can be focused. Early studies (Papers I-III), revealed that when the child is aware of his influence on the simplest of events, interaction is maintained and attention becomes easy to monitor. Findings discussed in Paper IV describe how the spontaneous use of verbalisation, vocalisation and gesture indicated a desire to direct attention towards action. This was understood to have far reaching implications for children with autism, whose language is often not directly related to intentionality and purpose. Furthermore, Paper V links play and joint attention by using the idea of cause and effect as a focal point for reciprocal actions.

**Designing to widen attention**

Another contributing factor to the impact of attention on social communication is explained in the monotropism theory. Papers I, II, and III draw on monotropism to investigate why computers are understood to be particularly beneficial for people on the autism spectrum. Murray, Lesser and Lawson, published an article on the monotropism theory in 2005 in which they posited that the amount of attention available to the conscious individual at any one time is scarce. Autistic attention tends to be deeply aroused by sensory stimulation and topics of interest. The monotropism theory states that the difference between being autistic and non-autistic lies in the strategies employed in this distribution of attention. Papers I-V explain how I interpreted and speculated on the monotropic ability to focus on task, but took this as a starting point for gaining interest. Findings from studies documented in Paper V revealed decreases in
persistently monotropic behaviours as children widened their attention beyond repetitive actions to more creative ones. The children's curiosity was aroused by exploring cause and effect and was maintained without the use of adult prompts.

Paper VI represents the point in my research when I begin to specify conditions that motivate social interaction through the design of prototypes.

These conditions were:

- to provide a simple focal point by using abstract, non-representational forms that make no unnecessary demands on cognitive processing;

- from a simple focal point, make it clear to the child that they are in control, through cause and effect;

- to draw attention to action by mirroring input and rendering it visible to the child and others through the output device. For example, introducing effects such as colour trails in response to movement and changes in scale in response to pressure and sound volume;

- to avoid tasks that create attention tunnelling, so that a child can notice things that occur on the periphery of their attention. For example, a circle might appear and float on a new part of the screen, drawing attention from the point of focus to another possibility for action.
• To avoid unnecessary gratuitous feedback, such as system beeps, that may be interpreted as negative.

With these conditions informing the design of a prototype software application, ReacTickles, Paper VI focuses on the impact of sensory engagement on certain aspects of social communication not normally considered in assessing the abilities of children on the severest end of the autism spectrum. With reference to the non-verbal dimensions of conversation, for example, repetition, rhythm, pointing and imitation, I provide examples of how ReacTickles triggered joint attention and playfulness. The next section briefly explains the theories relevant to understanding the significance of sensory integration in the design of the interface.

**Working with Sensory Integration Disorder**

Sensory Integration Disorder (Ayres, 1972) is a term used to explain behavioural problems associated with abnormalities in processing and interpreting sensory information experienced through touch, vision, sound, taste, movement and smell. Paper IV provides an overview of sensory issues and concentrates on the vestibular and proprioceptive senses, which enable spatial and bodily awareness. Sensory abnormalities are not exclusive to people on the autism spectrum, and they remain excluded from the diagnostic criteria (DSM-IV), despite the fact that evidence from autistic self-report demonstrates a significant impact on daily functioning. Research revealed that the standard clinical assessment tool, *The Sensory Profile* (Dunn, 1999), designed to gather data on responses to sensory input, had limitations when it comes to using the information to discover a child's sensory preferences (Jackson, 2008). Jackson's PhD thesis attempted to address the issue of sensory processing in autism and its impact on interface design. Her research revealed the need to move
beyond the notion of customisation and addressed the potential of technology to harness sensory interest as novel method of capturing a child's attention. This approach, she emphasises, requires the acceptance of a child's uniqueness and basic human right for their expression of identity. A recent interview conducted with Jackson for this Critical Overview suggested that little progress has been made in this area since the publication of her thesis in 2008.

My research speculated on the specific impact of dysfunction in the vestibular and proprioceptive sense. These senses are rarely considered in the design of technology interventions, as vision and auditory sensitivity tend to be more obvious and easier to manage through user preference settings. However vestibular and proprioceptive sensory disorders contribute to feelings of anxiety, hypersensitivity, and distractibility and as one of my aims was to reduce anxiety whilst at the same time adopting an action-driven, rather than cognitively driven approach, understanding the impact of these dysfunctions was paramount. Paper IV documents my deepening interest in sensory integration, particularly in the vestibular and proprioceptive senses and discovers an important link between tangible interaction and sensory interest. At the time of investigating the role of sensory interaction on play and social interaction, I presented my work at a workshop run by a well-known sensory play organisation. Their approach was to use the sensory properties of real-world objects as prompts for social communication. At this point I recognised that any object has potential for sensory arousal, even a computer mouse or hard flat Interactive Whiteboard surface. From my studies it became clear that these mundane, everyday devices were not being utilised for their potential to arouse sensory interest and thus I speculated on this potential in the presentation. As a result I was approached by a senior occupational therapist at Scope, Victoria, Western Australia, interested in using
ReacTickles with people who experience movement and co-ordination disabilities. Scope are now using ReacTickles in their centres in Melbourne and have introduced it to Speech and Language therapists at La Trobe University, also in Melbourne.

In summary, research attributes the underdevelopment of playful social interaction in children with autism to poor joint attention and tunnelled attention. Without the awareness of others beyond one's own frame of reference, all other areas of social development and cognition will be impaired (Hobson, 2004). During the iteration of the ReacTickles concept prototype certain user requirements became vital for addressing joint attention and sensory motor play. These were: consistent structure, instantaneous feedback, appropriate point of focus, repetition in order to practice and gain confidence and providing opportunities to gradually move from current point of focus through exploration. The significance of these features will be explained further in the section of this review that draws on tangible interaction and embodiment, most importantly, the challenge was to incorporate these requirements in the most simple, pared-down manner, so that no child would feel inhibited by the sense of failure.
3. Participatory Design: Inspiration, Speculation, and Communication

In this section, I describe how an iterative process of prototyping and video analysis contributed to the empowerment of end-users within the design process. I argue that children were empowered by being offered opportunities to explore prototype interfaces without judgment. By allowing children to perform to their strengths they could influence design specifications simply by being themselves rather than conforming to routines set by others. The impact of direct observation, that is observing children in their own settings, doing things that come naturally for them, is reflected in the studies. From the earliest explorations with prototypes, which weren't even expected to be representative of a proposed technology solution - they were made to prompt ideas - it was clear that it would be possible to include even the most anxious of children. No rules or instructions were imposed on them. They were encouraged by their teachers to touch the mouse and keyboard, but other than that no prompts were needed. Teachers were quickly able to step back and observe. This directness, where little intervention was needed, resulted in increased confidence in both children and their teachers. Feelings of positivity and self esteem were reported to have increased as soon as children recognised they were able to control the interface without adult intervention.

This lack of intervention represents an important concern for participatory design. When researcher intervention is high, for example in setting tasks and influencing outcomes by managing the process, the participant has less control over what they are being asked to do, even though the outcomes influence design.
Autistic children continuously seek control in a world that appears alarming and confusing. For many of these children, the opportunity to simply explore, practice and gain control without adult intervention is rare. This section draws on the origins of participatory design and its significance in end user empowerment. With reference to each of the papers I will provide the methodological foundations for the research and describe the generative tools that contributed to new knowledge in participatory design.

In many PD projects it is not possible for all those affected by the design effort to fully participate. In these cases the choice of user participants and the form of participation must be carefully considered and negotiated with relevant organisational members, including management and workers themselves


The Participatory Design (PD) movement constitutes theories, practices and studies that transcend many disciplines. PD is motivated by the substantive role end-user communities play in activities that can lead to the creation and improvement of applications, particularly software and other technologies, and their appropriation in real-world contexts (Muller, 2003).

This section describes how my research was enriched by end-user participation through the use of generative research tools, particularly prototyping, observational studies, interview and online feedback, as well as evaluative tools, such as video analysis. These methods ensured that the previously undetected abilities of the target population emerged through exploratory studies and were valued as core indicators of the likely impact of the proposed technology system. The significance of this
evolutionary process for research is that it enabled a shift from requirement and result driven design towards responsive, cooperative design.

With reference to the generative stages of the research, the first section of the chapter briefly captures the earliest formative work undertaken with the target population of children with autism, their teachers and primary carers. The literature reviewed at this time considers the origins of participatory design and its importance in representing the point of view of disenfranchised groups.

Creating Conditions for Participation
While children with on the autism spectrum are known to enjoy using computers, those with the severest difficulties have little or no input into the selection or design of such technologies. There are examples of involving children with learning disabilities in requirements gathering, but more often, the wider community of caregivers, teachers and other experts are involved as proxies for design input, with the direct input from users in usability testing (Svensk, 2001; Moar et al 2007; Moar et al 2008).

In many cases technologies are offered as assistive devices, which, while they may enhance functionality, may also emphasise ‘difference’, thus creating a resistance and propensity for abandonment (Francis et al, 2009). This implies that involving autistic children in the design of technologies that impact on their lives is not only an ethical issue, but also pragmatic one, leading to enhanced acceptance.

The purpose of participatory design in this research has been to inspire and inform the conceptualisation, development and implementation of a technology interface from the perspective of an autistic child, guided by
insights into the pedagogical context for use provided through consultation with expert practitioners. A major goal was to ensure that the methodology adopted supported a sustainable process of cooperative development.

Paper I introduces methods that encourage creative collaboration between autistic children and adult carers. At this stage in the research, sketches and storyboards were used to quickly capture ideas, and a number of designs were made into prototypes. The function of these was to act as an envisioning tool for exploring new contexts for using desktop technologies that couldn't be explained through drawing. Finding ways to assist teachers envision experiences that do not yet exist proved essential for gaining acceptance and access to contexts which interaction may arise. As a result of discussion, using drawings and prototypes and prompts, an idea to use interaction to learn about colour names, complimentary colours, and shapes, became the focus of the next stage of idea generation.

In relation to PD, a key motivational factor for introducing this method was the participation and empowerment of children who would normally be disenfranchised by virtue of their lack of communication skills. Empowerment in this case, I argue, arises from the freedom to explore and express oneself through action, without having to conform to operational systems that predetermine a sequence of events. Furthermore, teachers were empowered to observe, interpret and speculate on the nuances of behaviour and to influence how the research may be implemented and maintained.

With the theoretical knowledge that children would be more likely to be interested in a object's properties than it's social or symbolic meaning, ideas were formed on the basis of interpreting phenomenological
properties of cause and effect. Initial design concepts for technology prototypes are described in the papers in terms of how they met the child’s need for control though structure and choice. Rather than draw on human computer interaction theories of usability, discussed in later work, the experimental design took a more serendipitous approach. The overarching goal at this point was to assess how children would react to, and interact with, a range of visual stimuli, when complex interface graphics were absent.

Field studies were undertaken in order to inform this design process. Three kinds of data collection were used (1) video observations (2) semi-structured questionnaires with scalar options (3) storyboarding as visual documentation.

Paper I introduces the first participant sample of children attending a full time autism unit. The groups varied in chronological age between 5 years in one group of six, to 9 years in another group of six. This purposive sample (Patton, 1990), were selected for their particular developmental level of pre-verbal. They were settled in their peer group and classroom routines, and they were able to take part in activities with a minimum of disruption. Following the advice of teachers, the children took part in a series of formal and free-play activities in sessions that were repeated over a short period of time. They explored prototypes in familiar settings using desktop computers, a laptop and a newly acquired interactive whiteboard; the activities were conducted as part of their classroom routines. Furthermore parents were invited to try out prototypes at home and comment on the project website.

At this stage of PD the purpose of experimenting with rudimentary activities was to ensure that end user participation was the most powerful
influence in the design lifecycle. Although certain features could be informed by research, these could only be developed as interactive play strategies when observed in real world settings where interaction arises without the need for prompts - without being explicitly taught or goal driven. This is where the true understanding of the potential of digital media was formed. Teachers taking part in video observation were inspired by evidence of increased concentration in some of the children who were normally difficult to engage. Furthermore they were motivated to explore interactive play with technology as a strategy for encouraging social interaction within existing curriculum frameworks. It was the suggestion of teachers that the wider community of parents and experts should be invited to comment on the design as it evolved. The paper concluded by indicating how online methods could extend participation beyond classroom settings. As the first paper to be published in a design journal, Digital Creativity, the work begins to intuitively map out a framework for the empowerment of a socially vulnerable group by providing a mechanism for capturing personal expression and the inspiration of adult carers. The papers that followed investigated theoretical perspectives on PD in order to speculate on, and concretise, a robust framework for sustained participatory involvement.

Papers II and III describe this framework as a research, inspire, listen, develop iterative cycle specifically developed for the purpose of designing with children and their teachers. The cycle was informed by Druin’s model of Co-operative Inquiry (1999) and focussed on using an iterative prototyping methodology in order to elicit different forms of feedback that could be understood according to both emergent and contextual factors.

The methodological approach built on the qualitative methods described in Paper I and used three kinds of data collection, (1) expert analysis of
video recording, (2) interviews, and (3) suck it and see experiments using experience prototypes, (described in the following section) documented through anecdotal feedback and primary observation.

The approach to data gathering was participatory and inductive. Results of analysis were presented in the form of qualitative descriptions of individual experiences of the children, rather than an empirical picture of failure or success.

**Participatory Design in Use: Prototyping**

In the generative stages, experience prototypes (Buchaneau & Suri, 2000) gave all participants a starting point for suggesting ideas and possibilities, and helped to envision interaction as a playful, emergent experience rather than a predefined routine for maintaining order. The prototypes functioned as tools around which new experiences could emerge. This contrasts with the typical use of prototypes as testing mechanisms. The object was not to test the prototypes but to enable children to experiment through repetition and practice. This formative process enabled nuances, idiosyncrasies and unpredictable behaviours to be examined and embodied in design. Experience prototyping as a generative approach requires a very different form of analysis than prototyping as testing. Experience prototypes explore possibilities rather than technical feasibility and fitness for purpose. These possibilities were initially discovered through teacher observation of children exploring prototypes in classroom settings. Papers I-IV document these experiments.

This crucial design research stage preceded any empirical evaluation of usability. When children acted on ReacTickles prototypes in an experimental environment with no concern about skill, qualitative data captured revealed a form of playfulness that had been missed in the use
of existing technology interfaces, and new ideas for supporting joint attention were openly suggested by teachers. Papers V and VII describe the playfulness that became apparent when children played with shadows. This was not designed in the prototype, but occurred by accident, however it became a highly motivating and creative game for some children and one that has since been exploited in new work beyond this PhD.

At later evaluative stages, reported in papers V and VIII video analysis was used in order to capture a permanent visual record of subtleties that may have otherwise been lost. This methodology led a breakthrough for the research as experts observing video began to recognise that playfulness with technology could boost the self-esteem and confidence of even the most anxious autistic children. Paper VIII evidences how direct observation also provided essential ecological information, which informed new contexts for interaction and the organisation of the studies.

**Reflecting on Designing Participation**

Designing with and for children with autism spectrum conditions requires careful consideration, particularly as their developmental impairments may limit their understanding of the design process. Typically, design requires abstract thinking and interpretation, as well as a willingness to accept change. For children who are easily upset by a change in routine and who have difficulty in predicting the behaviour of others (Marans et al., 2005) having strangers introduce traditional design led activities would be inappropriate and unlikely elicit any useful data. During the evolution of this research, generative tools in the form of prototypes provided a focus for learning about the abilities of children and their capacity for interaction.

As a method of co-operative enquiry these tools proved the most effective for triggering ideas and identifying contexts in which the research could be
validated. It is important to note that this research benefited from the easy installation and implementation of prototypes on hardware devices that were already in use. Participation increased and was negotiated on the basis of direct practitioner engagement, as teachers were able to observe the progress of children in natural settings. Furthermore, the practitioners were given the freedom to try out the prototypes over time, and to be responsive to the children's interests. This kind of participation, which builds on the knowledge and motivation of experts, is vital for maintaining the momentum of PD throughout each stage of the research (Dearden & Light, 2008). Essentially, it provides vital inspiration for designers that cannot be achieved through empirical processes that fail to acknowledge individuality and changing contexts (Kouprie & Sleeswijk Visser, 2009; Battarbee & Koskinen, 2005).

Situating prototypes in settings where they can be easily integrated into existing practice in the earliest stages supports a gradual acceptance of something new. In this way design emerges in response to use. Central to this is the need to ensure that users are able to use the prototypes independently and that they have strategies for documenting experience, both anecdotal and structured. This process establishes strong methodological connections between the tools for design research and the perceived goals of the research (Hagen & Robertson, 2010). In this respect participation in design is also participation in design in use (Ehn, 2008). The following section aims to articulate how the emergent PD process coupled with a simple, iconic design led to the understanding that technology has the potential to empower children when it is driven by action rather than cognition.
4. Design in Use: everyday tangible interaction

In the previous section I reviewed how the participatory process, described in Papers I-VI, deepened through regular iterative prototyping. An interface design emerged as a result of being used in authentic settings, driving a strong connection between the tools used for the research, and the subject of the research. In situating development in everyday environments, utilising familiar hardware devices, opportunities emerged to bridge existing and future practices in the use of Information Communication Technologies (Hagen & Robertson, 2010). Teachers readily engaged in exploring prototypes with children and as a direct consequence, designed new opportunities for introducing everyday technologies into the classroom as playful objects. The idea of perceiving technology as an object with physical properties is explored through a comprehensive literature review of tangible technologies - detailed in Papers IV-VIII. For the purposes of reflecting on the significance of this, and particularly how teaching practitioners became innovators through their mastery of the technology (Dearden & Light, 2008) this section is devoted to the design of the interface and the significance of physical directness in interaction.

Direct Manipulation and Interface Design

The earliest inspirations for this research arose from my interest in the work of artists who exploited the expressive, dynamic qualities of movement to choreograph inanimate 2D forms. The idea that we could understand a simple two-dimensional form as having emotion, weight and the physical capacity to respond to force appeared to be under-researched in the domain of human computer interaction. My early experiments examined a new form of expression by enabling the use to orchestrate light and colour through the direct manipulation of the interface using a mouse or key press. As I introduced these ideas to
teachers, and consequently to autistic people, it was suggested that there may be significant benefits to this population of being able to visibly maintain control of an environment through direct manipulation (Shneiderman 1983). The investigations that followed led to the finding that when control is realised through repetition and the opportunity to predict and manage change, children discover a rare opportunity to express their interests without fear of failure. This reduction in anxiety increases emotional self-regulation and could ultimately motivate social interaction. I mention this here in order to explain my interest in tangible and embodied interaction, which was discovered through observations of this idea in action.

**Manipulation and Perception**
Papers I-IV made reference to an initial series of software prototypes. Observations of children exploring these revealed that without the necessity to process complex information, such as graphic symbols, text or pictorial imagery, the dynamic qualities of movement could arouse curiosity. Added to this, it seemed that children were able to perceive a shape as an imaginary object when there was no surface detail. In these prototypes, the notion of elasticity, velocity, gravity, inertia and momentum was coded into the system so that when the child interacted with a shape the effects suggested magical qualities that were freely open to interpretation. No further representation detail was required. The flat 2 dimensional shapes became triggers for imagination purely by implying the physicality of weight and tension. Importantly, direct manipulation and perception occurred through the same sense – touch. By using the input device to change the behaviours of shapes, for example through pressure and movement, many rich interactions were possible. These concepts are explored in Paper I using computer technologies in a special school with a dedicated unit for children with autism.
Paper II makes a strong connection between user participation and direct manipulation and draws on research on how tangible technologies forced new paradigms in the relationships between users and machines. My interest in tangibles deepened following a review of the literature describing the impact of computer use for young children, implying that computers drain valuable cognitive resources and are thus developmentally inappropriate for young children (Healy, 1998; Levin and Rosequest, 2001; Plowman and Stephen, 2005). Very little of this work concerned the use of the computer for play activities that could be guided by the interests of the child. At this stage I had not reviewed embodiment theories. However, in observing children as they became curious and eager to maintain their interest through manipulation without instruction, I began a deeper investigation into interaction and its impact on relaxation and play.

**Everyday Tangible and Embodied Interaction**

Learning that is mediated through tangible interaction provides more varied opportunities for reasoning about the world through discovery and participation than more traditional forms of desktop computer interaction (Price et al., 2003). For younger children, having the freedom to explore and reflect on the effect of their actions through a combination of sensory and cognitive processing gives rise to developmentally appropriate uses of Information Communication Technologies (ICT). Considering the difficulties experienced by young autistic children in the areas of sensory disorder and their need for repetitious coping strategies, the potential of tangible interaction to allow children to combine and recombine the known and familiar in new and unfamiliar ways through sensory investigation rather than instruction is of particular interest (Hoyles and Noss, 1999).
Tangible interaction derives from an approach to computing where the
digital world of cognitive information is closely coupled with physical user
input, maximizing on people's innate familiarity with interacting in the
physical world (Honecker, Hornecker & Buur, 2006; Hornecker, 2006).

Tangible systems encompass interfaces and artefacts that may involve
physical manipulation, physical modes of representing information,
embedding electronics within objects and forms of computational
augmentation in real-world environments (Ullmer, 2000; Fiskin, 2004).
Providing people with opportunities to access information through the
senses reduces the demand on the cognitive system and thus interaction
is more intuitive. Dourish (2001) describes this as embodied interaction,
meaning that bodily instincts and sensory perception provide the vital
clues on how to interact. When we are able to control our physical and
spatial relationship to the world through our senses, particularly through
movement, touch and vision, we have the tools to find meanings and
intentions (Heidegger, 1971; Merleau-Ponty 1962). Embodiment theory
evokes the idea that perception governs the way in which we find the
possibilities for action from an exploration of how things feel, how they
appear and how they react. This is further explored in human computer
action theory as an “affordance” (Norman, 1998; Norman, 2005; Gibson,
1987).

Paper III, proposes that the interface could have aesthetic qualities which
allow it to be perceived through the senses and explains this by drawing
on animation techniques that suggest foreground, background, space and
weight. Paper IV, however, represents a breakthrough in terms of the
discovery that the perceptual mapping of input and output through the
same sense, touch, the Interactive Whiteboard could engage children for
longer periods of time and could elicit more playful, imaginative responses.
Furthermore, the scale of the device enabled bodily interaction, spatial awareness and the amplification of action. This Paper compares these large-scale interactions with the limited range of explorations available on desktop set ups and in so doing makes an important link to embodiment. Whilst my interest in embodiment has stemmed from the practical experience of observing behaviour in context, the body of literature reviewed provided the theoretical underpinnings from which to deepen my investigation in relation the research aims: relaxation and play. Paper V, develops the argument for embodied user interfaces as a calming experience thus removing some of the anxieties that inhibit communication. The Paper revisits play theories in relation to embodiment and tangible interaction, and focuses on how embodied interaction encouraged improvisation and performative self-expression. The aim of the paper was to contribute to research on tangible technologies by describing the potential of everyday devices to engage young children through physical manipulation. In my earlier work I made reference to the positive role that technology plays in assisting people with autistic spectrum conditions in their day-to-day functionality, and why it is introduced to children from an early age to develop and optimise on their communicative capacity. This Paper extends this notion and is informed by the literature review, which focused on embodiment and how the body mediates social communication by transforming our innermost emotions into external actions and gestures (Merleau-Ponty, 1962; Healy, 1998; Thackara, 2005; Singer, 2006). With reference to studies undertaken in educational settings, I attempted to draw conclusions on the impact on social communication of touch and direct manipulation, where input and output are closely coupled and thus provide an alternative perspective on the uses for ICT.
Two studies are reported in this paper. Study one employed an empirical methodology with a sample group of 3 children aged 11-19 years diagnosed with autism and severe learning difficulties. The study aimed to evaluate the quality of playfulness aroused in children whilst using a keyboard to explore ReacTickles. The children selected had poor receptive and expressive communication abilities. Quantitive data was gathered during sessions that were timed, observed, recorded and annotated using the measurement scales of Aldred, Green and Adams (2004) and the observational checklist of Cumine, Leach and Stevenson (2000). The second study aimed for a much broader picture of interactive play using the interactive whiteboard in a variety of settings. The study used a semi-structured questionnaire methodology conducted with teachers in a number of schools with specialist provision for autistic children. The format for the study was adapted from a social skills checklist familiar to the teachers (Quill, 2000).

Findings from both studies evidenced increases in levels of concentration and behaviours that could be considered creative as they moved beyond repetitive actions to more intentional ones. Curiosity was aroused in the children by exploring cause and effect, and was maintained without the use of prompts. Unsurprisingly, the scale and proximity of the interactive whiteboard enabled freedom for expressive and gestural communication. Importantly in both scenarios, teachers felt more inclined to experiment with using technologies to support free play rather than purely for task-based purposes, this in itself was considered to be an important benefit as many children are known to find free-play sessions stressful if they mean a break from routine.

