ABSTRACT
ReActivities© are digital play sequences which encourage the integration of social, emotional and cognitive development in children on the autistic spectrum.

Funding from the National Endowment for Science, Technology and the Arts (NESTA), Learning Programme, has enabled a collaborative approach to the development of the ReActivities© software. As a result of working directly with children on the autistic spectrum and those who support them, an organic design process has emerged which embraces their distinct needs and characteristics.

Discovering how autistic children play has been revelatory. Something which normally developing children experience so naturally is often profoundly missing in autistic children for whom high levels of anxiety 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.
Thus 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, which are so often suppressed by the tensions and anxieties of daily life.
In response to this 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, Interaction, Collaborative Design, Digital Environments, Monotropism

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, (Beyer and Gammeltoft, 2000; Jordan, 2003; Leslie, 1987; Sherratt, 1999).
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, (Baron-Cohen, 1987; Ungerer and Sigman, 1981), 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).

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 - mono-tropism - (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”. 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.

**REACTIVITIES© PROVIDE APPROPRIATE CONDITIONS FOR PLAY**

Murray, Lawson and Lesser's theories on tunneled 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, (Sherratt, 1999; Libby, Powell, Messer and Jordan, 1998). 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 multi-sensory 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 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 programmes 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 familiar with the ReActivities© routines will have the opportunity to define and customise their unique individual experience.

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 (ICT) 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 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, onto a large-scale environment. 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 Assitants (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.

METHOD
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 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.

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.

ACKNOWLEDGMENTS
The developers of the ReActivities© software, Wendy Keay-Bright, Ben Norris and Alun Owen are indebted to the staff and children of the Hollies School in Cardiff, Wales, in particular, to Glynis Thomas, head of the Autism Unit, for their continued, unwavering support and belief in this project.

REFERENCES