It was notable that whilst empirical methods revealed that children were far more playful when their sensory interests were aroused through the
technology, the data was inconclusive. The observational scales adapted for the studies did not account for idiosyncratic responses or a holistic overview of the impact on self-esteem for each child. On reflection, I see that as an important milestone in the research. Having gained an understanding of existing uses of ICT and the metrics by which behaviours were evaluated as communicative, I realised that improvisation, performance and playfulness were neglected in school based environments. Paper VI provides a detailed tour of desktop and interactive whiteboard affordances, and describes each device according to the level of physical and perceptual directness made available through prototype ReacTickles. In analysing data from studies undertaken in a variety of settings, the paper captures the benefits of tangibility in fostering an action-led approach to determining the communicative abilities of children on the autism spectrum.

Reflecting on Affordances and Direct Manipulation
An ongoing commitment to disseminate the findings of the studies to a public and practitioner audience involved presenting at conferences such as the Autism Cymru International Conference in 2004, 2006 and 2008, NASEN seminars and at public events such as BETT. These presentations prompted interest in the research from both teaching and research specialists as well as parents.

One such specialist, Professor Amanda Kirby, Head of the Dyscovery Centre, approached me to discuss ideas on how ReacTickles could be introduced at the Centre. The Dyscovery Centre offers service provision and education for adults and children with learning difficulties and related movement and communication disorders. Having pitched a concept for a taking ReacTickles onto new, mobile platforms to the Content 360 competition at MipTV, Cannes, France in 2007, and successfully winning
an Award for Socially Responsive Media Across Multiple Platforms, I suggested to Professor Kirby that the funding award could be used to run a design workshop with children attending a holiday club at the Dyscovery Centre.

Paper VII reports on this workshop. Children in attendance were aged nine years old and were diagnosed with dyspraxia, dyslexia and ASC. The general goal of the workshop was to explore communication and to develop designs that exploit the tangible properties of mobile devices. Previous observational studies had indicated why the software was effective as a relaxing, playful environment on the basis of physical interaction and the reduction of cognitive overload. This next phase of observation considered what children did with it when given the freedom to explore. Importantly we needed to discover more about how they invented their own purpose, was it predominantly through direct manipulation and physical affordances or might there be some desire, beyond this, for social interaction? The workshop reported in the Paper was an exploratory event that was staged to allow children to discover what might be possible with ReacTickles and how they might use it to playfully collaborate with each other.

The workshop was structured around playful interaction, beginning with relaxation and exploration of existing ReacTickles on a variety of surfaces. Other activities that followed invited children to make communication devices from non-digital materials and unusual objects. A think aloud feedback session captured comments and connected ideas using a mind-map. A short yoga practice provided a break in the interaction, and offered relaxation through full body movement, before the introduction of rudimentary prototypes on mobile phones and the iPod™ touch.
Dyscovery Centre staff acted as a focus group for advising on the structure of the workshop and in how best to use observation without biasing the responses of children. We therefore took a very “hands off” approach, using a fixed and handheld video camera to capture the action. The staff provided more detailed observations based on their knowledge of the children. These guided observations revealed that children were able to engage in bodily interactions that were more expansive and experimental than usual for this group; they expressed excitement discovering the range of visual effects for themselves. The staff focus group was surprised at how eager children were to draw attention to their creations with ReacTickles and to involve others. The think aloud session lacked structure, children were not used to managing turn-taking without guidance and the session was unruly. It was, however, a useful quick-fire way to capture responses, but it was more beneficial to the researchers than the children.

After yoga, children played with mobile ReacTickles prototypes that enabled them to create patterns, they enjoyed handling the devices and very quickly grasped the idea of sharing and moving on. No-child was left out and no child became anxious. Some of the children readily engaged in interviews with the researchers about their ideas for new applications and the less verbally confident children drew ideas on A1 size templates. Whilst the prototypes were rudimentary and used abstract shapes and lines, the children clearly enjoyed using buttons and movement to create their own designs. The non-representational forms encouraged fluency and experimentation and placed less demand on manual dexterity than having to type. Involving children directly provided valuable insight into the benefits of mapping the physical elements of the device into design. Children's ability to experiment, and willingness to show others, challenged our expectations that they would desire sophistication and task
from an interface, based on their prior gaming experience. These findings formed the basis of the new ReacTickles open source website, released in 2010.

Paper VIII provides a reflective overview of how the affordances of everyday technologies used in the early years school curriculum can be harnessed to support direct manipulation. Whilst the children's interaction reported in the paper provided confirmation that the ReacTickles interface may have wider potential than children with autism, it focuses on how technically unskilled playworkers could make use of ReacTickles in supporting inclusion for pre-school children.

The study uses qualitative observational methods to enable practitioners and children in an inclusive playgroup to design their own experiences with technology. As part of an every-day playgroup activity, the ReacTickles software was introduced using a variety of inputs: microphone, touch screen and Wii controller. The hardware was introduced gradually over a series of six sessions. At the start of each session play workers were able to explore the software and input device and to suggest how it might be incorporated into play routines. Before any technology was introduced direct observation techniques were used in order to gain crucial environmental knowledge of the playgroup setting. As the technology was introduced observation was supplemented by video analysis, based on a well-known Play Behaviour Scale (Rubin, 1989). Interviews conducted in later stages provided contextual ideas from play workers as they observed the nuances of playful interaction. These forms of unobtrusive observation enabled play workers to maintain their usual level of support, without dictating activities. With the exception of a child with cerebral palsy who needed constant care, children were organised into small mixed groups where they were able to interact with the minimum
of adult intervention. This in itself was considered exploratory and worthwhile and provided many ideas for integrating prototypes in the traditional, non-digital activities enjoyed by the children.

Play worker involvement was key to acceptance and inspiration. By introducing prototypes that could be used to enhance regular, non-digital play, the digital activities always started with the familiar. Thus the known and familiar led to new discovery, through the opportunity to simply observe children's responses. The children, who were aged 24-30 months, found activities that provided direct manipulation the most stimulating. When they could observe the amplification of their actions they very quickly grasped cause and effect and that they could control the environment. Most effective were activities that had only one visible focal point, for example a square, which could change scale, position or speed depending on volume of sound created by the children. More complex activities using the Wii controller, whereby the interface appeared to map the movement of the child, were more demanding, although the child with a motor coordination disability (Cerebral Palsy), mastered control very quickly. When ReacTickles amplified sound made by children – singing, clapping, and instruments – with guidance from play workers, children were very quickly able to take control. They were observed to repeat their actions, gradually introducing change and making their own personal impact on the interaction. The paper concluded with guidelines for designing age appropriate technologies for young children prior to their formal education.

To conclude, research on tangible and embodied interaction led to the design of ReacTickles prototypes that could be used to include children diagnosed with low functioning autism and other learning difficulties and their teachers in generating ideas for using computers as a therapeutic medium for relaxation and play. Inspired by children's interest in the way
objects behave when they are subject to the conditions that surround them. The prototyping method allowed the participants to experiment through repetition and familiarity in order to realise new and unfamiliar ways to play.
5. Conclusion

This critical overview has described the theoretical underpinning and research methodology that led to the creation of an original software application for children with autistic spectrum conditions (ASC). In reflecting on the development of the research documented in the papers, it is clear that participation in the lives of others, even in the narrow context of classroom environments, has shaped the development of a concept prototype, ReacTickles, and the interpretation of data that revealed the potential of everyday technologies to be relaxing and playful. Underlying theory has provided the vocabulary for inviting contributions from communities other than design and provided the necessary framework for critique and the interrogation of ideas. Making the design process visible and accessible through a responsive prototyping methodology has ensured that the design represents the views of participants whilst seeking to determine an aesthetic that is intriguing and unique.

Documenting the studies described in the papers with video and photography had provided an invaluable communication tool and the window that enabled adults to gain insight into the child's emerging interests and development (Helm, Beneke, & Steinheimer, 1998). Indeed, many people have been inspired by the digital video and images of children in action. In turn these have led to further research, curriculum design, professional training and development, parent involvement and also as a support for learning for children themselves. The outcome of this process has been a software product, printed resources, a website, presentations, workshops, and a worldwide network of users, practitioners and carers who have maintained communication on the basis of their involvement with the research.
Whilst the research has not sought to provide a discrete solution to a predetermined problem, or to function as an educational intervention or a satisfy a scientific viewpoint on the autism condition, for many of the people involved in the research these outcomes have been possible through the exploration of ReacTickles in emergent contexts. Papers VII and VIII describe how the final, commercially available version of ReacTickles, inspired ideas to transfer playful interaction onto other devices. Again, the user is at the heart of this process, revealing, through use, novel forms of interaction triggered by curiosity.

**Impact**

In 2008, ReacTickles was licensed to a major UK distributor of educational technologies. The final version included a set of supporting curriculum resources, the content of which was created by teachers. The success of ReacTickles exceeded all expectations, particularly for a software product made by an independent producer, and licenses have sold to more that 500 schools throughout the UK. Such has been the demand and interest in the product, that version 2 is now ready for release and includes additional features for Switch assistive device users. ReacTickles for SMART table has also been pre-released to the press and gained excellent reviews. This will be available in the autumn 2010 education catalogue. Thanks to increasing interest in from Scope Victoria, ReacTickles is being widely used by occupational therapists with children and adults with disabilities including Cerebral Palsy and Autism. In New Zealand, Alpha Autism, a support network for the employment for young people with autism, has included ReacTickles in their programme as well the Department of Education Geelong, through a number of Primary Schools and Melbourne Wantirna School (for children with Autistic Spectrum Disorders). At La Trobe University, David Trembath, a specialist Speech and Language therapist is conducting his own experiments with
ReacTickles, and following the presentation and publication of Paper VIII, a therapy Centre in Bangalore, India is also including ReacTickles in its programme.

The National Association for Special Educational Needs (NASEN), the Autism Centre for Education Research (ACER), the Autism Education Trust (AET), Autism Cymru and the National Autistic Society (NAS) have all recommended ReacTickles, and as a result I have been invited to present at public seminars and national conferences.

**Contribution to New Knowledge**

The goal of this research has not been to design new technologies, it has been to make a contribution to new knowledge by demonstrating how the interpretive and adaptive qualities of design research can impact on the lives of those we design for, hearing their voice, empowering them to be innovators by adapting design solutions to their own needs. The surprise that the mundane and ordinary could be playful has brought delight to many parents and teachers, without whom none if this research would have been possible.

The benefits to this research of using prototyping methodology on conventional devices cannot be under-estimated, and the impact has been significant. Access to participants, familiarity and ease of use, acceptance of novel and unconventional methods, dissemination beyond academia and distribution through school networks and specialist provision have all been enhanced by the potential to demonstrate and experiment using everyday devices.

As a result of this involvement I learnt that for many children and adults with severe learning difficulties, the opportunities to feel playful and in
control are few and far between, as the need to develop skills and improve functionality is given priority over benign, creative and playful pleasures. Rather than think of computer interaction as something sophisticated that satisfies a purpose, I have demonstrated that the ordinary devices that surround us could offer an accessible, exploratory, playful and relaxing experience when they simply afford the enjoyment of the phenomena of cause and effect. This requires simplicity – if the first, most tentative action is mirrored and amplified then there is a greater likelihood that more curious, ambitious actions will follow. When that curiosity is rewarded, even the most profoundly autistic child may feel the sense of satisfaction and self-awareness needed for emotional growth and well-being.

*Design pared down to the minimum can be quiet, yet iconic, and the simplest of interactions can be refreshingly direct and immediate*

Designing for Playfulness: Investigating the Therapeutic Potential of Technology Interfaces for Children on the Autism Spectrum – Wendy Keay-Bright

6. References for Critical Overview


Designing for Playfulness: Investigating the Therapeutic Potential of Technology Interfaces for Children on the Autism Spectrum – Wendy Keay-Bright


Designing for Playfulness: Investigating the Therapeutic Potential of Technology Interfaces for Children on the Autism Spectrum – Wendy Keay-Bright


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APPENDIX ONE
Co-Author Statement
# Co-Author Statement

With reference to the contribution to the conceptualisation, design, conduct of the research, analysis, and writing up of the publication the following statement states out the contribution of each author on the paper *Designing Inclusive & Playful Technologies for Pre-School Children (2010)*

<table>
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| Wendy Keay-Bright | Conceptualisation, design, conduct of the research  
|                 | Analysis and writing up of the publication  60%                 |
| Adam Martin     | Conceptualisation, design, conduct of the research  40%        |
|                 | Analysis and writing up of the publication  30%                 |

**Comments**

Both authors were involved in the design of the project and attended each of the evaluation sessions. The ReacTickles touch screen and microphone applications were design by Wendy Keay-Bright. The Wii and Dance mat applications were designed by Adam Martin based on the original ReacTickles concept.

# Adam Martin

3/1/2011
The structure of the paper was cohered by Wendy Keay-Bright together with the literature review, research design and analysis. Adam Martin added the technology review and provided detail on technology implementation.

The writing of the paper and presentation of data was co-ordinated between the two authors via email to ensure that the results were correctly represented.

Wendy Keay-Bright submitted the paper and attended the conference.
APPENDIX TWO
Author Brief CV
Curriculum Vitae 2011

Wendy Keay-Bright BA (Hons) Graphic Design  
Cardiff School of Art & Design  
Reader in Inclusive Design  
Principal Lecturer: Graphic Communication  
E-mail: wkbright@uwic.ac.uk

Journal Publications and Conference Proceedings


Selected International Conferences, Workshops & Invited Lectures


2011 *Repetition, Rhythm and Reaction: making the ordinary extraordinary* University of Dundee, School of Computing, Scotland, UK

2010 Phenomenology as a Framework for Participatory Design, PDC 2010, Sydney Australia

2010 *Design for Play, Design for All*, SCOPE Victoria. Melbourne, Australia

2010, June  *Design for Play, Design for All*. Design for [every]one Conference Howest University, Belgium


2010: ECHOES: Improving Children’s Social Interaction through Exploratory Learning in a Multimodal Environment. The Education Show, NEC, Birmingham
2009: Autism Today: Royal College of Physicians, Edinburgh

2009: Inclusion & Personalised Learning with Interactive Whiteboard Technology, BETT2009

2009: ‘By Us, For Us, About Us’ Children and Young People’s Festival of Participation of Research, Cardiff

2009: 3rd International Conference on Design Principles and Practices: Berlin, Germany

2009: NASEN, Understanding and Supporting the Child on the Autistic Spectrum, Devon, UK

2008: 10th Computers for Social Responsibility Participatory Design Conference, Indiana, USA

2008: Sparkle and Shine, Sharing Excellence in Multi Sensory Practice, London

2008: e-Inclusion, King College, London, UK

2008: Buckinghamshire SEN Conference, England, UK

2008: Third International Autism Conference, Cardiff, UK

2008: 4th International Conference on Technology, Knowledge and Society, Boston, Mass, USA.

2007: Dancing with Disorder: Design, Discourse and Disaster: 7th Conference of the EAD at the Faculty of Fine Arts and Design, Izmir University of Economics,
Turkey


2006: Awares’ Online Autism Conference


2005: Integrated Media Gaming and Augmented/Virtual Reality Approaches to Autism Treatment Interventions, Cleveland Institute of Art, Ohio, USA

2005: Autscape 2005, Bath, UK

2004: First International Autism Conference, Cardiff.

2003: Broadening the Band: Association of Internet Researchers 2003, Toronto, Canada.

**External Funding Awards**

2011 RAYNE FOUNDATION

2011 HIGHER EDUCATION COUNCIL FOR WALES: STRATEGIC INSIGHT PROGRAMME

2010 WELSH ASSEMBLY GOVERNMENT (WAG) EARLY STAGE DEVELOPMENT FUND/UWIC IP FUND
2010 WELSH ASSEMBLY GOVERNMENT (WAG) TECHNOLOGY & INNOVATION TRAVEL FUND

2009 HIGHER EDUCATION COUNCIL FOR WALES:STRATEGIC INSIGHT PROGRAMME

2008 ESRC/EPSRC/TEL Echoes II

2007 NATIONAL FILM BOARD OF CANADA, CONTENT 360 AWARD

2007 NESTA LEARNING PROGRAMME AWARD

2005 NESTA LEARNING PROGRAMME AWARD

Design/Leadership Awards

2007 & 2006: Design Wales Showcase: ReacTickles™ Creativity Box & Reactive Colours

2007: Winner of the Innovative New Forms of Socially Responsive Media category in the MIPDOC Content 360 competition at MipTV, Milia, Cannes, France

2007: Finalist Wales Leadership Awards Leadership in the Public Sector.

2006: Finalist-Welsh Woman of the Year Awards: Woman in Science and Technology.

2006: BECTA ICT Excellence Award Short-listed
2006: **Tech Museum Awards**: Short-listed for a Tech Museum Award in the US

2006: **S4C National Charity Awards**: Winner Autism Cymru Wales Autism Award

**Reviewing**

- Digital Arts and Culture
- *International Journal of Design Principles and Practices*
- *International Journal of Technology Knowledge and Society*
- *Interacting with Computers*
- *Computer Professionals for Social Responsibility (CPSR)*
- Associate Editor, *Journal of Assistive Technologies*

**PhD Supervision, 3 Current Students studying**

- Wearable Technologies
- Design for Visually Impaired
- Interaction Design for Dyspraxia and Coordination Difficulties
Reactivities©: autism and play

Wendy Keay-Bright

University of Wales Institute, Cardiff, UK
wkbright@uwic.ac.uk

Abstract

ReActivities© are digital play sequences which encourage the integration of social, emotional and cognitive development in children on the autistic spectrum. High levels of anxiety in autistic children can inhibit playful experiences and increase the rigid, stereotypical and challenging behaviours which have a negative effect in social situations. Interactions with objects that offer repetition, pattern and similarity combined with colour and rhythm are regularly used by autistic children as methods to reduce anxiety, however little has been done to interpret these sensations in digital environments. The aim of ReActivities© has been to offer a rich physical and cognitive experience which simulates the perceptible characteristics of phenomena such as elasticity, velocity, gravity and inertia. This is an advanced form of cause and effect that promises a unique form of expression in response to exploration with computer technology. There are numerous thoughtful and engaging websites designed and maintained by autistic people which are testimony to the theory that computers, and particularly electronic networks, offer enormous possibilities for creativity, communication and fun. The project is utilising open source technology to enable autistic users, many of whom are already conversant with programming languages, to adapt and re-generate the software. Fostering a community approach to development affords further opportunities to explore an innovative, inclusive design method that, should it prove successful, could provide a model for other marginalised groups.

Keywords: autism spectrum differences, collaborative design, digital environments, interaction, monotropism

1 Introduction

There is a significant body of research to show that children on the autism spectrum find play difficult, in particular they lack ability and interest in social forms of play (Leslie 1987; Sherratt 1999; Beyer and Gammeltoft 2000; Jordan 2003).

Most of these children have problems with the expression and interpretation of verbal and gestural language, which can lead to unwillingness to share experiences. These problems, coupled with apparent inflexibility of thought, tend to result in a lack of understanding of the intentions and motivation of others as well as difficulties creating imaginary situations.

In typically developing babies and toddlers, play routines evolve from explorative sensory-motor play to more complex social and imitative responses, forming the foundations of social interaction and communication. This gradual process involves the separation of meaning from the object and meaning from the action (Vygotsky 1978). This progressive differentiation is most evident in functional and symbolic play, which locates objects and experiences within an operational and social mode and directly assists children in successfully experiencing and understanding the world as they use it to mediate and explore the intentions of others.

Interaction, mirroring and the emotional interchange between parent and child, condition a child’s perception of intention and goal throughout early years.

Most autistic children do not demonstrate this range of play behaviours, preferring
instead the physical approach: playing with an object of interest without accounting for its formal characteristics. Sensory-motor play of this kind—for example, banging, spinning and oral exploration, such as biting—is often repetitive and persistent and is notably non-goal-orientated and unusual. Children on the autistic spectrum enjoy engaging in repetitive actions because of the opportunities this gives them to predict and potentially control their environment (Jordan 2003).

Some children with autism spend hours on end on the same monotonous and repetitive activity, making it difficult for others to involve them in more meaningful activities. (Beyer and Gammeltoft 2000)

However, whilst there is a body of research to suggest that there is a significant deficit in spontaneous symbolic play in children with autism (Ungerer and Sigman 1981; Baron-Cohen 1987), some researchers have identified that the ability to engage in meaningful functional play may depend on the child’s individual circumstances, particularly their family and learning environment. People within a child’s immediate circle will introduce function through their own use of objects, but the extent to which children engage with others may impact on the acceptance of this function (Williams et al. 1999).

2 Why is play important?

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

Underpinning play is interaction. As a child develops through interactive play, a sense of personal identity grows alongside the awareness that perspectives other than their own exist, which require co-operation, respect and understanding (Beyer and Gammeltoft 2000).

As well as using play to discover how things work, creative outlets such as movement, dance, drawing and music enable children to express their inner emotions, which can lead to increased self-esteem and pride (Moor 2002).

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

Given that play skills have a central role in development and that these skills are underdeveloped in individuals with autism, integrating play activities into daily routines could offer significant opportunities for encouraging social interaction, communication and imaginative thinking.

The autistic condition is puzzling, however, and not well understood; much research focuses on deficits in joint or shared play. Genuinely shared play requires a shared focus and an acknowledgment of the interactions and experiences of another. To appreciate why this differs in autistic individuals it is necessary to understand one of the central features of the autistic condition—monotropism—(http://www.autismandcomputing.org.uk/hypothesis.en.html).

Dinah Murray, Mike Lesser and Wendy Lawson (2005) explain monotropism as having a deep and tightly focused interest system whereby attention is concentrated in single or limited areas of interest. They suggest that the difference between autistic and non-autistic individuals lies in having a few interests, highly aroused, the monotropic tendency, and having many interests less highly aroused, the polytropic tendency.

(Murray, Lesser and Lawson 2005)

Typically developing individuals will successfully manage the polytropic interest systems which facilitate social reciprocity, however for the autistic child, having to process varying types of information and multi-sensory stimulation can lead to confusion, high levels of anxiety and feelings of isolation.
3 Reactivities© provide appropriate conditions for play

Murray, Lawson and Lesser’s theories on tunnelled interest systems would explain why so many people on the spectrum become successful in areas that require a specific understanding of logic and routine and the appreciation of this ability has informed many of the design goals for ReActivities© software.

Of equal significance has been the discovery that the inherent structured, controllable characteristics of computers can provide a safe environment for communication, expression and, therefore, play, for autistic individuals, where the demands and distractions of the real world are distanced, if not completely removed (Murray and Lesser 1997).

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)

Identifying that the computer itself could provide a structure for play, assisted in setting the stage for ReActivities© software.

Many researchers describe the importance of structure when designing play schemes (Libby, Powell, Messer and Jordan 1998; Sherratt 1999). Structure provides a framework, a reason to start, a sequence of events, which ultimately lead to reward. For this framework to be successful, there needs to be an appropriate level of focus, without multisensory stimulation and the necessity to process complex information.

As well as the digital setting for ReActivities©, additional structure is provided through a simple clock interface. This cyclic mechanism for choice provides rules and prompts a sequence of interactions towards a goal—spontaneous sensory play. The clock hand follows the user and rewards exploration with movement and sound, both of which actually represent the actions of a real clock. When the user clicks on a clock number they select a ReActivity©. This action provides familiarity, it can be easily learnt and copied, the clock sets an appropriate challenge, which is consequently rewarded and reinforced by the ReActivity©.

Having highly focused levels of interest means that a child may need more time to work out rules or understand what is expected of them, they will need to interpret the activity and find meaning in it. Achievement may vary depending to the ability of the child, so possibilities for failure should be avoided as spontaneous play may be inhibited by repeated failures (Stahmer 1999). The clock reliably behaves in the same way however many times a child interacts with it, this predictability eliminates failure and reinforces the routine required to access the ReActivities©.

Sherratt (1999) proposes that children on the autistic spectrum are more likely to engage in imaginative and creative play when it is meaningful for them. When a ReActivity© is selected the nature of interactivity becomes fluid and expressive, and the child immediately

Figure 1. Selecting a ReActivity© from the ‘Clock Interface’. © Cardiff School of Art and Design 2005.
sees the affect of interaction. This adds meaning and value to the experience and, in shared play settings, has the potential to be further enhanced through the interaction of others.

Children express delight as their repetitive actions reward with a range of visual phenomena, and although repetition is central to the fun aspect of ReActivities©, no two actions are identical, thus the subtleties and nuances of movement are mirrored via the computer screen.

The ability to manipulate abstract forms and notice minute changes will have particular resonance for autistic children who have a fascination for detail.

ReActivities© go beyond the simple cause and effect experiences offered by other software programs as all references to external metaphors and representational objects, which require an additional level of cognitive processing, are removed. Without the necessity to determine contexts a richer physical, immediate experience is possible.

This highly reactive form of interaction is intended to simulate the sensory characteristics of phenomena such as elasticity, velocity, gravity and inertia, with the added experience of creating pressure, which can affect proximity, direction and motion. The inspiration for ReActivities© came from the objects children love—spinning tops, ‘Slinkies’, stampers, lava lamps, glow balls and kaleidoscopes. ReActivities© also recreate some of the more ephemeral sensations, like popping bubbles, flicking paint and twanging elastic. In the real world these simple actions can be curiously satisfying, in the virtual world, when the object is removed, these actions become pure, harmless fun as users focus on the effect of their interaction rather than a complex sequence of steps required to perform a task.

Thus, exploration with the keyboard, mouse, microphone and touch screen rewards the user with a series of visual, aural and temporal dynamics. The removal of a specific, point-and-click type of interaction reduces demands on fine-motor skills; although some children may require the assistance of switches, joysticks, or other forms of adaptive technology, this does not inhibit enjoyment as the ReActivities© reflect the sensory qualities of individual engagement.

The creation and control of pattern, together with the inherent qualities of digital mark making, can deliver a harmonious visual experience. Users are relaxed in their interaction because their focus is not directed towards managing the function of numerous tools, a process that can often demand big conceptual leaps. Instead, they manipulate the digital environment much as they would with their favourite objects, which does not require as much thought, reflection and judgment.

At any time during the ReActivities© play session a child can choose to return to the clock interface, where further ReActivities© may be selected. Motivation to choose is a significant indicator of engagement and one that is regularly monitored in classroom settings. As the design phase evolves to accommodate more opportunities for user customisation a simple menu is in development, which will facilitate the selection of colours, shapes, sounds, speed and input device. By extending possibilities for creative experimentation, those children who have become confident and

Figure 2. Inertia ReActivity© © Cardiff School of Art and Design 2005.
The purpose of early integration with a small school group was to test the concept of reactive interaction. Examples of ‘expressive’ activities were shown on a laptop computer to teaching and support staff. Simple inspirational prototypes prompted feedback and suggestions flowed which strongly supported the notion that should the digital play experience be a positive one, many other possibilities for learning could be accessed.

Building on the notion of creating a calm, therapeutic environment, a concept prototype was designed for the children to play with at school. Activities in the prototype varied from a blank screen of colour that changed as the child moved the mouse, with simple sounds attached to each movement, to more complex keyboard activated screens that visually transformed and played a sound as keys were pressed. Visual tracking was exploited in a number of mouse-orientated activities. The cursor was the point of focus but in the form of a shape that had the capacity to morph, to visually change in response to user action, in some cases leaving a trail, outwardly evidencing inner engagement. Sounds were used extensively to provide feedback, for example the closer to the centre of the screen the louder the sound.

Teachers became excited by the responses of children when they tried the prototype in different settings and they began to provide ideas for possible themes as a way of integrating the software into the curriculum. Genuine collaboration at this stage proved vital for the project as teachers and support staff invented new contexts for using the technology in the classroom.

Most significant was the installation of ReActivities® on a smart interactive whiteboard, which differs from other boards as it has a touch-sensitive surface rather than a stylus-only surface. From feedback and video footage of children using the ReActivities® it appeared that there are significant benefits from moving computation, including the ReActivities® software, into a large-scale familiar with the ReActivities® routines will have the opportunity to define and customise their unique individual experience.

4 ReActivities® design research methods

ReActivities® software is one of the proposed outcomes from the Reactive Colours® research project.

The Reactive Colours® research method is a slow evolutionary process of proposition, use, evaluation and modification, which is sensitive to the responses of those most likely to use, or support the use of any potential outcomes.

These methods have centred on collaboration with children and adults on the autistic spectrum as well as with their families, teachers and support staff. During the feasibility phase of the project, advice from Information Communication Technology experts and interviews with school staff from the special educational needs sector resulted in establishing a working relationship with a school with a high proportion of children diagnosed as having Autistic Spectrum Differences (ASD). The teacher with key responsibilities for ASD children and outreach support has subsequently become a central figure in the development team.

The iterative process for the concept design, development and early implementation of the Reactive Colours® project has been based on the four stage cycle:

• research,
• inspire,
• listen,
• develop.

This cycle is being employed to maximise user participation in the earliest stages of the project and to build in opportunities to understand how users experience using software in their own environments. It has been essential to embrace this process before specific design features are decided.
The possibilities for personal expression, creativity and interaction are greatly expanded as many of the barriers to bodily expression, enforced through the necessity to manage control in a confined space, are removed. This expressivity, when enabled in a structured, supportive setting, proved fascinating for the children and there has been evidence of increased concentration and joint attention as children are able to use their own fingers and bodies to choreograph a visual and auditory response.

In addition, Apple iBooks were introduced for children to try ReActivities© in small-scale environments. The portable computer enabled children to find a quiet, comfortable space to play, which prompted suggestions that ReActivities© could be fun on even smaller-scale personal devices such as personal desktop assistants (PDAs), iPods, mobile phones and Game Boys.

In recent months, as the interest in the project has spread and with the assistance of funding from NESTA, collaboration has been extended to include small, expert development panels made up of representatives from key areas related to the project objectives—computers, play and ICT, online communities and adaptive technologies. The expertise provided by these groups has proved invaluable. As well as ensuring that the status of the project is regularly reviewed, the experience of the panels has enabled the project to gain sponsorship, reach audiences beyond its immediate domains and to consider expansion beyond the original aims.

As participation in the development of the software is becoming more widespread, and with a view to attracting further funding, a more robust evaluation phase is proposed, enabling both formal and informal data gathering. Strategies are being considered, with experts from the Birmingham University Web Autism course, to meet the ‘Sure Start - Birth To Three Matters Framework’ (DfES 2001) together with the ‘Curriculum Guidance for the Foundation Stage’ (DfES/QCA 2000) (http://www.standards.dfes.gov.uk/primary/publications/foundation_stage/940463/).

The Framework recognises that all children have to develop learning through interaction with people and the exploration of the world around them. There is also acknowledgment that for some children this development may be inhibited because of difficulties with communication and interaction, cognition and learning, behavioural, emotional and social development of sensory and physical development.

Utilising this Framework enables evaluation to be considered within a child’s individual education profile (IEP). In many cases baseline assessments, which pertain to joint attention, will already exist within the IEP.

4.1 Evaluating the ReActivities© software

To fully authenticate research, data gathering methods have to be flexible and varied. Children on the autistic spectrum between the ages of four to seven years in full-time attendance at two schools for special education needs will be the subjects of the evaluation. Teacher observation, video analysis, structured and semi-structured interviews and case studies in

Figure 3. Playing with ReActivities© on the smart interactive whiteboard. © Cardiff School of Art and Design 2005.
outreach settings, are proposed. Data will be rigorously analysed and objective comparisons made in order to assess levels of concentration, attending, waiting, turn-taking and sharing, all of which are considered important in the analysis of joint attention. In addition, teachers in every class evaluating the software will be asked to complete a short questionnaire with scalar choices, which will include the current view of the frequency of joint attention between class members, and between class members and teacher. The same scalar questions will be asked about classroom time in general and about ReActivities© classroom time. In some cases questionnaires may be distributed to parents.

The Reactive Colours© website will continue to gather informal feedback through the forum and ‘blog’ from the many participants in the United Kingdom and abroad.

5 Online communities and multi-user environments

As the collaborative design community extends from small school groups and development panels to a much larger number of participants communicating primarily through the Reactive Colours© website, opportunities are emerging to experience the ReActivities© via online, multi-user environments.

The provision of an open-source community network will enable the players, that is children on the autism spectrum, and those engaged with them, to extend their participation in the design and distribution process. Access to the ReActivities© source code has the potential to extend use to highly skilled autistic individuals, many of whom may already be forming careers as programmers and developers. It is proposed that a Reactive Colours© online gallery will host selected ReActivities© designed by users.

This model is mutual, inclusive, and participatory and promotes the concept of “innovation commons” Lessig (2001). This represents a significantly extended meaning of the phrase ‘open source’ in order to encourage collaboration rather than to delineate a licensing scheme, such as the General Public License.

Reactive Colours© will ultimately bring together the knowledge of the community to evolve a process that is socially and economically beneficial, a process which is efficient at all levels of production, which nurtures creativity and reflects diverse human experiences, insights and needs.

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Designing for Playfulness: Investigating the Therapeutic Potential of Technology Interfaces for Children on the Autism Spectrum - Wendy Keay-Bright

Paper II
The Reactive Colours Project: Demonstrating Participatory and Collaborative Design Methods for the Creation of Software for Autistic Children

Wendy E. Keay-Bright
The Reactive Colours Project: Demonstrating Participatory and Collaborative Design Methods for the Creation of Software for Autistic Children

Wendy E. Keay-Bright, University of Wales Institute, Wales, UK

Abstract: This paper demonstrates the importance of participation with end-users and interdisciplinary collaboration with experts, to the design process. The context for this study is interaction between autistic children and computers in education. Whereas computers in education are conventionally associated with task-based learning, my research uses the computer as a tangible interface for embodied play activities. I make two claims with regard to the participatory design process. (1) There is, I argue, an important relationship between the participatory design process and the design of play for autistic children. End-user participation in this context allows the highly particular responses and reactions of autistic children to be recorded and included in the evolutionary design process. (2) The interdisciplinary approach to collaboration presents a challenging paradox for designers, as it requires both imaginative and empirical design methods. Whilst it is often critical to have statistic analysis to satisfy scientific approaches, it is of equal importance, within this area of research, to understand the idiosyncratic behavioural patterns of individuals on a spectrum of autistic difference. In this paper, (a) set out my work on the computer as a tangible interface for embodied play, (b) demonstrate, through examples of the Reactive Colours research methods, how autistic children claim the embodied play environment as their own, and (c) describe how this appropriation by the children and interdisciplinary collaboration is incorporated into the design process. I also indicate the benefits which the tangible interface has for enhancing the learning capacities of autistic children.

Keywords: Participatory Design, Interdisciplinary Collaboration, Tangible Interfaces, Play, Autistic Spectrum

Introduction

This paper will focus on the successful collaboration between young children on the autistic spectrum at a Special Education Needs (SEN) School in Wales, UK, together with their teachers, families and experts in a variety of related interdisciplinary fields, which has resulted in the ReacTickles software and the creation of the www.reactivecolours.org project website.

The research aims of the project have been to promote relaxation, encourage spontaneous play, and support learning for children on the autistic spectrum. By using the inherent flexibility and controllability of digital media to enable individualised sensory experiences, the project team realised that computers, when enabled as an embodied play experience, had the potential, beyond that of function, to support the inclusion of the most severely anxious autistic individuals.

A key issue in achieving this aim was to define a methodology that placed the target population at the centre of all design and development.

The participatory design methods used for the project represent a synthesis of methodologies undertaken by other researchers, most notably Druin (1999), whose work focuses on the co-operation of children in the design of technology and Dishman (in Laurel, 2003) who has undertaken projects which involve the ageing population as participants in the design process.

The Reactive Colours project has extended these methods by inviting autistic children and their teachers to contribute to the design of the software during critical stages of development.

Although the methods were time consuming, partly because the problems are so complex but also the need to become accepted by the participants, they ensured that any proposed solutions were designed from the point of view of the autistic child rather than the technology.

Background

This section presents an overview of the core principles of participatory design and how these approaches have influenced the Reactive Colours project.

Participatory Research

Participatory design requires that people, whose lives stand to be affected in some way by the outcomes of the research, are given the opportunity to identify themselves within the objectives of the research. There is no exclusive group in a position to determine the interests of others; the process is democratic and visible to all (Friere, 1974). Conventional methods...
which emphasise statistical data gathering do not put research in the context of a creative activity and are unlikely to result in something new and useful which does not already exist. Empirical methods rarely include the spontaneous and voluntary involvement of the target population and the possibilities that may emerge from allowing for the unpredictable are frequently missed. The way in which autistic children interact cannot be presented systematically; therefore gaining understanding through their actions, for example, body activities, expression, and language was paramount to the research.

This presented a significant challenge, many autistic children do not use verbal language to communicate and find the minutest change in their routines extremely painful; however becoming accepted by this group was crucial and so the methods had to be very carefully adapted. Direct knowledge elicitation techniques were avoided as they could create stress and anxiety.

Although other research projects involving participation and collaboration with autistic end users exist (Parsons et al., 2000) linguistically less able children (and adults) are rarely represented and those with the severest social and communicative dysfunctions tend to be disenfranchised by power shifting to the more socially able autistic people. There has been resistance by some researchers to include less able children in participatory research, lack of social competence being used as the delineating factor for exclusion. However, this question of competency arises from the perspectives of requirements and task and is not a component of the Reactive Colours experiential research, as competence for these children is different from, not less than, their more developmentally able peers.

An influential researcher in the design of software for children, Druin’s research presents a number of strategies for including children in the design process. The roles children may play include user and tester; in this capacity they are generally required to test prototypes, which are observed in later stages of development to assess usability and engagement. This process has limitations, as it does not recognise that children are inventive, imaginative human beings capable of interacting with technology in ways that are unpredictable. There are, however, benefits from involving children as testers, the process can be managed efficiently, with minimal interruption to school schedules, and where a strong relationship with teachers is fostered, designers may have an opportunity to further test as the work evolves.

The Reactive Colours methodology proposed that autistic children should become key informants (Druin, 1999) in the design process. This meant that whilst adults were ultimately responsible for decision-making, contributions made by children throughout, had significant impact on the both the process and outcomes of the research. Druin’s work proposes that with the appropriate amount of guidance, children may have an equal stake in decision-making as a design partner. Some of these methods, which include brainstorming, sketching, interviews and other ‘low-tech’ development activities, would have been unrealistic for the target population of autistic children aged 4-7, their difficulties in social situations being so profound. However these methods were successfully undertaken with teachers and support staff during the earliest stages of the research.

The visibility of the design process was reported to be highly educative and valued and served to lift self-esteem and confidence in children, parents and staff. Of equal significance is the boost in motivation for the design team who were met with enormous warmth and delight when they worked directly with participants, as each iterative phase of development had so evidently produced something new, which reflected the contribution of the children.

The participatory methods described in this paper are not presented as an alternative to traditional methods, but to question whether new methods can evolve from these parameters to close the gap between the empirical nature of the researcher and the ‘researched’.

**ICT and Tangible Technologies**

Within this paper our concern with technology is in the context of:

- Information Communication Technology (ICT), specifically, the role of computers for young children.
- The benefits of computers for autistic children.
- How the ReaTickles software can offer a tangible, playful approach to learning that is developmentally appropriate for autistic children.

**The Role of Computers for Young Children**

The issue of technology use with young children is hotly debated, on one side there is a view that computers can exhaust cognitive resources and are thus detrimental to health and learning (Healy, 1998), whilst advocates such as Plowman and Stephen (2003) have conducted many studies which promote technology for young learners where the interaction is guided and involves the sensitive sharing of experience with others. Papert (1996), and Pesce (2000), have identified that computers can represent a medium for social and intellectual development, particularly when playful exploration underpins task. This argument is directly opposed in the work of Levin and Rosequest (2001), who suggest that individualised and open-ended opportunities for play are inhib-
ated by the limited and repetitive operational actions
of the technological experience.

Much of this debate is 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. However, the emergence of new
types of computer technology has encouraged multi-
modal forms of interaction, which are closer to the
physical play experiences that dominate the develop-
ment of early play. Opportunities for imaginative,
sensory and manipulative play which evolve from
the exploration of objects though their physical attrib-
utes can be encountered in these tangible technolo-
gies (O’Malley C & Stanton Fraser D. 2005).

Interactive whiteboards, particularly the touch
sensitive boards manufactured by Smart Technolo-
gies™, are an example of this type of technological
advance, which is becoming widespread throughout
schools in the UK. Whilst tangible computing breaks
with the notion that the role of computers is to handle
textual information and allows for the direct manip-
ulation and feel of a system through experience,
much of the software used with interactive white-
boards fails to maximise on the sensory learning
potential enabled by the ability to perceive and ma-
nipulate information through one sense; point and
click, drill-style exercises dominate the market. In
this context, the interactive whiteboard has simply
become a digital blackboard.

When teachers first experimented with the Re-
cTickles software the levels of playful engagement
and motivation noted were startling and prompted
the widespread use of the software on Smart™ inter-
active whiteboards even though the earliest ideas
were to develop software for desktop computers.

Computers and the Autistic Child

For the purpose of this research it has been necessary
to consider these discussions in the context of the
particular target group – young autistic children aged
four to seven years in SEN schools. Preliminary re-
search conducted by the Reactive Colours researcher
using interviews and questionnaires revealed that
some children had used computers at home prior to
beginning full-time education but most would be
experiencing a range of educational technologies for
the first time at school. Of the parents whose children
were already using computers some expressed con-
cern that whilst using the computer their child be-
came intensely focused and would not participate in
other activities.

One of the prerequisites of a positive learning en-
vironment is the sharing of activities, particularly
waiting, turn-taking, mirroring and co-operation and
the ability to recognise the intentions of others
(Jordan, 1990). For most autistic children these types
of joint experiences are difficult, as they require an
awareness of situations that are often outside their
very tightly focused range of sensory and cognitive
interests.

This narrow range of interests, otherwise known
as ‘monotropism’, is one of the diagnostic criterions
for autism, so the facility to make areas of interest
shareable can assist in both communicative function-
ing and creative self-expression (Murray, Lesser and
Lawson, 2005).

Research has evidenced that, for children on the
autistic spectrum computers offer a predictable,
controllable and highly perfectable medium where
many of the multi-sensory inputs of the real world
can be reduced (Murray and Lesser, 1997; Parsons,
2000). In particular they have been shown to assist
communication by providing a routine for turn-taking
and waiting which in the course of face-to-face inter-
actions would be governed by understanding the in-
tentions of others through language and gesture. For
autistic children this represents a significant benefit,
as the many layers of interpretation required in face-
to-face communication may cause confusion and
anxiety. For most children the computer can provide
a safe exploratory space for creativity and imagina-
tion where they will find their own interesting and
novel way for interacting, without fear of failure
(Dix, 2003). For the autistic child, this universal ap-
pel of computers can assist in the inclusion of the
most anxious of individuals.

Rationale for the ReacTickles Software

This creation of a neutral ‘space’ via the computer
screen or interactive whiteboard has provided a
foundation for the evolution of the ReacTickles play
experience.

Structure and routine are important to foster cre-
ativity and imagination in play (Vygotsky 1978;
Piaget, 1962, 1945) and are particularly essential for
autistic children (Sherrat, 2002, 1999). This presented
an interesting dilemma for the designers whose early
concept ideas had been based on the notion of free-
dom and autonomy in interaction. However many
unstructured ideas were dismissed as they caused
confusion and children did not feel motivated to ex-
lore.

With this in mind, the rationale for the Re-
cTickles software has been to encourage tapping,
smoothing, and circling, using the keyboard or
mouse, and to use these modes of interaction to en-
courage the child to explore the technology rather
than be dominated by it. The designers were inspired
by the discovery, through observation and interviews,
that the objects children found most playful were
spinning tops, Slinkies™, lava lamps, glow balls and kaleidoscopes, all of which offer repetition and reward through touch.

Recreating playfulfulness involved the deconstruction and analysis of the ‘real’ experience to determine which elements foster the enjoyable sensation of repetition, pattern and similarity, but rather than this being a visual reconstruction of a physical toy, the design focused on the sensory qualities of interaction.

Key interactions such as pointing, choosing, clicking, dragging, pressing keys and vocalising are associated with performing a function with computers. In the design of ReacTickles these are elements of embedded action that do not require mastery, instead they are used to prompt a sense of curiosity which can lead to motivation, attention, and intentionality.

An influence on the rationale for the design of the ReacTickles software has been the understanding that repetition, continuity, sound, smell or touch (Winnicott, 1982), are all characteristics of play which are non-goal orientated, these actions form the foundations of early child development and are often linked to a favourite object. Children on the autistic spectrum characteristically enjoy engaging in repetitive actions because of the opportunities this gives them to predict and potentially control their environment (Jordan, 2003).

This theory has been key to ensuring that the ReacTickles software can support children as they face the challenge of changing social and technological environments in their early school years.

**Participatory Design Methods**

The Reactive Colours model has a four stage cycle iterative cycle:

- Research
- Inspire
- Listen
- Develop

The project has four main stages and the Research-Inspire-Listen-Develop model has been applied at each stage. 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 a successful proposal for funding from the National Endowment for Science and Technology Awards (NESTA) which supported the addition of two designers into the team. The design phase that followed funding centred 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 technological landscape. 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 website. This paper will focus on the significant contribution provided by collaborative partners and the subsequent analysis of experience.

**How Autistic Children Influenced the Project**

A critical research phase was undertaken before approaching collaborative partners in order to develop an informed understanding of the theoretical issues. Impairments in social communication, (Baron-Cohen, 1989; Frith, 1989; Wing, 1975) are considered to be the most significant behavioural characteristics evidenced in individuals on the autistic spectrum. There are many complex theories which provide explanations for this apparent lack of social functioning which may vary widely from severe to mild, however the issues are puzzling and for the purpose of this paper I summarise the ‘monotropism’ theory, (Lawson, Lesser, Murray, 2005), which has been most helpful in determining the context for the design of the Reactive Colours project.

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’ (Lawson, Lesser, Murray, 2005). Intensity of focus can result in an apparent lack of interest in other people and may explain why autistic children may have difficulties with imaginary and social play, which require openness and flexibility of thought rather than a tightly focussed interest in the functional use of an object. In addition, autistic children characteristically have problems with the expression and interpretation of verbal and gestural language, which can lead to unwillingness to share experiences.

**The Significance of Play**

Play can be categorized in developmental terms under three broad headings (Piaget, 1971): firstly, functional or sensorimotor play requires the manipulation of objects; it is their visual and physical prop-
erties, which arouse interest. Secondly, in representational play the child begins to invent imaginary sequences and actions with the object of interest that correspond closely to real-life experiences. Thirdly, the child will direct interest to more symbolic forms of play and will create new meanings for the object and imagine a purpose other than one that directly relates to its function, for example, using a banana as telephone. For many autistic children the development of a capacity for using symbolic functions and the onset of representational play are severely delayed, instead they tend to prefer the functional approach; sensory-motor play of this kind, for example, banging, spinning and oral exploration, such as biting, is often repetitive and persistent and is notably non goal orientated and unusual (Leslie, 1987).

**Determining the Context**

The staff and children at one particular special school with an ASD support unit have participated throughout the design of the software and although other schools have since become involved, it has been the dedication and commitment of this core group that as made the most significant contribution to development of the project. Visits to classes, brief introductions to children and an audit of current educational technology followed before sketchbook ideas were shared and discussions on a potential design partnership were proposed. During this stage, the researcher gained valuable insight into teaching routines and the specific difficulties experienced by autistic children; teachers also enjoyed the opportunity to have input into the project.

What became clear from this early research was that the use of computers in schools tends to be limited to task-based activities that prompt functional interaction guided by specific educational objectives. Many software programmes adopt a heavily directed approach with explicit rules and highly organised structures, which are designed to specifically minimize the stress of uncertainty. However, the tasks tend to be inflexible, require minimal genuine interaction with others and therefore afford little creative and imaginative potential. This heavily guided structure may result in a child learning the rules rather than engaging in the joyful interaction that can occur when opportunities for discovery, surprise and curiosity are made available (Sherrat, 2002).

**Designing with Children and Teachers**

Simple storyboards, with no technical references other than anticipated mouse or keyboard activity, were prepared in drawing books, to quickly capture and represent ideas. The aim was to inspire teachers by showing mock-ups to help them envision possibilities beyond the confines of traditional interfaces. Prototype 'expressive' activities were developed and shown on a laptop computer to teaching and support staff, which prompted further feedback and suggestions.

Activities in the prototype varied from a blank screen of colour that changed in response to mouse action, to more complex keyboard activated screens that visually transformed and played a sound as keys were pressed. Visual tracking was exploited in a number of mouse-orientated activities. The cursor was the point of focus in the form of a shape that had the capacity to change in response to user action, in some cases leaving a trail, outwardly evidencing inner engagement. Sound effects and music were to provide feedback, for example the closer to the centre of the screen the louder the sound.

The systematic exploration observed in children interacting with the software suggested that whilst the actions were repetitive, a pattern of primary, secondary and tertiary circular actions was beginning to emerge, which matched those suggested in Piaget’s stages of sensorimotor play. Initially children would simply repeat their actions for their own intrinsic reinforcement value; however, as they became aware that their actions had some impact on the digital environment, they more purposefully pursued a response, having gained this they repeated their actions, with the obvious intention of achieving a self imposed goal.

As a result of these observations and with the encouragement of teachers, the designs for ReacTickles which followed incorporated a more sophisticated form of reactive cause and effect, designed to provide not only the reassurance of repetition (Winnicott, 1982), but also the opportunities to move from innate behaviours to more coordinated, confident and powerful responses.

Teachers and experts noted during their analysis of video footage, that some children were imitating the actions of others, particularly at the interactive whiteboard. Piaget’s reasoning that if behaviour is observed during a particular activity and mirrored after some time has passed then some symbolic encoding has occurred, reinforced the suggestion that while playing with ReacTickles, children were actually engaging in forms of symbolic play that are not evident in other more regimented digital environments.

**Implementation**

During the early design stages the team concentrated their efforts on creating as many variations of the reactive activities as possible, each variation incorporating the ideas of teachers and video analysis of children. The rapid ‘suck it and see’ approach en-
abled mistakes to be identified and designs to be quickly reconsidered. An evaluation of the ReacTickles software was undertaken using questionnaires and video footage. Children were given CDs of the software to take home and parents were invited to contribute with comments and suggestions. The purpose of this was to provide further insight and inspiration rather than a quantifiable method of surveying and data gathering. Design decisions were made on the basis of these observational techniques, and the structure and interface for ReacTickles began to take shape. What became evident from video analysis at this stage was that children, given the appropriate prompts from their teacher, were able to demonstrate certain characteristics associated with symbolic play. This was most significant whilst playing at the Smart™ Interactive Whiteboard, it was clear that children were attributing 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.

Expansion

With participation in the project widening to a number of schools, the design team extended the research methods to invite contributions and feedback on the www.reactivocolours.org website. Building from the methods and findings described above, the team proposed to extrapolate from some of the experience of open source software development, particularly its use of collaborative networks to iterate and improve software (Raymond E.S.1998). As with Lessig’s (2003) “innovation commons” and initiatives such as wikipedia (Stadler 2002) and Think-Cycle (Ridgway, L. 2002) the purpose of the online research has been to ensure an innovative, inclusive development model.

The informal and anecdotal comments shared through the web have introduced a level of participation that would be missed had the project solely relied on formal methods. Parents who witnessed positive reactions to the software from their children at home were able to express themselves instinctively, without the pressure or bias that can occur in formal settings.

The ReacTickles software is freely available on the site, thus the philosophy of, “release early and often and listen to your customers” (Raymond, 1998), which is fundamental to the open source movement, benefits the project by reaching audiences in their own private settings. For the young children who are extending their experience of using the software at school into the home, the web site presents an opportunity to enrich the learning experience by enabling families to share activities that have been motivating for the child at school.

Summative Evaluation of the ReacTickles Software

As the designs develop, a more rigorous quantitative method of evaluation is taking place, using questionnaires with scalar choice responses. The primary goal of this evaluation has been to assess whether the task-free mode of interaction can provide a meaningful, engaging, exploratory environment for play, and whether increased confidence and self-esteem, can assist children in acting purposefully with others. Teachers discussed with the researcher aspects of the children’s experience that would be most appropriate to measure. Advice was also sought on standardised assessment procedures, however, whilst staff were familiar with these tools it was considered that none of them really worked for ReacTickles, as the purpose is to discover a child’s potential rather than gather typical data.

Therefore it was suggested that in order to determine whether or not the experience was meaningful, waiting and attending, would be useful to measure. In order to evaluate engagement and relaxation, concentration was measured, and in order to evaluate capacity for independent exploration and flexibility of thought, pointing and choosing were measured. Finally, the ability to act purposefully was considered by measuring mirroring and sharing.

The initial results of the formal data gathering process, using questionnaires with scalar choices, presented an interesting dilemma as a very clear pattern has emerged.

In a structured setting, with children using ReacTickles on the Smart™ Interactive Whiteboard, a group of six participants, aged five years, with severely delayed developmental ages (approximately one - two years) children evidenced good concentration skills and most were able to point and choose independently following prompts. Results evidenced that levels of attending and concentration were dramatically higher in these children for whom motivation and engagement in classroom settings is generally poor. However, waiting and turn-taking was
Two of the children became upset at having to wait their turn. When the same group were introduced to ReacTickles a week later some improvement was noted, and the teacher concerned has specifically requested that her study continues over more sustained periods. In free play sessions, where children selected ReacTickles as their choice of activity, the findings were similar as children showed excellent levels of concentration, with no need for additional prompts, but showed no desire to share. In a structured setting with six children aged five, who were developmentally more able and had already gained skills in waiting and turn-taking, the children were able to practice their skills independently and shared the experience enjoyably with others.

Teachers suggested that if the ReacTickles software were available to them as part of a structured learning session, where key elements of the curriculum could be addressed, it could be a highly rewarding, motivating resource.

As the evaluation continues, longitudinal data across more varied computer environments will be gathered, and will therefore be reported elsewhere.

In addition to user evaluation the ReacTickles software has undergone expert evaluation with ten other schools, the teachers participating have been enthusiastic and have provided the incentive to expand the project in the direction of developing a specific educational resource.

**Conclusion**

The methodology used during the creation of the ReacTickles project has highlighted the significant benefits of enrolling a dedicated and committed group around a model of research, inspire, listen and build. Children, teaching staff and experts in ICT, special needs education, adaptive and assistive technologies, psychology, media and graphic design have been extensively consulted during each phase of the project, even taking an active role in designing and producing documentation. Suggestions from teachers have been based on their thorough understanding of the children as individuals as well as their experience in educational practices and curriculum targets. However, they have not been constrained by the levels of attainment that dominate current thinking, and have been excited by watching children perform beyond expectation as they discover the delights of tangible technologies when the demands of pre-determined, point and click activities are removed.

As the project reaches the conclusion of its funded research phase, the possibilities for expansion have been clearly identified, most importantly, the future of the ReacTickles software will continue to meet the demands of potential audiences by pursuing democratic and flexible strategies for participatory design.

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About the Author

Wendy E. Keay-Bright

A graduate of Graphic Design and Animation, I began my career on the popular children's TV series, SuperTed, before becoming a freelance animation producer researching and producing animation content for BBC One, HTV West and S4C. It was during this period that I began working with children as co-designers; the productions for which I was responsible pioneered the notion of children as creators of original programme content. A fascination for technology as an experiential medium has provided the motivation to undertake research at a high academic level, alongside teaching responsibilities. All my research has involved users directly, as well indirectly through web technologies. Reactive Colours© and ReacTckles© represent my most recent research activity which has been awarded funding from the NESTA Learning Programme. My responsibilities include research, project management and design. I have presented and published my work internationally, most recently I taught multimedia design at Sichuan Fine Art Institute and presented my research at Xi’an People’s Hospital in China. I am a member of the Higher Education Academy.
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Paper III
People on the autistic spectrum are characterised as having difficulties with social and communicative functioning. They are understood to have unusual sensory experiences, in any modality, which means that their perception of the world is alarmingly different from non-autistic people. These experiences create confusion and anxiety, and for many autistic individuals their lives are dominated by fear.

A body of research exists, however, to suggest that computers present an ideal medium for reducing the confusing, multi-sensory distractions of the real world and that given the right approach, there is a strong possibility that some aspects of computation could prove relaxing and therapeutic.

This paper will document the participatory design and development methods of the ReacTickles© software, which, by encouraging exploration and experimentation from a simple, structured interface, aims to promote relaxation, encourage spontaneous play, and support learning for children on the autistic spectrum.

The paper will reveal how the entire design process from concept development through to the varied and flexible evaluation strategies, has been informed by the distinct needs and characteristics of the target population.

**Keywords:** Autistic Spectrum Differences (ASDs); Participatory design; Collaboration; Development panels; Sensory software; Open-source; Play

1. **Introduction**

ReacTickles© use an expressive form of computation with a range of digital technologies to promote relaxation, encourage spontaneous play, and support learning for children on the autistic spectrum.

*Corresponding author. Email: wkbright@uwic.ac.uk*
The design features aim to recreate the sensations of gravity, temperature, change, space and enclosure, to foster a harmonious and therapeutic approach to interaction. Using the inherent flexibility and controllability of digital media, the research proposes to enable individualised sensory experiences to support the inclusion of the most severely anxious individuals. It is the playful, feel-good nature of the project, and its lack of any potential for error, that defines the experience. There is no Right or Wrong, just intrinsically rewarding exploration.

The motivation for this research grew from trying to find methods for teaching complex computer programmes to design degree students who had a fear of technology and any form of programming that wasn’t a one-step, drag-and-drop action. Finding playful activities to ease this anxiety that could be managed by the most novice student provided the incentive to investigate the development of play, particularly the kind of play activities that adults find enjoyable on a purely sensory level, and to introduce these experiences into the teaching of software programmes. In order to re-discover playfulness, without the inhibitions of adulthood, it was decided to study young children in a natural environment for imaginative play. It was whilst observing the play routines of pre-school children in a reception class and talking to teachers that the research found a purpose that would never have been discovered had this remained an academic exercise. Consequently, a relationship began with a group of young autistic children in a Special Educational Needs (SEN) school, which was to provide the foundations for the project.

In a move towards an ethnographic, theoretically informed critical design research practice, formal and exploratory strategies have evolved to enlist collaboration from experts in a variety of fields. The paradox for this interdisciplinary process has been the need to be both imaginative and empirical. Whilst quantitative surveys have been traditionally considered by researchers to be trustworthy sources of information about ‘users’, the autistic spectrum represents such a wide variety of human beings that a ‘typical’ user simply does not exist. The underlying needs of individuals are not clearly evident at the outset and are unlikely to be understood from theoretical and statistical perspectives alone. Emotional and practical considerations that reflect the diversity of the spectrum are difficult to generalise and pose extraordinary challenges to the designer. Therefore it has been necessary to develop many discovery-led, qualitative methods in order to consider experiences and explore possibilities, which place the autistic child at the heart of the development, both in real, face-to-face settings and through social media on the Reactive Colours website in an attempt to ensure that participation and collaboration are prioritised at each stage.

The Reactive Colours website (reactivecolours.org) deepens collaboration through the rapid iteration of ReacTickles© software prototypes, a ‘suck it and see’ process which can quickly adapt to feedback and where those experimenting with the software see the value of their participation as it evolves. It gives individuals a chance to show often-unexpected capacities and make a good impression on other people. This positive effect on other people is a highly significant part of the process.

In addition to using the internet as a collaborative research model, it is proposed to ensure that both the site and the software are fully open-source (Coffin 2006, Stadler and Hirsh 2002) to enable users to freely adapt and modify it to suit their unique sensory interests.
2. The theoretical framework

2.1 Autism and play

Autism is a pervasive developmental condition that typically appears during the first three years of a child’s life. It affects areas of the brain that control language, social interaction and abstract thought (Baron-Cohen 1998, Wing 1975). Although the term ‘autism’ is used generally within this paper, ‘autistic spectrum differences’ (ASD) (Lawson 2006) provides a closer definition of the variety of autism conditions.

At the more obviously able end of spectrum the intellectual ability of the individual is often greater than average, due to highly focused interest systems; at the less obviously able end of the spectrum, individuals may lack speech and display severe developmental and processing disabilities. In between lies a variety of autistic behavioural symptoms with degrees of learning disability. Most people with ASD, however, will experience difficulty in three areas, known as the ‘triad of impairments’, social interaction, social communication and imagination (National Autistic Society).

ASD is not a handicap which prevents physical interaction in social situations; autistic people experience a fragmented or unusual perception of their surroundings which impacts on their ability to process new information in a coherent manner (Frith 1989, Murray 1997, Murray et al. 2005). This makes for an alarming world, where anxiety dominates; the order and meaning of events and experiences are frequently misunderstood, causing confusion and stress. From what has been learnt from the testimonies of autistic people, they do not want to be isolated from the world of normal people, they are aware of their differences, and often memorise and learn social behaviours; however, they will generally withdraw from situations that are unpredictable and confusing (Lawson 2001).

For young autistic children one of the areas of development most significantly affected by the lack of understanding of the intentions and motivation of others is in play (Jordan, 2003). It is believed that play is the source for human imagination, and therefore of language and reasoning, and that learning occurs through co-experience (Bruner 1972, Dix 2003, Piaget 1962). Play is fundamental to everything we do, and from a very young age is exhibited through children’s mimicry of the social activities they see around them. Interaction, mirroring and the emotional interchange between parent and child, condition a child’s experiences throughout early years; however, for many children with ASD the poor ability to imitate and respond to the actions of others can result in limited or unusual play activities. In typically developing young children play routines evolve from explorative and manipulative play to imaginative social responses, forming the foundations of social interaction and communication, which directly assist in successfully experiencing and understanding the world (Vygotsky 1978).

Most autistic children do not demonstrate this range of play behaviours, preferring instead the physical approach: playing with an object of interest on a sensory and perceptual rather than conceptual level (Beyer and Gammeltoft 2000). Sensory-motor play of this kind, for example, banging, spinning and oral exploration, such as biting, is often repetitive and persistent and is notably non-goal-orientated (Jordan and Libby 1997, Leslie 1987). However, whilst there is a body of research to suggest that there is a significant deficit in spontaneous symbolic play in children with autism (Sherratt and Peter 2002), some researchers have identified that the ability to engage in meaningful functional play may depend on the child’s individual circumstances, particularly their family and learning environment. Given that play skills have a central role in
development and that these skills are underdeveloped in individuals with autism, integrating play activities into daily routines could offer significant opportunities for encouraging social interaction, communication and imaginative thinking.

2.2 Autism and computers

A computer-based environment presents an ideal medium for reducing the confusing, multi-sensory distractions of the real world, which, in many cases, are anxiety-inducing and may create barriers to social communication. Of equal significance is the role that computers play in enabling shared areas of interest, either in the same physical environment or at a distance. A narrow range of interests, otherwise known as ‘monotropism’, is one of the diagnostic criterions for autism, so the facility to make areas of interest shareable can assist in both communicative functioning and creative self-expression (Murray et al. 2005).

Of the many studies conducted to consider the effectiveness of computers in assisting the learning experience for individuals on the autism spectrum (Jordan and Libby 1997, Murray 1997), it has been the work of Murray and Lesser that has provided a practical definition of why the controllable, predictable characteristics of computers specifically suit the needs of autistic people, particularly in the way that they support non-verbal communication.

The research of Murray and Lesser considers the ubiquity of the computer and how creativity and friendship can be enhanced through the use of computer technology where the demands and distractions of the real world are distanced, if not completely removed. They have observed an increase in communication, sociability, creativity, and playfulness, even among people who do not speak and are regarded as ‘low functioning’. This contrasts with the accepted view that autistic people have limited imagination and little desire to communicate with others (Murray and Lesser 1997).

3. The Reactive Colours project

3.1 Participatory design methods at the beginning—developing a concept

The research project is called Reactive Colours, which grew from early participation which teachers who identified colour as a useful theme for classroom activities, thus Reactive Colours embodies a participatory process. Participatory design requires direct involvement from the target population, so that all stages of the project are informed from their unique perspective (Druin 1999). In the case of Reactive Colours, although the participatory methods were time-consuming, partly because the problems are so complex but also because of the need to become accepted by the key informants, they ensured that any proposed solutions were designed from the point of view of the autistic child rather than the technology.

3.2 Feasibility

The feasibility phase of the project involved interviews with teachers in one special school and one mainstream school with a special needs unit. The purpose of this phase was to identify the context in which play with computers could be integrated into classroom settings and to explore the breadth of software currently recommended for school use.
Computers and computer-assisted technologies are used widely to support a range of cross-curricular activities in all schools with a provision for SEN. The use of Information Communication Technology (ICT) in classroom settings is guided by the notion of the computer as a functional tool that purposefully moves a child beyond their range of abilities by providing a task; computers are seen as having explicitly educational rather than play value and teachers are under pressure to evaluate the learning experience against pre-determined guidelines which are designed to measure skill and do not promote ‘feeling good about oneself’ as a measurable objective for attainment. National Curriculum Guidelines and Performance Descriptors for ICT are widely used in all schools providing Special Education in the UK, and so it was suggested that Reactive Colours would fit well within these benchmarks for achievement. The researchers are indebted to a number of open-minded teachers who saw the possibilities in the software for gaining ICT skills through a relaxing, stress-free environment in which skills are embedded comfortably and unobtrusively, thus the earliest context in which the software was used simply enabled teachers to assess competence with the computer.

3.3 Inspiration

The staff and children at one particular special school with an ASD support unit have participated throughout the design of the software and although other schools have since become involved, it has been the dedication and commitment of this core group that as made the most significant contribution to development of the project; engaging beneficiaries in the research early on so that they informed conceptualisation and design prior to implementation proved invaluable. Routine visits to the school, questionnaires to parents and teachers enabled the designers to become immersed in the culture of the child and led to understanding how computers can be effective in fostering mutual respect and empathy, simply by providing a precise focus, where interests can be shared. This is not simply a method to involve users in the testing of how usable software is, rather it is to find out what motivates them, what makes them feel valued and what unique characteristics they possess that might not otherwise have been discovered. The close relationship that the researchers formed with the school children and their teachers enabled insight into the intense anxiety that children experience in periods of uncertainty and transition, especially in situations of sensory or cognitive overload over which they have no control. Some of the coping mechanisms for managing high levels of anxiety can be alarming, disturbing and disruptive in classroom situations. This anxious state of mind can inhibit learning in most people, but for autistic individuals the challenging behaviours clearly have a negative impact on the whole learning environment.

Observational studies and ‘think aloud’ techniques were conducted with teachers and support staff; from these sessions, simple storyboards, with no technical references other than anticipated mouse or keyboard activity, were prepared in drawing books, to quickly capture and represent ideas. The aim was to inspire teachers by showing mock-ups to help them envision possibilities without the need to grasp complex technical processes.

3.4 Visualisation

These early idea drawings were later visualised on the computer so that the nature of ‘reactive’ interaction could be explained and explored with children directly. Whilst these reactive screens were crude in their execution, teachers found them easy to integrate into
classroom activities. They were initially introduced to a group of six children, aged five years with the developmental ages of approximately two years, using an Apple iBook™. Concept activities varied from a blank screen of colour that changed as the child moved the mouse, with simple sounds attached to each movement, to more complex keyboard activated screens that visually transformed and played a sound as keys were pressed, either in a random manner or in sequences that created tunes and patterns. Visual tracking was exploited in a number of mouse-orientated activities. The cursor was the point of focus in the form of a shape that had the capacity to visually change in response to user action, in some cases leaving a trail, outwardly evidencing inner engagement. Sounds were used extensively to provide feedback; for example, the closer to the centre of the screen the louder the sound.

These were experiential forms, broken down into simple steps, with no potential for error, as many children on the autism spectrum find failure intensely aversive and some may be completely demotivated by it (Gabriels and Hill 2002, Wing 1975).

Teachers took photographs and video footage of the children playing in order to observe interaction and engagement. Responses were further recorded in interviews and questionnaires, with both direct (yes/no) and indirect (what/how) questions, which focused on experience, rather than the assessment of skill. In particular, the project team looked for evidence of relaxation and increased confidence with the computer. Everyone was invited to contribute with ideas on how the experience could become more playful. It became apparent very early in this trial that the sensory differences of autistic children were to have major influence on any further developments of the software as some children in the group, even though the screens were made up of abstract shapes and colour, were clearly experiencing sensory overload caused by the combination of movement, colour, and sound. An unexpected joy, however, came when the children expressed delight at the vibrancy and purity of the primary and complementary colour schemes, as brightness and contrast proved to be an enjoyable rather than disturbing sensation.

3.5 Usability and navigation

Many of the most effective ways to teach children involve them being paced in an environment with the right prompts and materials and letting them play within that carefully selected place (Dix 2003). When the structured setting provides a space for creativity and imagination, children will usually find their own interesting and novel way for interacting, without fear of failure. Designing a digital setting which could provide structure, rules and prompts and yet still encourages exploration and meaningful discovery provided an enormous challenge (Sherratt 1999). Classroom observations of children playing in their free choice of activity and video analysis of the same children using the early trial software in the classroom provided the ideas for an interface from which reactive colour screens could be selected. Fussy detail needed to be avoided and an appropriate level of focus enabled. Autistic children often have obsessive interests and may have a tendency to focus on details rather than the bigger picture; with this in mind great care was taken to reduce features that could be too attention grabbing. Auditory aspects were also carefully considered to avoid sensory overload and the possibility that sounds may be distracting or disturbing. Following much experimentation the interface took the form of a simple clock. The cyclic movement, pattern, regularity and familiarity provided all the elements needed to create a structure. All pictorial elements were filtered and reduced to a circle of numbers and a linear ‘hand’, of which the pointer end followed
user interaction. Each number represented a screen, which could be accessed by one click. Evaluation of the interface specifically considered usability; again using video analysis and interviews, the number of prompts required to motivate choice and the regularity of spontaneous choice were monitored.

Children responded positively to this highly structured, controlled interface, and once the sequence of actions leading to choice had been understood, they were able to make selections, in many cases without prompts, and were observed looking for recognition from others.

4. **Participatory design in the middle—defining experience**

4.1 **The objectives of the software**

The feasibility phase informed a series of objectives on which a successful funding proposal was based, these were:

- To create a reactive, experiential, interface which could introduce children on the autistic spectrum to the operating functions of a computer in a comfortable, playful, explorative, expressive environment.
- To develop flexible methods for evaluation and customisation in order to explore and inform an innovative design and distribution model.

4.2 **Creating a calm environment**

Methods for facilitating relaxation for autistic children using rhythms, colours, movement, interaction, in an environment that is unhurried where children can take turns and process information at their own speed have been well documented (Moor 2002, Sherratt 1999). However, little has been done to apply these in digital interfaces (Seigal 1996), which generally rely on assumptions and relationships that are analogous to, or stand up as metaphors for real world experiences rather than the recreation of sensations.

In the widely referenced text *Playing and Reality*, Winnicott (1982) suggests that to make relaxation possible the object of play must be allowed to communicate a succession of ideas that are not linked to purposeful outcome. He adds that children need repetition, continuity, sound, smell or touch, the experience of which is often linked to a favourite object, to cope with the stress that occurs during times of change.

Therefore the aim for the production phase has been to recreate the sensation of repetition, pattern and similarity, but rather than this being a visual reconstruction of a physical toy, the design focused on the sensory qualities of interaction, which do not make huge cognitive demands, and which encourage tapping, smoothing, circling on the computer, using the keyboard or mouse. Inspiration came from the objects that children most enjoy playing with, for example, spinning tops, Slinkies™, lava lamps, glow balls and kaleidoscopes, all of which offer repetition and reward through touch.

The reactive screens that resulted were designed to simulate phenomena such as elasticity, velocity, gravity and inertia, with the added experience of creating pressure, which can affect proximity, direction and motion.

The research team also experimented with some of the more ephemeral experiences that create sensations, like popping bubbles, flicking paint and twanging elastic. The emphasis is placed on simple reciprocal actions as the neutral interface allows users to
focus on the effect of their actions rather than on a complex sequence of steps required to perform a task. On a small screen the demands on fine motor skills are reduced as even the most casual of interaction is rewarded, which can arouse curiosity and promote self-confidence.

4.3 Considering context

With the evidence suggesting that a playful experience could enhance learning, through the relaxing interchange of shared interest, teachers began to trial the software was on a Smart™ Interactive Whiteboard, an ideal environment for shared experiences.

In their analysis of the video footage of children playfully involved through touch and movement at the whiteboard, the development panelists agreed that children were clearly being imaginative—imitating and mirroring, moving and exploring, using gesture and action to express their engagement—as many of the barriers to bodily expression, enforced through the necessity to manage control in the confined space of a computer screen, were removed (see figure 1).

The impact of the child’s shadow as it projected onto the whiteboard was of particular significance for the research. In most settings interactive whiteboards are lit in a manner that deliberately reduces the intensity the shadow caused by the projection of the image on the screen. In experimental sessions where the lighting allowed the shadow to appear, children were clearly aware of their own presence on the whiteboard screen and purposefully interacted, experimenting with movement and tension to create dynamic visual effects. This expressivity, when enabled in a structured, supportive setting proved meaningful for the children and there was additional evidence of concentration and joint attention as children were able to use their own fingers and bodies to gain control of their experience in an embodied play activity.

Figure 1. Choosing from the Clock Interface at the Interactive Whiteboard.
4.4 The cycle continues

Many trial versions have been created during this middle period of development, with the iterative process of inspiration, visualisation and validation continuing to provide ideas for improvement; the rapid 'suck it and see' approach has enabled mistakes to be identified and quickly reconsidered. The clock has been refined, and after a number of versions which became more complex than necessary, is becoming much closer to a working version, and with this success the identity of the project has taken shape and the software has become known as ReacTickles© (see figure 2).

4.5 Validation—rigorous analysis of experience

The evaluation of the ReacTickles© software has focused on how children interact in a range of informal and formal contexts: mainstream and special education schools, an out-of-school club, and in the home.

Within these contexts the nature of interaction with the ReacTickles© interface was explored, using questionnaires and video footage, in order to describe and analyse what motivates emotional engagement and the desire, if at all, to share playful experiences with others. The process has been undertaken to provide insight and inspiration rather than as a quantifiable method of surveying and data gathering. Design decisions have been made on the basis of these observational techniques.

As the design becomes more refined, and closer to meeting the needs of users, a more rigorous quantitative method of evaluation is taking place.

Following advice from experts, questionnaires with scalar choice responses, video-tape analysis and interviews have been undertaken with small classes of children in two special schools with a high proportion of ASD children. Other participants in schools and at

Figure 2. Exploring ReacTickles on the Interactive Whiteboard.
home are continuing to use the Reactive Colours© website and email as a mechanism for sharing their experiences of using the software.

The primary goal of the quantitative evaluation has been to assess whether the task-free mode of interaction can:

- provide a meaningful experience whilst interacting with the software directly or whilst watching others—waiting and attending;
- reduce environmental distractions and thus engage a child in a relaxing sensory experience—concentrating;
- motivate a child to explore the interface independently with limited prompts or assistance—pointing and choosing;
- gain control of the body to act purposefully with others—mirroring and sharing.

4.6 Early results

The evaluation has been specifically conducted with less able children, the benefits of the programme for these children has been highlighted as most significant as very few experiences are available to them that are genuinely motivating.

The initial results of the formal data gathering process, using questionnaires with scalar choices, present an interesting dilemma as a very clear pattern is emerging.

In a structured setting, with children using ReacTickles© on the Smart Interactive Whiteboard, a group of six participants, aged five years, with severely delayed developmental ages (approximately 1 – 2 years) evidenced increased concentration skills; most of the children were also able to point and choose independently following prompts. The teacher co-coordinating the session noted that, although attending and concentration was dramatically higher as the children were clearly playing happily, waiting and turn-taking was problematic and two children became upset at having to wait their turn.

The same children were introduced to ReacTickles© a week later and some improvement in waiting and turn-taking was noted; the teacher concerned has specifically requested that her study continues over more sustained periods.

In free play sessions, during which children selected ReacTickles© as their choice of activity, the findings were similar. The two children observed showed excellent levels of concentration, with no need for additional prompts, but showed no desire to share.

In a class of children aged nine years, with developmental ages of 12 – 18 months, the six children observed showed some concentration and attending but needed much more support from their teacher. However, they were more accepting of others in the group when given the opportunity to share the experience at the interactive whiteboard, as the physical environment so clearly provided an appropriate space for joint play.

In another class, six children, aged five, who had previously used ReacTickles© on a Smart™ interactive whiteboard, were able to practice these skills independently and were able to share the experience enjoyably with others.

As the evaluation continues, longitudinal data across is being gathered which will specifically measure levels of challenging behaviours. Challenging behaviours are routinely monitored in all classrooms and residential settings; they are regarded as highly correlated with autistic spectrum differences, and can be extremely costly both in time and money. It has been suggested to consider the immediate effects of challenging behaviours during sessions and the short-term effects in the two hours after using ReacTickles© compared with a baseline derived from records of the prior three months. After regular classroom use of six months or more the team will look at possible
longer-term effects on levels of challenging behaviour outside of ReacTickles® sessions against the same baseline.

5. Participatory design for the future—refinement and expansion

5.1 Personalisation

The sensory abnormalities which impact on the way in which autistic people perceive events can result in certain colours, sounds, movements, or even textures causing pain and discomfort (Bogdashina 2003). In a classroom setting this can lead to the disruptive challenging behaviours discussed above. Specialist collaborators have encouraged the designers to extend the parametrical environments so that adjustments can be made to reduce the problems caused by sensory dysfunction. New ReacTickles® are being designed to offer user preferences, which can set the volume of sound, intensity of colour and speed of response. Further to this users will be able to experiment with colour directly from the clock interface by choosing a range of complimentary, rainbow or black and white colour schemes. Ultimately, in extending possibilities for creative experimentation, those children who have become confident and familiar with the ReacTickles® routines will have the opportunity to define and customise sensory experiences.

5.2 Participatory design online

The Reactive Colours© website has been established to enlist collaboration from a wider community and has attracted regular comments from parents and carers who would otherwise have little opportunity to share their experiences and contribute to progress. The informal and anecdotal comments shared through the web have introduced a level of participation that would be missed if the project had solely relied on formal methods, most significantly in the way in which parents have witnessed positive benefits of the software for children at home. Instant feedback on the web allows people to express themselves instinctively, without the pressure or bias that can occur in formal settings.

The blog section records the project history, providing an open repository for useful information on all areas of development, where comments are easily added and dialogue flows. This openness and transparency is further supported by the release of the ReacTickles© software on the site, for users to freely explore.

The philosophy of release early and often and listen to your customers (Raymond 1998), which is fundamental to the open source movement, has the benefit of reaching the target population directly in their own environments, where spontaneous feedback is valued and encouraged (St. Laurent 2004). For the young children who are extending their experience of using the software at school into the home, the web site presents an opportunity to enrich the learning experience by enabling families to share activities that have been motivating for the child.

5.3 Expansion

As new technologies and services evolve and the role of the computer shifts from functional tool to more ubiquitous environments, ReacTickles® represent a scalable, transferable experience of computation that can provide the skill, satisfaction, confidence and reassurance needed to support the seamless transition from one immediate environment to another and in so doing, provide a valuable link between home, the
classroom, workplace and the community. ReacTickles® are not intended as a substitute for existing educational approaches, however, by incorporating the software into an overall educational strategy, the software may be well placed offer a positive playful, inclusive, mutual experience for all learners. ICT for the future will need consider the entirety of children’s experiences of the technological environment rather than discreet elements of it—yet the challenge remains to ensure that the integration of any informal tools for learning can be pedagogically grounded whilst at the same time playful and rewarding (Plowman et al. 2003, Lucklin et al. 2003).

With this in mind the Reactive Colours® team are leading a proposal to work with Birmingham University, School of Education, to develop a ReacTickles® DVD Creativity Box, which will directly address areas of the Curriculum.

6. Conclusion

Computers have been shown to have enormous value for people on the autistic spectrum and those in the wider community who support them. Within this paper the researchers have considered many approaches, which use computers to assist in understanding social co-operation.

In the long term, the impact of gaining skills with computers can assist not only in gaining academic, managerial and social skills, but also in boosting confidence and self-esteem. The significance of the Reactive Colours® research has been the departure from the necessity to gain skill, but rather to enable an environment where individuals are free to express their interests, which can be shared with others. Each touch or keystroke immediately creates a visible response so that the current area of focus can be identified and comfortable interaction can occur around a shared interest (Murray and Lawson 2006). For the linguistically less able children, this provides a manageable, failure free, social climate for joint play, a feature often missed in most software applications.

The task of including these children, who may not choose to communicate verbally and for whom change can be extraordinarily uncomfortable, appeared daunting from the outset; however, the strategies documented in this paper ensured that their ability to inform the direction project was prioritised. Furthermore, the participatory nature of the design process was especially significant for the area of research. Being aware of the end-users as a community gave the researchers greater awareness of the possibilities for bodily and social interaction which could be elicited from the children by the ReacTickles® technology. One of the difficulties of this participatory design process has been the necessity to evolve these strategies alongside design and development. The management of the project has demanded new skills from individuals and new methods for defining deliverables and milestones, where the notion of a deliverable is not necessarily a tangible, visible outcome, but closer to creating a condition from which progress can occur. These conditions arose through the availability and commitment of the many parents and teachers who, through their instinctive understanding of the behavioural characteristics of each individual child willingly, on the internet and at school, shared the minutest changes they observed and each incremental change has contributed to the understanding of possibility.

Without this involvement they project may have become a feast of ‘reactivity’ solely within the domain of the designers; making the design process democratic and visible, has ensured that the software that is not only relaxing and satisfying, but is also desirable, aspirational and delightful.
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**Related Links**
National Curriculum guidelines for Social Skills for pupils with Learning Difficulties: http://www.nc.uk.net/ld/PSHE_content.html
National Curriculum guidelines for ICT: http://www.nc.uk.net/ld/ICT_perf.html#2
Sure Start—*Birth to Three Matters* framework: http://www.surestart.gov.uk/resources/childcareworkers/birthtothreematters/
DESIGNING PLAYFUL SENSORY EXPERIENCES WITH INTERACTIVE WHITEBOARD TECHNOLOGY: THE IMPLICATIONS FOR CHILDREN ON THE AUTISTIC SPECTRUM

Wendy KEAY-BRIGHT
University of Wales Institute, Cardiff, Wales, UK
wkbright@uwic.ac.uk

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 (Domínguez 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 proprioceptive 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 focused 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

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 in 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

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Figure 1 Exploring the interactive surface

Figure 2 Getting help to reach the top
Figure 3 Stretching at the SmartBoard

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Designing for Playfulness: Investigating the Therapeutic Potential of Technology Interfaces for Children on the Autism Spectrum - Wendy Keay-Bright

Paper V
Tangible Technologies as Interactive Play Spaces for Children with Learning Difficulties: The Reactive Colours Project

Wendy E. Keay-Bright
Tangible Technologies as Interactive Play Spaces for Children with Learning Difficulties: The Reactive Colours Project

Wendy E. Keay-Bright, University of Wales Institute Cardiff, South Glamorgan, UK

Abstract: The positive role that technology can play in learning has been well researched and whilst there have been arguments raised by some that computer use, particularly with young children, may drain precious cognitive resources, there has been significant progress in the area of embodied tangible technologies. Drawing on this research and bringing together perspectives from human computer interaction (HCI), psychology, linguistics and graphic communication, I will present the findings of the Reactive Colours project, which has been developing customizable sensory software, ReacTickles, and investigating the impact of embodied user interfaces on social communication and learning for children with autism. Through my work I aim to demonstrate a democratic and participatory approach for the design of embodied user interfaces where manipulation is intuitive and expressive acts foster improvisation and an opportunity to encounter experiences independently of skill, knowledge or directed task. ReacTickles aims to subtly trigger collaboration between individuals and co-ordination through performative actions rather than the necessity to complete a directed activity. This novel approach allows the emergent idiosyncratic needs of the child to lead activities rather than the typically operational modes of traditional computer interaction. The significance of this for children with autism is that meaning is created and understood through sensory arousal and action, rather than the necessity to interpret a graphically mediated environment. Within this paper I will demonstrate ways in which my research has been introduced in pilot studies in a number of schools throughout the UK and the impact partnerships with schools has had in developing ReacTickles and the emerging heuristics which may prove useful for all young learners, irrespective of individual developmental levels.

Keywords: Embodied Tangible Technologies, Embodied User Interfaces, Manipulation, Improvisation, Collaboration, Performative Actions

Introduction

There is an increasing desire within school-based frameworks, to prepare children of all ages for the complex world of digital technologies. Even in the home, parents favour educational applications when selecting software for their children, which follows a general belief that children must be competent with technology in order to succeed in school and in the future workplace (Plowman & Stephen, 2003). In the UK, there is widespread support for the use of Information Communication Technologies (ICT) as a means to improve the quality and standards of education and to assist teachers in the management of their daily teaching routines. Although positive motivational outcomes are frequently found when ICT is used to support engagement, research, writing and editing, and presentation of work (Passey and Rodgers, 2004), there is still little use made of sensory engagement, particularly, kinaesthetic, spatial/visual, interpersonal and intrapersonal, as a means to encourage collaborative learning, creativity and flexible thinking.

Most educational software is designed around a structure that tends to dictate a sequence of actions rather than allowing the child to initiate with his mind or body. Choice or options consist of selection from buttons or interface menus and task-driven activities tend to dominate the experience. The active areas of the screen are usually restricted to routine mouse clicks and key presses and sensorial interaction is limited to visual or aural feedback, rather than genuine sensory stimulation. When used in this way the computer takes responsibility for selective attention, meaning that children are not developing the ability to control their attention through planning and understanding the consequences of their actions (Healy, 1998).

The predictability and controllability of computers make them ideal environments for people with Autistic Spectrum Disorders (ASDs), who typically experience discomfort at unexpected change and the uncertainty of face-to-face communication (Jordan & Powell, 1990; Murray, 1997; Murray & Lawson, 2006). The testimonies of many autistic adults clearly evidence the use of technology for many highly creative and communicative purposes (Lawson, 2001; Grandin, 2000). The concerns within this study, however, have been with how the operational mode of computing can reinforce a mindset intent on finding one right answer leading to narrowness in thinking skills and imagination. Children with Autistic Spectrum Differences (ASDs) may be able to
master their responses to a pre-programmed set of stimuli however, in this mode joint attention and spontaneous play skills are difficult to support as many social skill interventions do not offer reciprocity or child led initiations; instead they focus on discrete individual skills and inflexible modes of communication. These approaches that teach rigid behavioural routines do not appropriately reflect the unpredictability of typical human interaction.

Murray, Lesser and Lawson (2005) describe the autistic condition as 'monotropic', suggesting that in the competition between mental processes for scarce attention, monotropic individuals will have few interests that are highly aroused, as opposed to having many interests that are less highly aroused, which is the polytropic, non-autistic tendency. This issue of managing attention and how it impacts on children with ASDs has been of interest to the ReacTickles research and will be discussed within this paper for its relevance to (1) social communication and joint attention; and (2) relaxation and task. Feedback from parents and teachers during preliminary interviews raised concerns at the intensity of focus children with ASDs demonstrated when engaging in computer programmes - they were described as becoming 'locked in' and impenetrable, often unable to tolerate the presence of another or to co-operate in other activities, suggesting that their interests were highly aroused and their attention focussed deeply on the task.

In this context, when computers are predominantly employed to assist in analytical tasks, they are rarely used to support mutual awareness and improvisation. Through the discussion and analysis of the ReacTickles software, presented in this paper, I will demonstrate a much wider range of experiences and possibilities afforded by computers when the emphasis shifts from operational routines to a computationally enhanced landscape for performative acts of personal expression.

ReacTickles are embodied user interfaces that use physical manipulation and perception to encourage playful exploration and collaboration in a variety of technological settings, they do not require specialist equipment or training as they utilize existing equipment in homes and classrooms to support different sensory modalities. The natural bodily interactions afforded by the attributes of the technologies, for example mouse, keyboard, touch-screen, interactive whiteboard or microphone, are at the core of how ReacTickles work. ReacTickles do not function unless they are played with through touch or sound; for the player, this multimodal interaction offers a dynamic experience that is predictable, but it is also infinitely variable, as each encounter encourages further improvisation, allowing the user to more flexibly determine the sequence of actions, an approach which is far more closely aligned to natural human behaviours (Dourish, 2001).

**Play and Learning with Computers**

Many of the skills children need in their development as social beings, for example turn-taking, decision making, language skills, monitoring and reciprocity, evolve naturally through play. Piaget (1945/1962), in his studies of child development, argued that children actively acquire knowledge through interacting with their physical surroundings, and the process of interpretation, which occurs as a child actively investigates his environment, is the precursor to imagination and abstract thought. Many psychologists and philosophers agree that a child’s developing mental capacities emerge in the context of social interaction, and as the child progresses from perception of the physical properties of objects to theorising about them, they are drawing on generally developing capacities for causal understanding (Elian, 2005). When two individuals co-ordinate and interact with an object or event, they begin to acquire joint attention skills (Tomasetto, 1995). Joint attention encompasses a range of behaviours, including gaze following, social referencing, shared engagement and imitation. As children develop these skills they will increasingly use eye gaze and gestures such as pointing, rather than screaming or challenging behaviours, to draw attention to their needs and demonstrate a desire to participate in a social world.

Play has also been shown to reduce stress and to enhance creative and imaginative thinking; children learn best when they are given the opportunity to construct knowledge without direct instruction, when they are give full control in an open-ended play environment (Papert, 1972 & 1977). Papert’s book, Mindstorms (1980), set the foundation for the generation of educational technologists who have been profoundly influenced by his ideas on the computer as a “transitional object” and its role as a cognitive bridge. Although there are clearly alliances with the work of child psychologist D.W. Winnicott (1982), who presented the emotional relationship between inanimate objects as a substitute for the presence of the mother, Papert’s theory draws on the affective role the transitional object has in children’s learning and therefore, is more relevant in the context of this work and children with ASDs.

For the purposes of this study our interest is in the play routines of typically developing young children, chronologically aged between four and seven years, and those of children of a similar developmental age with a diagnosis of autism (Kanner, 1943). It is at this age that children begin to use their imagination and to practice managing behaviour, they are able to keep concentrating when something distracts, them or their interest fades, and use language to draw at-
Intention to their actions; they are able to complete tasks without continuous reminders and they show empathy and understanding towards others (Healy 1998). For young children with ASDs, this natural development is likely to be delayed. Although they vary individually in terms of the severity of their autism and intellectual ability, children with ASDs will generally experience difficulties in non-verbal and verbal communication, the ability to understand social behaviour, and the ability to think and behave flexibly. (Wing, 1998)

The apparent lack of flexibility of thought can be observed in the unconventional play activities of young autistic children. Whilst their play patterns will vary widely, many children will engage in repetitive actions and may show an unusual or obsessive interest in the function of an object rather than engage in more imaginative, pretence and social activities (Leslie, 1987; Seigal, 1996). Many children with ASDs many not understand social cues and therefore may not seek social stimuli in their interaction with others, suggesting a preference for solitary play (Sherratt, 1999 & 2002; Jordan & Libby 1997; Seigal, 1996; Beyer & Gammeltoft, 2000). As a result joint attention, which arises when two individuals mutually attend to and share an interest, can be a difficult concept for many young children with ASDs.

**Embodied Play**

As the technological parameters for information, education and entertainment have merged, and with the most recent developments in tangible, or touch-activated interfaces, the distinction between digital and embodied play is weakened and the opportunities to use pointing as a joint frame of reference increase. Interactive whiteboard screens, plasma screens and even a touch screen monitor can afford manipulations that present an opportunity for more embodied forms of interaction. Traditional Graphical User Interfaces (GUIs) rely on the interpretation of symbols to construct meaning, which in turn will lead to a digitally represented task; the typical process is 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). Embodied tangible technologies enable a close relationship between manipulation through input and perception through output. One function is generally assigned to one action, the focus is on direct perception rather than the semiotics of form. 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 et al, 2000).

**Embodied Interaction**

The most profound learning experiences involve embodiment, live experiences and interactions between people and the world they inhabit. More than seventy per cent of learning experiences are accidental or informal (Thackara, 2005), and occur during face to face communication as our body acts as a medium that transforms our internal emotions and intentions into external signals actions, expressions, gestures movement and so on. Direct contact with the environment that surrounds us is critical to learning. Touching and various forms of manual investigation influence brain function, even language and culture (Singer, 2006), for the young child, movement and physical activities provide the foundation for higher-level cognition through the integration of the brain’s sensory association areas (Healy, 1998). Cognitive forms of intelligence, such as language, as well as certain visual-spatial skills, are all learned from using the body to perform movements in sequence and by navigating the body through space. The child’s muscles register the spatial organisation of the environment, which provides the foundation for higher conceptual understandings, such as proportion and velocity.

Embodied user interfaces attempt to make interaction with technology more like everyday actions, which are continuously improvised and adapted in response to unpredictable forces, and where interactions are rarely stable objective phenomena. In the real-world actions are organised in response to the setting in which they arise and as a result form part of an ongoing improvised activity, (Suchman, 1987). Therefore the notion of embodiment is not simply about experiences that we encounter directly through actions in the physical world; it also encompasses the notion that real-world experiences include phenomena that unfold directly in shared actions and conversations (Merleau-Ponty, 1962).

**Description of Reactickles**

The preference that young children with ASDs demonstrate for physical, sensory and manipulative play has been very influential on the design of ReacTickles and reported widely in previous work (Keay-Bright, 2006 & 2007). In this study the interest is in the manipulative potential of embodied user interfaces to enhance social interaction by providing a safe place for mutual awareness, which can be demonstrated through actions such as pointing and gesture.

ReacTickles consists of a simple cyclic interface - a clock - when the numbers of the clock are touched
or the corresponding number key pressed the player is immediately linked to a ReacTickle game (see figure 1). The games are played using any standard input device and well as touch screens, switches and joysticks. Some of the games will be generic to all input modes, although they will respond differently, according to the actions afforded by the device; others will be specific to the particular mode of input. The games take the primitive actions associated with familiar objects or phenomena, such as squeezing bubblewrap, popping bubbles, twanging elastic and flicking paint and combine them with more complex patterns which endow these activities with the potential for symbolic meaning (Keay-Bright, 2007). At any time during play, the player can return to the clock, choose a new game or input mode, or even change the colour palette, speed of performance and volume of sound. Whilst this facility to personalise the game is an essential aspect of improvisation and experimentation for any individual, it is of particular significance to the child with ASD, for whom sensory differences may result in exclusion from activities that arouse the sensory system as the coping mechanisms that arise from this can be disturbing for others.

![Figure 1: The Clock Interface](image)

**Rationale for the Design**

The ReacTickles environment aims to consistently elicit positive user experiences by reducing the cognitive burden of computer-mediated overload (Weiser & Seely Brown, 1996). By engaging the senses, particularly the kinesthetic sense (the sensory awareness of the position and movement of the body), and removing the necessity to conform to the demands of a task, ReacTickles foster a more natural flow of interaction between the user and the interface. Thus the availability of attention may be widened, making the experience cognitively less demanding and more ambient, playful and relaxing than more traditional software interfaces. In the text, The Coming of Age of Calm Technology (1996), Weiser and Seely Brown suggest that to promote relaxation, the user must be able to shift attention back and forth between what is of explicit interest and what may be occurring on the periphery of attention. The authors imply that by placing things in the periphery, a more natural relationship between an object in the world and the intention, perceptions and capabilities of the user is afforded.

This concept of affordances (Norman, 1988 & 1990; Gibson, 1979), which encourage a tight coupling between the environment and a range of possible actions, encountered directly rather than abstractly, are strong feature of ReacTickles. Dourish (2001) describes this coupling of activity and environment as central to embodied interaction, as the source of meaning is found through actions and the possibility for actions, rather than though a cognitive process requiring the interpretation of graphically mediated symbols. To illustrate this concept, when playing with ReacTickles using a mouse a range of spatial smoothing, circling and dragging movements are afforded; the keyboard activities promote tapping, pressing, and repetition, which elicit locational responses on the screen that match the spatial organisation of the keys on the keyboard; using the microphone will create a response depending on the volume of sound created by the user, either through the voice or some other instrument. When ReacTickles are played on an interactive whiteboard, gesture and pointing are employed both to manipulate the interface and to draw attention to the actions, gross motor movements such as stretching and jumping become key actions in the experience as fine motor demands are reduced (Figure 2).
The point of focus for the interaction is an important feature of ReacTickles and represents a significant difference to the way attention is managed when operating a computer. Traditional interfaces tend to have a single or limited number of areas on which to focus, defined by the position of the cursor or the active window (Thackara, 2005). When inside a ReacTickles game, the cursor disappears, allowing the player to focus attention on their actions using the entirety of the screen, selecting from deep focus to peripheral focus as required. For example, popping a bubble will cause a number of new bubbles to appear, the player may choose to reach for a more challenging bubble to pop on another part of the screen, or to wait while a seemingly endless array of bubbles afford a range new possibilities as they float and wobble spontaneously on the screen, changing scale and popping themselves as they collide. The cursor remains invisible until the player returns to the clock. As no cursor resides on the screen to prompt action, progress is directed by the player through exploration, or another player should he be invited to join the game.

The value of this approach is that it shifts the focus away from the functional demands of the technology towards encouraging users to explore, create and communicate through the actions they perform. Social interaction is supported through different forms of activity rather than being limited to the confines of the interface. Actions such as pointing and turn-taking can occur through the technology rather than enforced in a heavily structured sequence of interface actions.

Methods

As Suchman’s (1987) work on “situated actions” states, human activity does not correspond to a sequence of formulated plans; our interactions with the real-world are active interpretations formed in response to the features of the setting in which they arise. This model of behaviour as an ongoing improvised activity was very influential determining the design methodology for ReacTickles, and is of particular interest in the desire to offer experiences that are transferable across a variety of settings - an important factor in promoting generalisation and reducing reliance on learnt cues and stimuli. The complexity and range of differences between children on the spectrum can be extreme, so observational and qualitative, as opposed to purely empirical design methods, were to provide the greatest opportunity to discover how children would perform with the software and how their particular interests could be encouraged, supported, maintained and made visible through their interactions. In order to develop a design approach that is conscious and considerate of the young target audience, collaboration and consultation at all levels of the design process had to be implemented. Druin’s (1999) contextual research studies that involve children as co-designers provided the basis for the design research methodology which centred around participation with children and teachers from a specialist ASD Unit in a school in South Wales, UK.

The relationship was initiated by a series of preliminary activities in which teachers were encouraged to integrate simple prototypes into a regular teaching day; they were given complete autonomy to decide when and how they would use the samples. Formal evaluations were avoided in favour of more speculative and qualitative assessment of interest. These methods allowed the idiosyncratic behaviours of the children to present themselves naturally as they explored the software under the expert guidance of their teachers. Each iteration of the ReacTickles software consisted of short feedback loops, with regular reflection and evaluation which aimed to ensure that the role of key informant (Druin, 1999), played by the children and teachers, was understood and valued.

Traditional forms of evaluation normally concentrate upon the ability of the user to perform a series of actions within the options offered by the computer, however, for ReacTickles, these metrics were ultimately only helpful when used in conjunction with other qualitative methods. Whereas usability is conventionally tied (1) to the capacity of the interface
to undertake one particular, pre-defined action, and (2) to the user’s understanding and completion of the pre-defined action, ReacTickles in contrast makes available (a) a network of possible actions enabled by the user’s open, playful interaction, and these are evaluated (b) as a range of actions which are performed and invented rather than having to be understood and completed. Thus the primary interest in evaluation was to detect how and where in the experience children were being most playful, and how play and the reduction of anxiety can support and encourage socially motivated behaviours such as pointing and turn-taking. Ease of use, however, was fundamentally important to teachers as a breakdown or lack of response from the system could result in an interruption in the flow of activity or fears that children could become upset by unpredictable or inappropriate responses. Regular interviews and video analysis of children as they encountered the software in their natural settings demonstrated that teachers were actually finding imaginative ways to experiment with the software in both structured and free-play sessions. Although an inherently time-consuming process, a sense of trust and ownership emerged which enabled to project to evolve organically as part of teaching routines.

**Pilot Studies Evidencing Enhanced Bodily Awareness**

A number of studies have been conducted throughout the project, (Keay-Bright 2006 & 2007). The paper will concentrate on two studies which considered whether the ReacTickles embodied user interface could provide a useful and effective classroom tool to increase motivation, confidence, imagination and sociability for children with ASDs in a different classroom settings.

**Study One - Keyboard Reactickles**

The group in this study attended a Community Special school in London, UK that had pupils with autism spectrum disorders and other low incidence special educational needs. The children were chronologically aged 11-19 years and had poor receptive and expressive communication. Good use of technology is made across the school, though teaching staff advised that it could be difficult to motivate and engage those pupils with a dual diagnosis of severe learning disabilities and autism.

A consultant researcher with expertise in the use of ICT for pupils with learning difficulties conducted the study and the input device chosen was the keyboard. The sample group comprised of three pupils (one female, two males) with ICT skills at P6 of the National Curriculum Performance Levels, meaning they could respond to simple instructions and use the computer for specific tasks with support. None of the children were able to use the keyboard in terms of letter recognition, but all had the manual dexterity to press and hold individual keys. Most of their speech was echolalic, repetitive or unrelated to the task being undertaken. All the children could follow three word instructions so directive speech was kept very short and simple to ensure they understood each activity.

The coding categories used in the study were adapted from the measurement scales of Aldred, Green and Adams (2004) and the observational checklist of Cumine, Leach and Stevenson (2000).

- **Behaviour** – was the child interacting physically, verbally or attending to the activity using only eye contact?
- **Operating** – which key or keys was the child pressing or holding down? It was decided in advance that approximations to keypresses would not be recorded, only those achieved.
- **Creativity** – would the child only press keys that they were directed to, or would they imitate, or would they try new key presses by exploring the keyboard themselves?
- **Social** – were there instances of shared attention, turn taking or communicating their experiences to others present? This included sharing the focus of the activity by looking, showing/pointing or body orientation.

The findings of this study were very encouraging and showed small yet significant progress for each participant. For all three there was a noticeable increase in confidence, displayed in choice making, touching previously unexplored areas of the keyboard and learning that holding down keys gave them different, often longer lasting results than simply pushing a key and letting go. It was reported each child in the study wanted to touch different areas of the keyboard and moved from pressing individual keys to trying out the idea of holding down a key whilst concentrating on the effect this created on screen. One of the most exciting observations was the way in which both the participants and their support staff found new ways to approach the keyboard, simply to play. The children were very enthusiastic and rapidly learned to operate the interface, which was considered to be a rare occurrence for this group. The researcher reported that the software could easily be integrated as a regular part of the curriculum, which was a welcome change from seeing software used in isolation, as a specific component of a literacy lesson, or as a behavioural reward.
**Study Two - Interactive Whiteboard**

**ReacTickles**

Another study, using questionnaires with scalar choice responses as well as interviews and video analysis involved participants from schools throughout the UK, recruited through conference presentations, school networks and the community of interested teachers and parents fostered through the reactivecolours.org website (Keay-Bright 2006 & 2007). The format for the study was adapted from social skills checklists - Kathleen Quill’s Do-Watch-Listen-Say: Social and Communication Intervention for Children With Autism (Quill, 2000) and Autism in the Early Years Observation Profile, (Cumine, Leach and Stevenson, 2000), with additional expert guidance from the University of Birmingham, UK, School of Education. The study was conducted in a variety of settings, monitored over three sessions at intervals of approximately one week. For the purposes of this paper I will summarise the feedback given on activities that took place using a Smart® Interactive Whiteboard. Smartboards® enable children to control their experience through the touch of their fingers. When used in this way ReacTickles become interactive surfaces, which render visible the outward response to being touched or stroked visible through a corresponding movement, shape morph or colour change (Figure 3).

![Figure 3: Smoothing and Circling](image)

What became evident from video analysis of the different groups using ReacTickles on the interactive whiteboard 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 pointing and gesture 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 fine 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 expressed discomfort at the start of the session; he was observed running backwards and forwards flapping his hands violently, however, following encouragement from his teacher, he began to engage with ReacTickles, and within minutes started smoothing the Smartboard® as he and became calmer and in control of his actions. 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 interactive whiteboard the levels of concentration improved, as they were able to see their actions mirrored on the screen. It was also noted that expressive communication also improved, as the children were able to demonstrate their interest through actions.

A different group, who were able to use verbal language, demonstrated certain characteristics associated with symbolic play. They attributed properties to actions in an imaginary way. For example, when filled circles ascend and wobble, a child enthusiastically points and says, “Pop the bubble!” Another child voluntarily joins the activity and shares instructional vocabulary as the pretence continues. A third child joins the group and extends play, imitating the actions of his peers and adding his own variations. In a different type of activity, where 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.

Findings from questionnaires (Figure 4) suggested that levels of attending and concentration were dramatically higher for most of the children for whom motivation and engagement in classroom settings is generally poor. Most children were able to wait and watch another child play although some found waiting problematic and one child was reported to become anxious and upset at having to wait. Results for turn taking were inconclusive; the reason being that many of the children were playing on their own or the teacher was not able to introduce turn-taking.
routines into the sessions. The assessment of mirroring, showed similar responses as when there was no other child present it was difficult to monitor, however the majority of responses indicated that the child copied the action of the teacher, and demonstrated an improvement over the three sessions, particularly with complex actions, such as pushing, popping, pulling, controlling speed. The facility to choose has been a very successful feature of the project; the additional comments provided by staff indicated that most children enjoyed the clock interface and were able to freely make choices without the need of assistance once the rules had been demonstrated and understood. Many of the children required very little prompting, which indicated increased confidence and motivation. Of the responses to questions on imaginative thinking, most indicated that children were able to move from simple repetitive actions, to more purposeful ones where, smoothing, circling and dragging could be extended and pointing, gestural and verbal responses were employed to direct attention to the action.

**Figure 4: Analysis of Data**

**Conclusion**

The challenge for the Reactive Colours project was to create playful experiences that could engage through experimentation with bodily sensations and interests in a manner that is both direct and personal. For this existential medium to be of any value it had to be motivating, relaxing and demonstrate potential for social interaction which is a prerequisite for learning in young children. As Powell and Jordan state, a common goal in approaches to learning for children is that it “…can be greatly enhanced if the tasks chosen are highly motivating for both staff and pupils and if they can be enjoyed together. That seems to be the real therapeutic context in which children can experience the sharing of emotions that has not occurred naturally and spontaneously in the course of early development” (Powell & Jordan, 1997, p167). From the studies conducted during the development of the ReacTickles software it became evident that children were able to play, explore and share without discomfort. For these children, there was perceived value in extending the use of computers, widely acknowledged as a beneficial environment for learning and communication, to provide a stimulating starting point for bodily exploration and the outward representation of interests that might otherwise not be expressed. In this wider context, manipulation, performance and improvisation, typical actions in everyday life, could occur comfortably in the computationally mediated environment. The ultimate goal of finding a sustainable, scalable and transferable way to integrate the ReacTickles experience into busy teaching routines, was addressed in the latter stages of the work and was realised though the enthusiasm and support of dedicated teaching staff and lecturers at Birmingham University, School of Education. This work will be reported elsewhere.

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Related Links


National Curriculum guidelines for Social Skills for pupils with Learning Difficulties: http://www.nc.uk.net/ld/PSHE_content.html

National Curriculum guidelines for ICT: http://www.nc.uk.net/ld/ICT_perf.html - 2

Smart Technologies: http://smarttech.com/

About the Author

Wendy E. Keay-Bright

A graduate of Graphic Design and Animation, I began my career on the popular children's TV series, SuperTed, before becoming a freelance animation producer researching and producing animation content for BBC One, HTV West and S4C. It was during this period that I began working with children as co-designers; the productions for which I was responsible pioneered the notion of children as creators of original programme content. A fascination for technology as an experiential medium has provided the motivation to undertake research at a high academic level, alongside teaching responsibilities. All my research has involved users directly, as well indirectly through web technologies. Reactive Colours© and ReacTickles® represent my most recent research activity which has been awarded funding from the NESTA Learning Programme. My responsibilities include research, project management and design. I have presented and published my work internationally, most recently I taught multimedia design at Sichuan Fine Art Institute and presented my research at Xi’an People’s Hospital in China. I am a member of the Higher Education Academy.
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Paper VI
ReacTickles: playful interaction with information communication technologies

Wendy Keay-Bright

Reader in Inclusive Design,
Cardiff School of Art and Design,
University of Wales Institute Cardiff,
Cardiff CF24 0SP, Wales, UK
Fax: + 44 0 2920 416609
E-mail: wkbright@uwic.ac.uk

Abstract: This article presents a vision of information communication technologies (ICTs) as a playful trigger for relaxation and exploration, and investigates the benefits of this approach for young children with autism spectrum conditions. Playfulness in this context is considered for its repetitious, rhythmic and experiential value rather than as an intervention for the acquisition of skills; ICT is proposed as a medium for its physical and sensory affordances rather than as a task-focused application. To explain this notion, I describe how the ReacTickles software system, designed to harness the multisensory properties of ICTs, has increased the potential for unique and personal forms of interaction through the close coupling of physical input and digital output. To conclude, I discuss how adopting an interpretational approach enabled many of those who contributed to the design of ReacTickles to determine its context of use.

Keywords: affordances; ASCs; autism spectrum conditions; embodied interaction; experiential; ICTs; information communication technologies; playfulness; repetitious; rhythmic; sensory; tangible technologies.


Biographical note: Wendy Keay-Bright is a Reader in Inclusive Design at the University of Wales Institute Cardiff. Her practice-led research has been awarded major funding and sponsorship from NESTA, the National Film Board of Canada and Steljes Technologies. She is a partner in the ESRC technology enhanced learning ECHOES project: improving children’s social interaction through exploratory learning in a multimodal environment. In 2007, she was awarded the International Award for Excellence in Design Principles and Practices. Other awards include a Content 360 Award for Socially Responsive Media across Multiple Platforms at MipTV in Cannes and a Wales Autism Award at the S4C Charity of the Year Awards. In 2006, she was a finalist in the Welsh Woman of the Year Awards and in 2007, a finalist in the Leading Wales Awards. Publications include: Digital Creativity, CoDesign, International Design Principles and Practices, Int. J. Technology, Knowledge and Society and Journal of Assistive Technologies.
1 Introduction

Information communication technology (ICT) is ubiquitous; our children are immersed in the technological world, incorporating tools that have both functional and cultural significance. However, most curriculum frameworks rarely consider children’s developing knowledge of ICT in this context and place far more emphasis on technical ability and the use of the computer as a tool to increase critical thinking and problem solving. Even though educational computing is moving beyond the physical confines of the desktop with the widespread use of interactive whiteboards and mobile devices, task-based, cognitively loaded, operational interaction tends to dominate the user experience and the unique kinaesthetic features of ICT that could allow for more individually expressive and creative experiences have yet to be fully realised. Curriculum frameworks in the UK, make implications that ICT should be ‘holistic and integral across the curriculum’; expressive communication and creativity appear consistently as aspects of learning that are essential for all young children; however, the use of ICT to support these areas is biased towards competency and skill rather than individual and diverse forms of expression. ICT is known to be particularly empowering and motivating for children with special educational needs, offering experiences that they may not be supported through any other means and giving them access to a more inclusive curriculum. For people with autism spectrum conditions (ASCs), computer technologies offer a safe, predictable and controllable environment where they can usually work at a pace that suits them (Murray, 1997; Murray and Aspinall, 2006; Murray and Lawson, 2006). However, interviews with teachers conducted during this research revealed that although hardware offering a range of experiences was becoming more widely available, there was perceived to be a lack of educational software designed to support the individuality and diversity of children with extreme learning difficulties. Aligned to this, and of particular relevance to this research is the similar approach to play in the curriculum, which tends to be valued as something to be learnt rather than an experience to be enjoyed (Seach, 2007).

The body of research that underpinned the design and development of the ReacTickles software revealed the potential of ICT to enable less formal types of learning experience; that the type of learning gained experientially when the learner is given control of the technological environment through sensory engagement and explorative play. For this reason, I draw on recent research on the use of tangible interfaces and the increased potential for embodied experiences that arise through a close coupling between input, action, cognition and the situation in which interaction arises (Suchman, 1987; Dourish, 2001).

Tangible technologies include a broad range of systems that rely on the creative use of physical and spatial manipulation to control objects or interfaces (Hornecker 2006a,b; Dourish, 2001; Fishkin et al., 2000; Ishii and Ullmer, 1997). The trend in the design of tangible technologies is for the operational components of the computational artefacts to be embedded, and therefore hidden, within material objects. Examples of tangibles designed for very young learners include toys that are augmented with computing power in an attempt to capture some of the personal, imaginative and symbolic significance of the play experience (O’Malley and Stanton Fraser, 2004; Marshall, Rogers and Hornecker, 2007). Research in this area suggests that tangibles increase the opportunity for sensory engagement particularly, kinaesthetic, spatial/visual, interpersonal and
intrapersonal, as a means to encourage collaborative learning, creativity and flexible thinking (O’Malley and Stanton Fraser, 2004).

Although the actual learning and other cognitive benefits of tangible technologies have yet to be extensively investigated (Marshall, Rogers and Hornecker, 2007), for children with learning difficulties, tangibles afford the use of physical and perceptual skills which can enable a more inclusive route to learning. For this reason, I draw on research with tangibles with interest in the way in which the physical control device is used to manipulate the environment. Specifically, I suggest that when children are able to appropriate technologies through sensory qualities, rather than the operational components becoming hidden, they actually become salient. Discovering that functional properties are simply an opportunity to gain control of the environment can increase feelings of pleasure and intrinsic reward. This will be illustrated in the section on the design of ReacTickles, where I will describe how the software aims to exploit the physical directness of the devices and how manipulation can lead to rhythmic, dynamic and colourful outcomes that embody interest and reflect intentionality.

Of particular importance to the ReacTickles project has been the involvement of end users and experts in all stages of the design process (Druin, 1999; Laurel, 2003). The project could only develop with the centrality of the target population as a core objective, as this unique and diverse group is known to experience differences that cannot be understood through theory alone. Research methods that tend to produce empirical data and measure values on the similarity of behaviours that subjects adopt when using technology would not present a holistic understanding of autistic difference. Thus, the impact of the autistic condition had to be understood in contexts where it would have most influence on idea generation as well as implementation. In response to this, a multidisciplinary team, including parents, teachers, ICT advisors, assistive technology experts, as well as academics from special education, educational psychology and linguistics, worked together at relevant stages during the project lifecycle to observe, document and analyse how the unpredictable and idiosyncratic behaviours of the children that emerged during play could inform development in a realistic and useful manner without fear or judgement (Keay-Bright, 2007a,b).

In section 6 of the article, I draw upon video analysis and observation to illustrate how children have been able to invent purpose and amplify their interests through movement and performance when using ReacTickles. The examples have been collated from feedback given by experts, who have spent time using the software with children with ASCs in a variety of settings.

In this article, I propose that the unique properties of ICT, when coupled with software systems like ReacTickles, could foster forms of interaction that are experiential and meaningful for all young children. This approach, I argue, is developmentally appropriate and far more likely to encourage creative thinking and playfulness for children with ASCs, who will be naturally drawn to physical and perceptual experiences. Giving agency to the individual to create meaning and amplify interests is not only desirable for positive teaching and learning environments, but also could provide real opportunities for ICT to meet curriculum objectives by offering holistic experiences that are genuinely inclusive and open to a wider range of interpretations by practitioners and other children.

In Section 2, I will explain why there is an important correlation between physical and perceptual interaction and behaviour and the significance of the physical object the development of knowledge.
2 Autistic difference

Autism is a complex and diverse developmental disorder. The testimonies of adults with ASCs suggest that their experiences of the world are strikingly different from those of non-autistic people (Mottron et al., 2006; Lawson, 2001). Abnormalities in sensory processing can mean that the properties of objects may be more salient than their functional, emotional or social significance (Jordan, 2002; Bogdashina, 2003; Grandin, 2000). The feel of the object or the physical environment may cause sensations that result in behaviours that could be perceived by others as unusual or even alarming. Of interest to this project is the impact of sensory differences that children experience in the tactile, vestibular and proprioceptive sensory areas. Broadly speaking, these are the senses that affect deep touch, movement and a subconscious awareness of body position through muscles, joints and tendons. Characteristic behaviours of an over- or under-stimulated sensory system are biting, spinning, rocking and hand-flapping, and difficulties in any of these areas can lead to high levels of anxiety and an individual becoming isolated, distracted, hyperactive and generally ill at ease (Bogdashina, 2003). 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 (Ayres and Tickle, 1980).

People with ASCs are also 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 (Murray, Lesser and Lawson, 2005). When using computers, excessive focus leads to attention tunnelling where peripheral areas are ignored. When a problem arises in interpreting information, people, not only autistic people, will tend to focus their attention on the problem to the exclusion of all other factors, resulting in a disruption of flow and increased stress (Norman, 1998). The impact of tunnelled, directly and tightly focussed attention for many young children on the autistic spectrum can be that they are unable to cope with subtle change or to control their situation, which in turn can result in extreme anxiety. Indeed, a significant body of research supported by interviews conducted with parents and teachers of children with ASCs, confirmed that although the computer provided a safe and predictable environment for children to play and learn, when children were deeply focused on task, they were unable to ‘tune in’ to other areas.

3 Physical interaction and play

In this section, I draw attention to the role of physicality on communication, creativity and collaborative play, and consider how the physical properties of objects can give rise to creative exploration, when their functional purpose is removed and their sensory qualities become salient (Loi and Burrows, 2006).

Many of the skills children need in their development as social beings, for example turn-taking, decision-making, language skills, monitoring and reciprocity, evolve naturally through playfully exploring the physical world (Bruner, 1972; Vygotsky, 1978). Piaget (1945/1962), in his studies of child development, argued that children actively acquire knowledge through interacting with their physical surroundings, and the process of interpretation, which occurs as a child actively investigates the environment, is the
precursor to imagination and abstract thought. In the course of typical development, children seek out and respond to the attitudes of others towards objects and events in a shared world, beginning with a developing awareness of the physicality of the body and its relation to another, described by Jennings (1999) as the 'embodiment stage'. These early experiences expressed though bodily stimuli and the senses are essential for the development of identity and condition the child’s experience of a world that is inhabited by others. The British child psychiatrist and psychoanalyst, Donald Winnicot drew attention to the value of objects in strengthening the child’s emotional capacity to adjust to change. His research into the experiential and emotional capacity of concrete things given to a child during infancy, led to conclusions that the feelings of comfort and belonging that a child attaches to a preferred object, could continue to support them emotionally during times of transition, anxiety and stress (Winnicot, 1982). Thus, objects and toys will have very specific associations and meanings for a child, they will use them to interact with the world, both directly and abstractly, enabling them to engage with others and as a source of comfort.

For children with ASCs, the associative properties of objects may hold very different meanings from their typically developing peers, and although the developmental trajectory will vary greatly among children on the spectrum, interaction with toys and everyday objects will often remain physical and manipulative rather than socially motivated (Beyer and Gammeltoft, 2000; Bogdashina, 2003). This can be explained in part by unusual sensory experiences, leading to the use of object for their sensory value, and a monotropic tendency to attend deeply to detail. The overriding interest in physical forms of play could explain why difficulties with social interaction become more pronounced at around the age of two years when, for typically developing children, sensory interest declines and objects are used to mediate experiences through imagination and pretence (Bruner, 1972; Roeyers and van Berckelaer-Onnes, 1994; Hobson, 2002; Jones, 2002; Jordan and Libby, 1997; Quill, 2000).

3.1 Playfulness or play skills?

“Playfulness describes the way in which children are able to make links between affect and creativity, giving meaning to their actions and allowing them to express their unique personalities in ways that are characteristic of all human behaviour”, (Seach, 2007, p.xiii). For many children with special needs, open-ended, exploratory forms of play are discouraged in favour of more functional activities that lead to assessable ‘learning goals’, and play is presented in many curriculum frameworks as a skill to be learned rather than an experience to be enjoyed (Greenspan and Weider, 1998). As mentioned in Section 2, sensory and physical play tend to dominate the play patterns of children with ASCs, but Jordan and Libby (1997) suggest that rather than view this as a deficit, playful activities that engage and motivate children through these interests should be viewed as an opportunity to increase social interaction through mutual enjoyment.

4 Information communication technology and playful interaction

In this section, I draw a distinction between conventional cognitive approaches to ICT and more novel, tangible systems that enable a more diverse range of experiences. Young children, who are introduced to ICT as early as four years of age, will be offered an array of educational software programs. Whilst many of these will be
described as playful learning experiences, they rarely address playing in the purest sense of simply controlling and manipulating things in a safe environment for no particular purpose, which is understood to be crucially important for human development (Healy, 1998; Hughes, 2000; Seach, 2007). Play with ICT tends to be instructional—biased towards learning goals and the acquisition of skills—and requires the ability to remain motivated and focused on task. Many of the young children with ASCs involved in the Reactive Colours project, some of whom experienced profound difficulties attributable to their autism, found these programs frustrating, and teachers reported that children often became upset, experiencing feelings of confusion and failure.

In addition to the demands of interpreting a task or understanding the point of an activity, the typical computer interface is cognitively demanding. To perform a function, the learner has to interpret a graphical user interface and to manually investigate the digital environment with a physical object that has no specific behavioural or representational meaning (Ullmer and Ishii, 2000; Fishkin, 2004). An example of this would be pressing a key or moving a mouse to perform many functions, which will have a different output, for example, menus, buttons, folders and controllers (Ishii and Ullmer, 1997). These applications are unlikely to start with, and reflect the interests of the child or imbue interaction with rhythmic, sensorial and performative responses. It is for this reason that I draw on research that suggests that tangible technologies can be far more motivating for young children when the emphasis is on action rather than cognition.

4.1 Tangible interfaces and embodied interaction

Tangible computing, that is interaction with computers that takes advantage of physical and concrete experiences to prompt and support cognitive understanding, has been shown to enable children to express and demonstrate their abilities through physical and gestural action (O’Malley and Stanton Fraser, 2004). Physicality in this sense reduces cognitive overload, enabling more varied, hybrid interactions that embody the interest and engagement of the user (Weiser and Seely Brown, 1996; Loi, 2007).

Rogers (2006), in her appraisal of Weiser and Seely Brown’s work on calm technologies (1996), suggests that when physical interaction is combined with bodily and spatial movement people are able to more actively engage in their tasks. Notably, tangible interfaces, that closely align control and response, have the potential to be ‘encalming’, particularly when they enable direct perception that does not require mediation or internal processing by the individual (Gibson, 1979). According to Gibson’s theory of direct perception, the properties of objects enable us to use sensorimotor knowledge to construct representational meanings of the world that surrounds us and we are therefore directly sensitive to the world and its capacity for action. Donald Norman (1988) described the affordances of objects as the “perceived and actual properties [of an object], primarily those fundamental properties that determine just how the thing could possibly be used” (p.9). These perceived affordances occur when a user’s senses combine with existing knowledge to provide strong operational clues and suggest the range of possible actions. In this context, the saliency of use and proximity of physical space afforded by tangible environments are particularly useful for drawing attention to the sensory qualities of experiences. For young children, this could mean that the simple handling and combining of objects in everyday situations may provide them with an opportunity to control and manage their learning in ways that may be easier to cope with than demanding tasks or structures that impose a predetermined sequence of events.
(Healy, 1998; Hobson, 2002). What is important to note here is that the very nature of embodied interaction means that it will be open to highly individual interpretations rather than a single authoritative perspective. When considering the role of technologies to support playfulness and creativity, having broader, more personal, idiosyncratic interpretations of experience, should be seen as highly appropriate and desirable (Sengers and Gaver, 2006).

To summarise this section, I propose that ICT has the potential to encourage creative encounters through the interplay between the child, the technology, the physical space and the context in which interaction arises (Suchman 1987). This view contrasts with the existing view that the primary motive for using ICT in educational environments should be as tools to help children to find and develop information and to create and present ideas. For children with ASCs, this kind of sensory exploration, particularly when it arouses curiosity and supports the non-verbal dimensions of conversation, such as repetition, rhythm, pointing, gesture and imitation (Seach, 2007), could offer a valuable starting point to the play experience.

5 ReacTickles: tangible and embodied interaction

The ReacTickles software resulted from the reactive colours design research project funded by the National Endowment for Science, Technology and the Arts in the UK. The overall aim of the project has been to provide a relaxing and genuinely playful experience with technology for young children with ASCs in a variety of settings, including the home and at school (Keay-Bright, 2007a,b, 2008a).

5.1 How ReacTickles works

The ReacTickles software is currently available in two formats. Firstly, on the reactive colours website, where users can follow a link to ReacTickles and create their own personal gallery space. Alternatively, there is a fully customisable standalone version of ReacTickles on CD Rom and a box of playful resources, the ReacTickles Creativity Box, which became commercially in 2007 (Keay-Bright, 2008a). For the purposes of this article, I will focus on the ReacTickles CD version in order to give a full description of how the software works and to describe some of the dynamic user experiences that have arisen in classroom environments.

Figure 1  The ReacTickles interface
5.1.1 The ReacTickles interface

The first screen to appear when the ReacTickles application is launched offers a choice of input device – mouse, microphone, keyboard and interactive whiteboard – prompting the notion that ICT is multimodal and that the unique properties of each input mode is relevant to the way the system works. In addition, opportunities for personalisation are offered through a preference menu with separate functional modules. This is accessed using a key press to avoid crowding the ReacTickles interface with burdensome features. For example, the speed of ReacTickles can be altered using a simple slider, to assist children who may have tactile, vestibular or proprioceptive needs. Likewise, colour preferences can be adjusted to support visual sensitivity and volume of sound controlled to avoid unnecessary stimulation of the auditory sensory system. For many children, this preference system offers a continuous process of exploration with ReacTickles, however for children with ASCs, whose sensory differences can cause discomfort and anxiety, the ability to customise the environment is central to usability, engagement, relaxation and success. Once the preferences have been saved, the input menu returns, and as soon as the desired input has been selected, the ReacTickles navigational interface launches and playful exploration can begin.

The ReacTickles interface is a clock, designed to incorporate circling movements, which cause the clock hand to follow exploration. Choosing a number from the clock links to a ReacTickle. As an alternative input, pressing a number key on the keyboard will activate the corresponding number on the clock. When the number is selected it magnifies and changes colour as the screen changes to the chosen ReacTickle. The clock functions are fixed with no obvious alternative, providing the necessary structure for children to feel safe and to maintain predictability (Sherrat and Peter, 2002; Figure 1).

5.2 Creating a playful environment

In the earlier section, I described the potential for ICT to trigger playful and creative encounters, when the physical properties are salient and context is open to interpretation (Loi, 2007; Sengers and Gaver, 2006). I illustrate this concept by describing how ReacTickles works using different input modes.

ReacTickles are flat colour abstract forms that offer a variety of phenomenological and chromatic effects, for example elasticity, velocity, gravity, inertia, translucency and layering, through user controlled movement. The focus is on physical rather than semantic directness (Norman, 1986 and 1988) as the affordances of the devices – the properties and constraints that lend themselves naturally to certain types of movement and exploration – arouse playful interest and embody the child’s unique behavioural characteristics (Gibson, 1979).

5.2.1 Mouse ReacTickles

The weight and surface of a mouse suggest it could be picked up easily and used for smoothing, circling and tapping. When it is utilised for a task, the link to function is arbitrary and bears no relation to the digital environment, the sequences of actions that lead to pointing, clicking, scrolling and dragging have to be understood through understanding the graphical interface (Dourish, 2001). Mouse ReacTickles are closely mapped to the device’s physical properties leading directly to a visual and auditory
response on screen, there are no instructions that force pointing, clicking, scrolling and dragging, the design of the software will naturally trigger these behaviours as the child explores the screen. For example, in mouse ReacTickle number two, clicking on one of the circles will cause a popping effect, reflected in both the visual and auditory response on screen. The circle disappears to the sound of a plastic bubble bursting, much like the ‘bubblewrap’ that is used for packing vulnerable goods. This will cause a new circle to activate on another part of the screen, encouraging a repeat of the action and reinforcing the feelings of success and pleasure that can be derived from these sensual forms. Taking the phenomenological responses a step further, mouse ReacTickle number seven, invites the user to drag a circle to another part of the screen, this will elicit an elastic effect and when the user releases the mouse the selected circle crashes into other circles, which in turn creates a crescendo of corresponding bounces (Figure 2). The more the circles are dragged, in effect pulled, the more the other circles are seen to bounce off each other, and so the performance continues. Mouse ReacTickle number twelve, behaves very much like a slinky™ toy, when the circle is dragged to a different part of the screen it leaves a trail of circles that can be choreographed by the user to create multiple patterns.

**Figure 2** Mouse ReacTickle

![Figure 2 Mouse ReacTickle](image)

**Figure 3** Keyboard ReacTickle

![Figure 3 Keyboard ReacTickle](image)
5.2.2 **Keyboard ReacTickles**

A keyboard has properties that allow for tapping, pressing, repetition and rhythm; its functional use relies on very specific hand-to-eye coordination and fine motor skills. Keyboard ReacTickles elicit responses on the screen that match the spatial organisation of the keys on the keyboard; increasing pressure and repeating actions can create an array of patterns, mirroring the tapping of fingers in a visually dynamic manner. For example, keyboard ReacTickle number twelve is a pattern of circles that are positioned on screen to loosely resemble a typical computer keyboard, when any letter key on the keyboard is pressed, the corresponding circle will bounce, the more the user presses the greater the bounce, eventually disturbing other circles that are in close proximity (Figure 3). Multiple keys may be pressed during this activity; the locus of control will always be mirrored, increasing confidence and the potential to make patterns. ReacTickle seven responds to the press of a letter key by exaggerating the letter on screen, the more the user presses the key the more dynamically it responds and by adding other letters words can be spelled or patterns created. ReacTickle five resembles the classic video game ‘space invaders’ with the cursor keys acting as a joystick and any letter key firing an array of circles that accelerate to the top of the screen before gently drifting back down. When the player presses any letter key in ReacTickle six, a circle appears in the corresponding location on screen and is rapidly chased by a worm-like form, if the user presses a letter in another part of the screen, the circle appears to jump to that location with the worm following rapidly behind it, leaving a trail of colour that varies in intensity.

5.2.3 **Microphone ReacTickles**

A microphone attached to a computer is typically used as a voice activation device to ensure wider accessibility. Microphone ReacTickles do not draw attention to difference in this way, instead they are designed to playfully encourage a range of interactions, through touch, vocalisation or other instruments. Sounds created through the microphone reward the child with patterns that vary in intensity of colour, scale and proximity in response to volume of sound. For example, ReacTickle six is also a worm-like form, however, in response to sound the worm becomes subject to acceleration; the louder the noise, the faster and further it will travel (Figure 4). Other microphone ReacTickles take on phenomenological dimensions as they respond to interaction through sound with an orchestrated array of elasticity, gravity, velocity and inertia. The visible amplification of action through the voice or any other instrument is, in itself, an embodiment of interest (Figure 2).

*Figure 4  Microphone ReacTickle*
5.2.4 Interactive whiteboard ReacTickles

An interactive whiteboard usually consists of a computer connected to a projector, which simultaneously projects the image from the monitor onto a large-scale touch or stylus sensitive whiteboard. Some newer, more sophisticated models mount the projector within the body of the board, which has the effect of eliminating the effect of the shadow created when the child is in front of the projector (Rudd, 2007). Whilst some boards are reliant on the use of a stylus pen for interaction, this research predominantly used Smartboards™, which enable users to control their experience through the touch of their fingers. Interactive whiteboard ReacTickles trigger gross motor actions, such as stretching, reaching and jumping. As these actions are dynamically reflected on the large screen they prompt the whole of the surface to be explored. The scale and proximity of the interactive whiteboard, coupled with full body movements, has the added benefit of prompting children to stand back and observe their actions and to move from repetitive behaviours to more self-directed and intentional ones. Stretching and reaching, for example, can be choreographed using ReacTickle five; floating circles dance on screen, when a circle is touched it disappears, causing another circle to appear in a different location, however, if the circle is ignored it floats to the top of the screen. ReacTickle three is similar to a tile slider puzzle, as the user moves around the screen the tiles move up and down, left and right, as if magnetically attracted to the finger. This is a very gentle and rhythmic activity that naturally induces relaxation as the tiles shift gracefully in response to touch.

5.3 Embodied interaction

In this section, I have described a number of possible scenarios for how ReacTickles work across different modes of input. However, in order to appreciate the value of this, it is important to recognise why ReacTickles have the potential so powerfully amplify the interests and potential of children with ASCs.

The ReacTickles software maximises on the natural mappings between the physical controls of input devices and a range of possible effects. Actions, such as repetition, smoothing, circling, pressing and tapping, and in the case of the interactive whiteboard, stretching and reaching are natural responses to the preferential interests of the child (Keay-Bright, 2008b). These movements and other actions to manage the sensory system are analogous to the operational techniques of the system. The software has the playful effect of dynamically responding to action via the computer screen. For the child, the opportunity to see actions mirrored has the potential to not only increase awareness of self, but also enable others to share the experience through emerging interest rather than command. The repetitive and recurring actions, rhythms and gestures, as well as imitative responses that typically dominate pre-verbal forms of communication can become the tools for play in a safe, creative digital playground. To conclude this section, I suggest that ReacTickles works because the emphasis is on an embodied experience that arises through the close coupling of sensory exploration and visually interesting chromatic landscapes and patterns that do not make unnecessary cognitive demands (Dourish, 2001; Figure 5).
6 Emerging contexts: how children have played

In this final section of the article, I draw together video analysis and interviews in order to illustrate how children have been engaged when using ReacTickles in a variety of classroom settings. Rather than using traditional methods for classifying behaviours—a system that tends to produce an epistemic record of skill—using video footage in an open-ended manner enabled the team of experts and researchers to view children’s reactions from multiple perspectives. This method placed value on both immediate and spontaneous as well as more reflective observations. Viewing the footage over time enabled contributors to draw attention to aspects of experience that were often missed on first inspection. The observations are broadly categorised under the headings of: repetition, rhythm and flow, pointing and gesture, and imitation. These headings have been chosen in order to structure information in a way that remains open to interpretation rather than to fit into specific behavioural coding categories. The relevance to creative expression and embodied interaction will be explained in each section.

The settings for this analysis range from one-to-one teacher and child experiences with a desktop computer, to a number of group sessions, a maximum of five children aged between four and seven years, at the interactive whiteboard. The children were in full time education at two special schools with an autism unit, and were diagnostically assessed as being on the autism spectrum, ‘low functioning’, and with little or no spontaneous use of verbal language. In addition, I have included feedback from experts using the software at an after-school-holiday club for children aged from nine to ten years, where children used all input devices as a part of play session.

6.1 Repetition

Repetitive actions can increase concentration as well as the capacity for understanding concepts, such as spatial awareness, pattern and shape (Seach, 2007). However, actions that are monotonous, with no evidence of intentionality, are frequently considered negative and can often become challenging in classroom situations. When observing the repetitive behaviours of children playing with ReacTickles, it was necessary to look for
the subtle distinction between actions that were perceived to be repetitious, with no interest shown in the outcomes, and those that were recurring, reflective and intentional.

In this study, most children began exploring ReacTickles through repetitive actions. Many of them manipulated the mouse repeatedly, pressed keys randomly or simply tapped the whiteboard. As confidence grew, most were able to move closer and further away from the monitor and whiteboard surface, and interact experimentally. A child using the mouse graduated from repetitive up and down movements to more expansive circling movements, anticipating responses to his actions; he was also able to concentrate and watch another child play. Another child, who began by playing with the mouse cable in his mouth, was observed shifting his attention from the mouse towards the screen, which was responding to his actions with an array of colours. As his concentration increased, he began to exert more pressure on the mouse, to move it in different directions and vocalise in response to his emergent interest and satisfaction. Three children using keyboard ReacTickles experimented with holding down keys in order to create more playful responses than repeatedly pushing a key and letting go. It was reported that each child wanted to touch different areas of the keyboard and moved from pressing individual keys to trying out the idea of holding down a key whilst concentrating on the effect this created on screen. At the interactive whiteboard, recurring actions were clearly being enjoyed as children were observed beginning their exploration with their fingers and quickly moving on to use their hands, front and back, arms, and in some cases turning their bodies around in between actions. The significance of this will be discussed in the subsection 6.2 in the context of rhythm and flow.

6.2 Rhthym and flow

Ellen Dissanayake (2000), in her powerful book, ‘Art and Intimacy’ describes rhythm and flow as the “patterned course of experiences, that unfold over time” and which are “instilled as part of our biological nature… predisposing humans to mutuality in the sharing of emotional states and patterned sequences with others” (p.6). She describes how children and adults with the most profound disabilities, both in mobility and language use, can participate in shared experiences that are rhythmically patterned. Further to this Csikszentmihalyi (1990) describes an aspect of flow as the intrinsic reward and pleasure that results from the unique exploration and interpretation of an experience.

For children playing with ReacTickles, rhythmic actions flowed from repetitive exploration. Coordination and concentration improved as children were able to fluently move the mouse around the clock interface. One child was able to play with the keyboard without actually taking his eyes away from the ReacTickles, he had created on the screen. By far, the most successful environment for experiencing rhythm and flow was the interactive whiteboard. The immediacy of touch, scale of experience and saliency of action enhanced the sense of play, as children were able to move from tentative touch to more forceful, gross motor activities. The qualities of rhythmic experiences, such as tempo, pressure and proximity were demonstrated through actions, such as stretching and circling, using full hand and arm movements. For example, one child touches the screen lightly with his finger, on realising that this created a shape, he repeats the action, when the shape appears to change position, he deliberately repeats the action but in a different part of the screen, this time the shape changes to a different shape. His excitement is clear to the other children in the class, and he choreographs the shape around the interactive whiteboard, laughing as it continues to morph according to position. Another child
W. Keay-Bright

touches the whiteboard with his finger and then stands back to watch the screen respond
to his touch, he touches it again, but this time, as he moves back, he turns around to draw
attention to his action. At the next repetition, he turns a complete revolution and the
dance continues with the addition of hand and body movements, expressively
demonstrating pleasure and satisfaction. One child was observed to violently flap his
arms and run back and forth from the whiteboard, his teacher encouraged him to touch
the screen and watch the effects of his actions, after a short amount of time he became
calmer eventually, choosing a ReacTickle that encouraged him to use sliding actions
across the screen and the anxiety passed.

6.3 Pointing and gesture

For most humans, the expressiveness of body language not only adds emphasis and
meaning to verbal communication, but also regulates attention and action (Bruner, 1972;
Goldin-Meadow, 2003; Hobson, 2002). For children with ASCs, the extended use of
gestures like pointing can reduce the complexities of communication and language and
provide a system for establishing mutual engagement.

At the interactive whiteboard, the use of the finger to control the action naturally
stimulates pointing as the primary input for action, whereas normally autistic children are
unlikely to use pointing to initiate actions, many of the children in the study used pointing
in combination with other forms of gesture to suggest that they wanted to draw attention
to their action (Figure 6). During group activities at the whiteboard, children regularly
used eye gaze, pointing and more exaggerated forms of gesture, to indicate that they were
in control and aware that others were watching. In a small number of cases pointing was
followed by simple declarative and instructional language, positively demonstrating
engagement. An example of this is the child who used a stylus pen to point to and control
‘bubbles’ and held them just above the shadow created by his head exclaiming, ‘look –
the bubbles are coming out of my head’. He then proceeded to make his shadow eat the
bubbles. One of the girls in the study played with ReacTickles using her toy to point to
the screen; as the ReacTickle responded she and her toy choose new ReacTickles from
the clock. She stands back from the surface and experiments with pointing the toy closer
and further away from the screen to observe the effect of the colours, as they appear to
change when they are reflected on the toy.

Figure 6  Pointing
6.4 *Imitation and mirroring*

Typically developing young children naturally imitate others; the exaggerated gestures they perform make it easy to mirror the actions of another and these forms of imitation are understood to be an unconscious way to demonstrate positive feelings, engagement and interest (Dissanayake, 2000; Edwards, 1996). Perks (2007), in a booklet designed to guide people with autism in body language and communication recommends mirroring body language, facial expressions, hand movements, gesture and posture as an initial way for children to bond with others. Whilst autistic children do not generally have difficulty in imitating the actions of others, they are understood to have problems in understanding the expressions of others as ‘expressive of their inner, subjective and emotional life’ (Hobson, 2002, p.250).

Although the studies evidenced some imitative behaviours, they were generally inconclusive. In desktop settings, imitation is difficult to encourage as activities are generally tightly focused on the monitor screen rather than communicating with a partner. Whilst the interactive whiteboard provides an ideal environment for imitative play, teachers seemed reluctant to exploit this opportunity and tended to use the environment for turn-taking activities. However, there were notable observations, for example, children playing at the whiteboard did use a progressive range of bodily actions to suggest that they were observing and imitating the interaction of their peers.

Although mirroring the behaviour of others was not an action that could be adequately monitored in these studies, the mirroring on screen of very personal and idiosyncratic movements did assist children in gaining confidence in a number of situations. This was considered to noteworthy because of the way ReacTickles spontaneously mirror the action of the child, which in turn encourages the child to respond and maintain the interaction through further mirroring. It was therefore suggested that ReacTickles prompt creative explorations with identity through reflected movement, light and colour effects. At the interactive whiteboard, it can also include the visibility of the shadow created by the position of the projector or the projection of colour onto the body. One child became fascinated by his shadow and chased it, with one finger in his ear, eventually appearing to dance. Two boys played with ReacTickle six by trying to get the worm to chase across the back of one, whilst the other observed and commented on the effect (Figure 7). What is significant is how these actions, when observed by others, became the trigger for the further exploration. Without the need for instruction, children learnt from watching each other, as no two actions are the same, each child was individually creative, and through maintaining interaction many were able to play collaboratively.

*Figure 7*  Using the body
7 Conclusions

This article aimed to present a vision of computer technologies as a trigger for expressive communication and creativity, through actions that are repetitious, rhythmic and experiential. Whilst the possibility of using different input devices for their physical qualities rather than as functional tools was considered a benefit, there was general agreement that the interactive whiteboard was the most playful environment; the directness of touch being cited as a high motivational factor together with the opportunity for exploring the impact of gross motor movements, shadow and colour effects. Using the whiteboard to encourage performance had the added value of assisting teachers to invent for themselves novel ways of integrating whiteboards into the classroom, as many of them had previously used it as a teacher-led digital blackboard (Rudd, 2007).

When interviewed about their role in the design process, experts reported that they found the experience valuable and particularly enjoyed seeing the project grow with their views reflected with each new development. Some suggested that the analysis of expressive and creative responses enabled them to discover more about the natural abilities children demonstrate when playing with ICTs. One consultant articulated this by stating that finding a design solution that addressed the learning needs of children who are struggling with a specific concept or language difficulty, ‘like the girl who was an elective mute who suddenly said ‘up, up’ when she had to physically stretch on the white board’, was particularly rewarding. Giving agency in this way to teachers and children to create meaning and amplify interests is not only desirable for positive teaching and learning environments, but also could provide real opportunities for ICT to meet curriculum objectives by offering holistic experiences that are genuinely inclusive and open to a wider range of interpretations by practitioners and other children.

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References


ReacTickles: playful interaction with ICTs


ReacTickles: playful interaction with ICTs


Note

Designing for Playfulness: Investigating the Therapeutic Potential of Technology Interfaces for Children on the Autism Spectrum - Wendy Keay-Bright

Paper VII
ReacTickles Global: A Non-Textual Mobile & Networked Play Space

Wendy Keay-Bright
Reader in Inclusive Design
Cardiff School of Art and Design
University of Wales Institute Cardiff
Cardiff, Wales, UK, CF24 0SP
+44 (0)2920 416609
wkbright@uwic.ac.uk

ABSTRACT
This paper describes, ReacTickles Global, an exploratory project that will investigate the potential of mobile and Internet technologies to encourage creativity and social interaction for young people with Autistic Spectrum Disorders. The paper will draw upon the experiences and outcomes of the Reactive Colours project, which developed on the basis of a flexible and agile design methodology that included the ideas and experiences of the target population at all stages. The broad aim of ReacTickles Global is to explore how the inherent connectivity of mobile and web technologies can be exploited to encourage playfulness and self-expression, and to evaluate the impact of this on learning that is both socially constructed and collaborative.

Keywords
Exploratory, playful, participatory, mobile technologies, experiential, self-expression

INTRODUCTION
The Reactive Colours project, funded by the National Endowment for Science and Technology Awards (NESTA), identified through both empirical and exploratory methods that certain fundamental aspects of social interaction and communication, two of the ‘triad of impairments’ that contribute to the diagnosis of Autism Spectrum Disorders, (Wing, 1996), could be promoted in young children with Autistic Spectrum Disorders (ASDs) through technology enhanced learning environments that enable children to use their physical and perceptual skills.

A practical outcome of this research has been the fully customizable ReacTickles software. The software is unique for this target group as it action driven, responding to sensory impulse rather than instruction. By modeling the design of the software on the highly individual capabilities and behaviours of a small number of children it has been possible to design an application that encourages social interaction through the act of being playful with desktop and interactive whiteboard technologies (Keay-Bright, 2007a).

Prompted by these findings, a proposed new phase of the research, described in this paper, will develop a mobile version of the ReacTickles software, called ReacTickles Global. Through this project we will evaluate whether mobile and Internet technologies, in promoting feelings of playfulness and feeling good about oneself, can encourage creativity and flexible thinking, the third of Wing’s (1996) diagnostic criteria and whether this can lead to increased motivation to share experiences with others.

Central playfulness is the need to ensure that the cognitive overload induced by many digital interfaces is reduced. This means that the activities must enable children to use skills their physical and perceptual skills, rather than purely cognitive ones. Technologies that appeal to a full range of skills are likely to be far more memorable and engaging for this target group, who will generally find sensorial experiences to be stimulating [12].

MOBILE LEARNING
Although research on the benefits of mobile learning is in its infancy, there is growing acceptance that mobile, personal and wireless devices are radically transforming societal norms of discourse and knowledge; the likely impact of both the technologies and pedagogies present significant challenges to formal educational practices [13].

For most young people mobile and Internet technologies shape the culture in which they live; increasingly ubiquitous, they offer seemingly endless opportunities for personalization. Many educational theorists have identified the potential of mobile devices as powerful resources in encouraging learning communities and meta-level thinking skills [9]. For social interaction via these environments to build critical knowledge, however, there must be willingness from others to participate in communicative exchange. Mobile communication, although ‘personal, situated and authentic’ [13], has an overtly cognitive dimension, and the opportunities for experiencing the sensory qualities for self-expression and playfulness which humans have naturally evolved to acquire remain limited. Much of the theory that surrounds mobile learning concentrates on the pervasive-
ness of the device in relation to the mobility of learners and the contextualization of learning environments [9]; there is very little research to suggest that mobile devices could have untapped qualities for self-expression though more abstract or symbolic expressions of ‘self’. However, online environments, particularly role-play games, have been shown to allow enthusiastic participation in the symbolic arenas of "embodied life" where players can then devote themselves to indulging their fantasies without guilt or fear of judgment [14]. In response to this ReacTickles Global proposes to explore how mobile and web technologies, through their inherent connectivity, can provide a portal for experimental expressions of self. The role of the technology is to provide a digital playground for constructing identity and discovering others. The wider application is to support constructivist approaches to learning, enabling learners to construct new ideas or concepts based on both their current and past knowledge [11]. In this context intersection of technology, child and practice could lead to a learning gain that is both socially constructed and collaborative.

REACTICKLES GLOBAL
An initial idea to migrate some of the salient features of ReacTickles to mobile devices won an award for “Innovative New Forms of Socially Responsive Media Across Multiple Platforms” in the Content 360 competition at MipTV in Cannes, France, in 2007. This led to a contract to develop a concept with promotional support from the National Film Board of Canada.

In this paper I describe our approach to concept development, which although heavily influenced by the Reactive Colours research, will endeavor to find novel and experiential ways of using mobile technologies, based on their unique properties for data capture, ie keypad, camera, GPS systems. In the same way that the ReacTickles rendered visible the idiosyncratic interests of its unique "players" in response to exploratory actions with the body or input devices, ReacTickles Global presents an opportunity for self-expression with mobile devices. For example, users might create ReacTickles using the numerical keypad or camera and add dynamic movements. In addition, it is proposed to enhance this experience through the Internet and to create a generative map of user “art”. In contrast with the current the Reactive Colours website (www.reactivecolours.org/gallery) which hosts ReacTickles in a “static” gallery, the idea for ReacTickles Global is to develop a more responsive environment for users to submit their creations and connect to ReacTickles created by others.

RATIONALE
Physical and Perceptual Engagement
Underpinning the design of the ReacTickles software has been the role of tangible interaction in learning and the beneficial effects on cognition that arise from physical and perceptual engagement for children with ASDs. ReacTickles used non-representational visual art forms to stimulate relaxation and to reduce the cognitive load. The software maximized on the notion of ‘calm technologies’ afforded through the tight coupling of the physical properties of input devices [15], (i.e. mouse, keyboard, mouse, interactive whiteboard and microphone) and a range of visually dynamic responses, that directly reflected user interest. In relation to this ReacTickles Global will investigate whether the unique properties of the hand-held device can encourage self-expression, not only as an authentic and personal means to enhance communication but also as a tool for making and manipulation [4].

Visual Arts
The visual arts, like other perceptual experiences, prompt creative self-expression through our evolved sensory and cognitive relations with the rhythms and modes of dynamic visual stimuli. As human beings we are naturally predisposed to respond to certain colors and other simple forms of visual phenomena. The vibrancy of tones and synchronicity of rhythms that underpin artistic practice provide an accessible route for personal expression and mutual exchange, demonstrating positive, emotional and motivational states of intent, pleasure and amusement [1]. For children and adults with profound disabilities, for example restricted mobility or limited ability with verbal language, the physical and perceptual qualities of non-verbal communication make it easy to mirror another’s expressed emotional state and to participate through actions such as intonation, rhythm and tempo. These imitative reactions remain an unconscious way to please and to induce positive feelings to others by communicating accord [1].

Technology as a Medium for Self-Expression
The concept of exploring technology as a medium for innovative aesthetic self-expression is not a new one. Avant-garde artists have long been fascinated by the possibilities of reading one system through another - using the tools and forms of one discipline to do something other than its original intent. For example, the Fibonacci number series has inspired visual and musical works of art through history. Long before the invasion of digital media, animator Oskar Fischinger created ‘visual music’ using shapes and primary colors as a direct interpretation of the elements of musical notation. In the mid 1970s, Rich Gold's algorithmic sounds led a group of like-minded artists to form the League of Automatic Music Composers (1978), his Goldographs became the inspiration for other forms of choreographed social performance [3]. Artists have traditionally engaged in making an as act of intrinsic pleasure, not for mass audience appeal, but for their friends and peers. This culture of sharing and openness is thriving among the interaction artists: ReacTickles Global, being intrinsically rewarding and fun, may have similar altruistic appeal as it maximizes on our innate desire to communicate with others, to strengthen bonds and make new alliances.

PROPOSED METHODOLOGY
Recent research on the role that people with learning difficulties have to play both as the subjects of research and as researchers themselves calls for innovative methods that enable and empower all participants to have a voice in interventions that are likely to impact on their daily lives.
The Reactive Colours project addressed this issue by placing young children on the Autism Spectrum, together with their families and teachers, at the heart of the development in face-to-face settings and through the Reactive Colours website. The aim was to introduce a level of participation that would be missed had the project solely relied on empirical methods. In order for the target group to be fully represented it was essential to devise a model that enabled the emergent, unpredictable and idiosyncratic behaviors of people to present themselves without fear of judgment.

For many of the young children involved in the study simply having a person present who was unfamiliar to them could be heavily disruptive, so at all times it was necessary to work at the discretion of teaching staff but to ensure that teachers could introduce activities to children in such a way as to allow the child to lead and demonstrate abilities that might not have been obvious within the confines of a typical classroom situation [5].

In addition to the involvement of a small number of children at a Special Educational Needs school, the rapid iteration and release of ReacTickles software prototypes on the Reactive Colours offered a ‘suck it and see’ opportunity to experiment with the software and give feedback through a variety of online methods. Significantly, the openness of the project prompted users to share with their experiences with others. For the young children using the software in trials at school, the website had the added benefit of extending the learning experience to the home and other environments (Figure 1).

![Figure 1: An example of a ReacTickle Screen © Cardiff School of Art and Design](image)

ReacTickles Global will build on this democratic and agile methodology in order to deepen our understanding of the potential of people who may lack motivation or skill with textual and verbal communication, in an authentic context that explores the constituents of interaction design. The process of involving stakeholders in the design of ReacTickles Global will begin with a design workshop and rudimentary prototypes, which will be offered to a small group of young people to play with. The purpose is to find out what they may find interesting in an application such as this and to invite them to contribute ideas, which will be and used to inform further development. Plans are under-way to work with a ‘focus group’ of young people from aged 9–10 years at a holiday club that provides care for young people with multiple learning difficulties. Giving agency to make suggestions and influence decisions to a small group will provide opportunities to explore the kinds of creative expression people find meaningful and wish to share, if at all, before considering wider applications for the technology. Trust can be established on the basis of openness and transparency, and unpredictable responses can be monitored and evaluated in the contexts in which they arise. It is important for the development of this concept that ideas can surface fluently, without pressure to ‘get it right’. This approach supports the belief that we are best placed to appreciate the benefits of technology when we allow people to explore, in other words, it is not about what technology can do, it is about what people do with it. Functionality will be considered in terms of learner objectives, so that requirements are refined without imposing premature design or technology on the outcome.

The programming and design team will iterate versions on the basis of a continuous flow of ideas generated through the collaboration with the focus group. The aim is for short feedback loops, with functioning prototypes resulting from each cycle, so that value to the learner is considered in tandem with ‘usability’.

To ensure that our methodology is open and transparent, versions of the software will be released as it evolves on the ReacTickles Global wiki. In addition to collaboration with the focus group, an open-source method for development and distribution will enable people to freely comment on, adapt, modify and share ReacTickles Global without the bias of questionnaires or observation.

**Evaluation Challenges**

As the technology application becomes robust we will evaluate whether:

1. playfulness with mobile devices can support creative thinking and imagination;
22. the emphasis on visual representations of self can increase the confidence to communicate with others;
3. an open online map can generate an interest in the activities of others.

Being playful is generally regarded as a fundamental element in the creative process. The National Advisory Committee on Creative and Cultural Education (NACCCE) describes creativity as an “imaginative activity fashioned as to produce outcomes that are both original and of value” [8]. However for many young people with ASDs their intuitive playfulness has been compromised by learning activities that are overtly cognitive, appealing to logical and systematic thought processes at the expense of more holistic, experiential approaches [12]. This research will undertake an extensive assessment of existing metrics that are designed to measure creativity and imaginative thinking. The goal of the assessment will be to discover an effective evaluation strategy for learning that is tacit and experiential.
CONCLUSION
Reactive Colours was a discovery-led project that gained critical acclaim because of the vital relationship between the design process and the creation of playful digital activities for autistic children, as their unpredictable and idiosyncratic behavioral patterns rewarded the research with a new perspective on interactivity. The interdisciplinary approach to collaboration presented a challenging paradox requiring both imaginative and empirical design methods. Whilst it is often critical to have statistical analysis to satisfy scientific approaches, it is of equal importance, within this area of research, to recognize the value of the anecdotal and spontaneous responses that flow when people are free to invent their own purposes for technology. We also learnt that using non-representational forms encourage fluency and experimentation. When there is no language or cultural constraint pleasure can be derived from the simple rhythms and modes of preverbal communication, such as touch, proximity and synchronicity [6]. Building on these achievements, but equally exploratory, ReacTickles Global will explore ways in which people can relate to each other through the inherent connectivity of mobile technologies. It is our belief that participatory design has a responsibility to faithfully represent the interests and ideas of disenfranchised groups in novel and exploratory ways. In this context, design has the potential to only address and solve problems but to challenge perceptions, reduce the barriers to inclusion and ultimately, to increase advocacy.

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Designing for Playfulness: Investigating the Therapeutic Potential of Technology Interfaces for Children on the Autism Spectrum - Wendy Keay-Bright

Paper VIII
Designing for Children
- With focus on ‘Play + Learn’

Designing Inclusive & Playful Technologies for Pre-School Children

First Author: Wendy Keay-Bright, Reader in Inclusive Design, Cardiff School of Art and Design
University of Wales Institute, Cardiff, CF5 2YB, wkbright@uwic.ac.uk
Second Author: Adam Martin, Senior Lecturer, Newport School of Art, Media & Design,
University of Wales, Newport, NP18 3QT, Adam.martin@newport.ac.uk

Abstract: This paper reports on an investigation into the potential of everyday technologies to foster playful experiences for young children prior to their formal education. The aim is to consider how best to design age appropriate experiences that are desirable and useful within pre-school settings, and to assist practitioners in experimenting with technologies in the early years school curriculum. This phase of the study focuses on observations of the real-time, non-digital play of young children in a pre-school playgroup and the subsequent introduction of group activities with affordable, non-specialist devices such as ReacTickles, Wii remote and microphone. The study captures the vital inspiration phase of design research. By utilizing observation and interview as an analytical framework to help practitioners to articulate the nuances of playful interaction, the designers have been able to draw early conclusions that provide the guiding principles for future design.

Keywords: play, inspiration, technologies, inclusive, interaction, pre-school

1. Introduction
Play is explicitly acknowledged in Article 31 of The United Nations Convention on the Rights of the Child, which states that:

- Parties recognize the right of the child to rest and leisure, to engage in play and recreational activities appropriate to the age of the child and to participate freely in cultural life and the arts.
- Parties shall respect and promote the right of the child to participate fully in cultural and artistic life and shall encourage the provision of appropriate and
equal opportunities for cultural, artistic, recreational and leisure activities.

The study was conducted in a pre-school playgroup with practitioner experts in education and inclusion. The motivation arose from a desire to design age appropriate technologies that support autotelic play; particularly the sense of immersion and flow achieved through concentration, repetition and imitation within early years learning settings (Csikszentmihalyi, 1991; Keay-Bright, 2007a). Autotelic play is valued as a non-formal learning experience, which encompasses “ludic activities motivated by curiosity, exploration, play and aesthetics rather than externally defined tasks” (Petersson, 2006, p40). Research has shown that autotelic play enhances a child’s sense of agency and self worth, which can advance skills in more formal areas as a child develops, particularly creativity and social interaction (Petersson, 2008). Furthermore, the study also needed to consider how to empower practitioners to use technologies creatively in their own contexts.

Whilst certain developmental play theories have informed this study (Rubin, 1989; Piaget, 1951; Vygotsky, 1962), the goal was to gain inspiration from the real-life interactions of children and the adults responsible for their well-being, and to determine methods of encouraging practitioners to articulate their observations and ideas. The analytical framework focused on gathering qualitative data through interview, observation and video analysis. The data was used to inspire, enrich and inform design, as well to consider the usefulness and desirability of prototypes, from the end-user perspective (Kouprie & Sleeswijk Visser, 2009; Keay-Bright, 2007b, Battarbee & Koskinen, 2005).

The phase of the study reported in this paper uses Rubin’s Play Observation Scales (1989) to assist in analyzing play experiences. Informed by early observations, the researchers discuss how a software interface designed for autistic children, ReacTickles, together with certain non-specialist technologies, such as the Nintendo Wii and a microphone, can support developmentally appropriate play, without making unnecessary demands on practitioner time (Keay-Bright, 2009). The findings from this initial phase of the study demonstrate the need for designers to strike a balance between creating technologies that are functionally interesting, without becoming cognitively overwhelming, and those that provide the opportunity for children to deepen interaction on their own terms, which is key to achieving the sense of flow and immersion so readily discovered in real-world interaction.
2. Design for children: the context for this study
This study involved collaboration with two external partners, Autism Cymru and Mudiad Ysgolion Meithrin. Autism Cymru is Wales National Charity for Autism and Mudiad Ysgolion Meithrin (MYM) is a voluntary organization that offers early years services and nursery provision for children under three years old through the medium of Welsh. Autism Cymru works closely with MYM in the delivery of training to celebrate diversity and promote inclusion. Both organizations support practitioners in delivering the Foundation Phase curriculum for 3-7 year olds in Wales.

Within the curriculum little use is made of sensory engagement with technology. Planning for physical development, including fine motor skills and an awareness of space, height and distance, is positively encouraged as a means to support play. However, the kinesthetic, and spatial/visual properties of technology are not featured as important for playful interaction. Play with technology tends to be instructional—biased towards learning goals and the acquisition of skills—flow and immersion can only be achieved if the child is able to focus on a predetermined task. For very young children this type of activity is developmentally inappropriate, cognitively overwhelming and inhibits personal exploration.

2.1 The setting for the study
The preschool playgroup included approximately 22 children, who regularly attend for either full- or half-day sessions. The atmosphere in room is busy, noisy, happy and relaxed. The space is designed to support clusters of activity and to accommodate the variety of playful explorations associated with children of pre-school age (2-3 years).

3. Methods
The approach undertaken by the researchers describes a feature of participatory design, whereby knowledge and experience of a situation and its potential for interaction is gained through close and regular contact with end users (Kensing, & Blomberg, 1998). Input from end-users and those who support them, not only serves as a validation process but also provides vital inspiration for designers that cannot be achieved through empirical processes that fail to acknowledge individuality (Kouprie & Sleeswijk Visser, 2009; Keay-Bright, 2007b, Battarbee & Koskinen, 2005).
Described here are three observational sessions undertaken with playgroup children and practitioners over a period of one month. Each session was guided by the practitioner and lasted around 20-25 minutes. The researchers focused the first observation session on non-digital interaction with the toys, objects, environment and other people. Whilst these interactions were clearly not augmented through technology they provided sufficient baseline information to enable the researchers to experiment with certain scenarios in which technology could be introduced during subsequent sessions. Other ecological information, for example: the risks to be assessed for installation, level of instruction required, location and scale of equipment, as well as need for children to freely to move around and ultimately share technologies, supported the researchers proposal to introduce non-specialist technologies such as the Wii controller, microphone and the ReaTickles software. The researchers conducted short interviews with practitioners in which they established that the sessions would involve small groups, maximum 10 children.

Later sessions will involve the use of Nintendo Wii remotes, inexpensive game controllers used to interact with gestural based console games. For example in the Wii golf game the physical action of swinging the controller like a golf club makes the onscreen character mirror the same action within the game. This ability to of the controller to mirror the physical activity of the real world-on screen could be used to further enhance the ReaTickles experience. The Wii controller when connected to a computer via Bluetooth can be used as an alternative to a desktop mouse and provides additional access to motion sensors and an infrared point-tracking camera. This makes the Wii controller an attractive device with which to develop unique gesture-based interactions. It is intended to modify the dancing squares ReaTickle to respond to the physical motion of the Wii controller as a child is manipulating it. By introducing further controllers up to four children could interact physically with the onscreen objects, creating opportunities for collaborative and social play.

One of the underlying principals of the study is to develop playful experiences that are available to practitioners with limited technical and financial resources. Therefore complex equipment setup, expensive cameras and specialist software are not appropriate for this target group of pre-school practitioners. Given these constraints it is still possible to use off-the-shelf webcams and the ubiquitous Adobe Flash player software to create interesting applications. The Flash software for example provides a simple method for detecting the activity level occurring in a webcam image. This could be used to create new ReaTickles that respond to varying levels of motion, much like the volume level of a
microphone. Using more sophisticated techniques such as edge detection and difference-images between frames it is possible to develop ReacTickles that respond to more specific movements and silhouettes of the children. However an initial test of the software found that the limited setup time of around 10 minutes and positioning of the projector and camera was prohibitive.

Further sessions will be used to assess the feasibility of applying these techniques in the pre-school environment. As further prototypes are developed and refined it should be possible to provide the pre-school with examples to use on a more regular basis with their own computing equipment. This would provide an opportunity to assess the longer-term impact of using this technology within the pre-school environment and give the staff more opportunity to develop their own play activities based around the software.

3.1 Gathering data
In contrast to research that relies on empirical data to assess the role of play in cognitive development, this study favored qualitative and discovery-led methods as a means to discover the totality of play situations. Practitioners were invited to participate in the design of the study in order to optimize the understanding of play patterns through their knowledge of individual children and to assist the researchers in appreciating the ecological and social contexts for play. Although none of the practitioners had experience with using technology with their young charges, they were happy with the proposals to introduce the non-specialist devices. It was proposed that relevant data should be captured using video recording, transcriptions of observations, open-ended interview techniques and photography, these being the least time consuming for practitioners and non-invasive for children. Hand held-video was used in the early observations in order to focus on interactive play, particularly to look for instances of functional and autotelic play. Although this method is frequently avoided as it can draw unwanted attention to the camera and thus bias responses, in this particular setting the children showed little interest in the camera and played naturally.

Rubin’s Play Observation Scales - POS (1989) were used as a general guide for the analysis of video footage. Observations and interviews were employed far more generally as a free-form method of capturing ideas for the implementation of technologies and as inspiration for design (Keay-Bright, 2009).

4. Playful Technology Interfaces
4.1 ReacTickles Software, microphone, and Wii remote control

The ReacTickles software is an example of simple, playful interaction design that was originally created for children with autism spectrum conditions (ASC). ReacTickles encourage the child to play with technology in a functional way, by manipulating physical properties, for example mouse, keyboard, switch, joystick, touch screen or if using a microphone, ReacTickles are sound activated. A dynamic visual response is rendered immediately visible wherever the output is projected – monitor, wall, whiteboard—that introduces the concept of space and proximity, pressure and movement through the behavior of primitive shapes and colors, Figure 1. The challenge for the child is to bring the projected surface to life by touching, smoothing, dragging, shaking, stretching or sound and to explore and maintain the interaction through repetition.

![Figure 1 Play with ReacTickles at the interactive whiteboard](image)

4.2 Embodied Interaction

ReacTickles and the other technologies described in this paper foster embodied interaction, which means that familiarity, ease of understanding, and engagement are gained from repetitive physical action and information in the environment rather than instruction. Dourish presents a perspective of embodiment as the “property of our engagement with the world that makes it meaningful” (2001, p126). When we act in an embodied way we are motivated by bodily instincts and our innate ability to interpret information in the environment through our senses (Heidegger, 1996). Conversely, when we interact in the virtual worlds of desktop computers, we become disembodied receivers of information and rely on cognitive, rather than physical processing. When information is presented with no physical constituents, successful interaction relies on instruction rather than intuition (Norman, 2005).
5. Discussion
5.1 Non-digital Play

The cognitive play behaviors of children were consistent with Piaget’s (1962) and Smilansky’s (1968) classification as: (a) functional — repetitious and sensorimotor with and without objects; (b) constructive — manipulative, with a desire to create something; (c) dramatic — creating an imaginary situation through the contextualization of objects in the environment; (d) games-with-rules — accepting prearranged routines. These four categories of play are understood to develop simultaneously and are related to the social context of play (solitary, parallel and group play).

Children were generally content to engage in functional solitary play with little desire for collaboration from peers or staff unless there was a specific purpose, for example requesting. When playing with toys, children became immersed when parts of the toy invited further interaction. Other children appeared content to watch the play of peers for short periods of time when they were at a close focal length; however, they rarely joined in unless the practitioner organized the activity. Group play was centered on making things and singing.

5.2 Play with Technology

Practitioner intervention made significant impact on optimizing the sessions where technology was introduced. The first two ReacTickles sessions used the microphone and keyboard and interactive whiteboard; these were conducted as small group activities. When the technology was introduced to the first group, children were happy to randomly explore without assistance and to play alongside each other in parallel, for example manually investigating a keyboard to make patterns, and jumping up and down in front of the projector to make shadows. However the playfulness of the session increased dramatically when the practitioner introduced games-with-rules, for example singing and using instruments. By far the most engaging ReacTickle, that held the children’s attention was a square that simply wobbles when there is no interaction. When interaction occurs though sound or touch the square splits into twelve smaller squares which appear to dance; the greater the input volume or pressure the further the individual squares move. As interaction decreases so does the momentum of movement until the square reforms as one. With practitioner support the children practiced a song that required them to understand the Welsh words for “quiet” and “noisy”. When the practitioner drew their attention to the movement and acceleration of the projected image they quickly grasped that they were in control and maintained the interaction. Those children who had
observed the first group of children quickly mastered the situation and used the technology to manage their own performances as soon as the formal session ended, without the need for instruction.

Intervention from the practitioner clearly assisted the children in the gaining confidence to playfully interact within the environment. High relevant to this, the practitioner immediately felt able to organize an activity without assistance from the researchers, having witnessed a demonstration of the software and some impromptu interaction from children, Figure 2. Thus the playfulness arose as a mutually enjoyable experience and acceptance of the technology was established. As a direct consequence, further ideas flourished, most notably the practitioners could articulate ways in which the technologies could be used to augment existing play strategies.

![Image](image_url)

**Figure.2 The technology set up in the playgroup**

**6. Results**

The overarching aim of the study is to consider how best to design age appropriate technologies that are desirable and useful within pre-school settings, and to assist practitioners in experimenting with technologies in the early years school curriculum. Our findings from the first stages of this study reported in this paper suggest that designers need to:

1. Take care to ensure that hardware is easy to install and to avoid the need for technical support.
2. Gain the confidence and interest of practitioner as the key to optimizing interaction.
3. Use one interaction modality (for example, sound or touch) to correspond with
one output response.

(4) Encourage repetitious and recursive actions to enable the child to observe his own action.

These design guidelines have been defined in relation to the ecological and social contexts in which play arises and is understood.

6. Conclusions
The limited conclusions of the study have enabled the researchers to meet the goal of finding inspiration by observing participants — children and practitioners — in authentic settings and gaining the confidence to extend the study by introducing new technologies and prototypes to the playgroup. Promoting collaboration between the researchers and practitioners has been highly motivating for all concerned, which has directly impacted on the children’s enjoyment of the sessions to date. As regards the introduction of technology into the early years curriculum, early findings indicate that when children are able to playfully interact with guidance from a motivated practitioner, autotelic play, non-formal learning and pre-verbal forms of social interaction, such as concentration and turn-taking, improve. Determining a mode of playfulness with technology where input is action-driven without overwhelming the child with complex adaptations, sophisticated imagery, metaphors and semantics has the potential to include all children and ultimately offer a positive introduction to their future uses of Information Communication Technologies.

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