

Designing Interaction Though Sound and Movement with Children on the Autistic Spectrum

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Abstract. This paper documents the making of ReacTickles MAGIC, a series of exploratory technology applications that use multi touch and sensor inputs on consumer devices. The ReacTickles concept is based on cause and effect activities that are highly responsive to individual interest. Especially targeted have been individuals on the autism spectrum who experience the most profound impairments in social communication, and have limited opportunities for self expression and meaningful interaction with others. The paper will review the basic design principles that emerged from early research with this target population and describe how these have been embodied in ReacTickles MAGIC. With reference to the impact of participatory design methods, the paper will discuss the early formative evaluation, from which we draw certain conclusions for future concepts.

Keywords: autism, cause and effect, communication, playfulness, motion sensor, multi-touch, interaction.

1 Introduction

The original ReacTickles applications were designed as cause and effect activities in which shapes and colours responded playfully to interaction with a mouse, keyboard, microphone and interactive whiteboard. Throughout the development of the software autistic children aged 4-7 years, and their teachers, were involved in envisioning, exploring and implementing prototypes. Over a period of two years, as the design became more refined, teachers made many compelling videos that captured the engagement of children as they explored ReacTickles in the classroom. Data from videos, interviews and extensive field notes led to the conclusion that the key to unlocking communicative potential through this technology was to make the interface as uncluttered as possible. This meant stripping out any extraneous detail that might presume level of cognitive ability, and avoiding any references to real world objects or to characters that impose meaning. What became clear from these studies was that the simpler the interface the more relaxed, expressive, imaginative and dynamic the actions of children.

In recent years multi-player inputs have become readily available to the consumer market through game consoles and multi touch tablet computers. The affordability of consumer hardware provided an ideal opportunity to extend the ReacTickles concept of user-led, responsive interaction with abstract forms beyond the desktop, which is being exploited in a new project, ReacTickles MAGIC.

In the same way that ReacTickles put children and teachers at the heart of development, inspiring and informing the design throughout, this extension into gestural interaction and multi touch has come about through an opportunity to design at a school that provides specialist education for some of the most severely autistic children in the district. This paper will describe the background, rationale, design principles and methods that have led to the creation of ReacTickles MAGIC.

The next section begins with a brief overview of the communicative impairments that constitute a diagnosis of autism. This is intended to provide the reader with a context for understanding the complexities of designing for this group, and the challenges faced when designing user-led technology applications within a special school setting.

1.1 Background to Autism: Social Communication and Repetitive Behaviours

Autistic Spectrum Conditions (ASC) affect approximately 1% of the child population, [1]. ASC is diagnosed when impairments in social interaction and communication as well as restricted, repetitive patterns of activities and interests are present. One of the key goals in the education of children with ASC is to help them acquire competence in social communication [2]. Social communicative competence plays a major role in our ability to form those relationships that allow us to interact happily and effectively in the communities in which we live. Positive long-term outcomes for individuals with ASC are strongly correlated with competence in social communication.

When social communication is misdirected or misunderstood a negative feedback loop is created that hinders social development profoundly. This can become all the more problematic when children engage in off-putting behaviours, such as repetitive self-stimulatory acts, or making inappropriate comments. Deficits in social skills have the capacity to lead to a harmful developmental trajectory, causing social anxiety, depression and isolation [3] [4].

Autistic children demonstrate core neuro- and developmental challenges that impact on their ability to predict the intentions of others [5]. Repetitive activities that enable them to predict and control an environment, and in which others can join in, are vital in gaining self-awareness, and, ultimately, the desire for social communication [6]. Difficulty predicting the intentions of others impacts on the ability to attend to the most relevant information, process that information and problem solve within social settings. When situations arise as a result of an unpredicted change to routine, heightened anxiety and social withdrawal often results.

Whilst many interventions are designed to support young people in the development of social communication, there have been few studies that aim to directly target this need for predictability in a positive manner that combats the negative effects of poor self esteem. In response to this, the work reported in this paper aims to assist people with

ASC in overcoming poor feelings of self-worth by enabling them to predict sequence, predict how to engage, predict how to regulate their emotions, predict that others can be a positive source of emotional support and to predict why they are engaged in a task. Individuals who display a greater capacity to self-monitor their emotional state are more able to maintain social engagement, to problem solve, to cope with unpredictable forces and to communicate effectively [5].

2 Design Principles for a Positive Emotional Experience

ReacTickles has been commercially available since 2007. Research conducted following its release has confirmed that certain features of the software have proved enabling for young people, demonstrating positive impact on concentration and flow, [7], expressive communication and creativity [8] and self awareness [9]. These features, described below, have been embodied in the design of ReacTickles MAGIC, a new series of applications that include multi-touch, motion sensor and sound inputs, which are amplified through a projector. The scale of the projected output makes interaction highly observable and palpable as an experience unfolding in the here and now. The look and feel of ReacTickles MAGIC remains consistent with the original ReacTickles; it is based on the use of shapes and high contrast colours that can enable children to focus their attention, and for this focus to be observed and shared with others. The cause and effect style interaction has been designed to mirror such phenomena as elasticity, gravity and inertia, meaning that as soon as the child disturbs the shapes, they respond by moving around the projected area in perceptibly magical ways, drawing the focus of attention away from the original location of the shape. The behaviours attached to the shapes, whereby they appear to be pulled, pushed, stretched, dragged or tickled are consistent in that they always settle and return to their start position. This playfulness and predictability has remained the most defining feature of the software. This is embodied in the following design principles:

- 1) *Meaning is discovered through action*: avoid unnecessary detail that presumes the user interest or level of cognitive ability, let the person add complexity in how they animate the interface through their interaction.
- 2) *Simplicity yields novel user-centred experiences*: depending on the mood of the user the interface can be surprising, joyous, relaxing, funny, energetic, cheeky and enduring. A design that does not overwhelm the user leads to experiences that are open to interpretation and purpose, thus avoiding the negative feedback loop that arises from perceived errors and confusion.
- 3) *Provide a rich playground for sensory exploration*: colour, light, texture and sound can specifically condition the experience and afford both an aesthetic and metaphoric surface for imagination. The main function of the interface is to trigger curiosity and to reward interaction with positive emotional experiences, for many people this will be the key to unlocking potential. This means designing elements that are naturally stimulating but that do not overburden the player with complex features that require an unnecessary level of cognitive processing and compliance.

4) *Trigger curiosity through repetition and flow*: the interface affords natural kinetics, rhythms that are created through a visual and aural syncopation between input and output. For example pressure may increase size; movement may change speed, scale, opacity, colour; sound may condition any of these, but the repetition of interaction can create rhythms and patterns that increase interest through the opportunity to personally choreograph the experience.

3 ReacTickles MAGIC

ReacTickles MAGIC has been developed at a special school for pupils on the autism spectrum. A small team of developers and the researcher established a base room at the school, which was a large unused space with little natural light. The room was set up with a laptop computer with in-built microphone, a projector and a Kinect motion capture sensor. Kinect is a consumer device sold with the Microsoft game console, xBox. No other technology was required.

The design of MAGIC was based on the simplest shape, a circle. A menu provides eight different MAGIC applications, each with three levels of difficulty. When the input devices pick up movement and sounds the circle will respond. Changing the levels of difficulty can increase amount of colour or make a new shapes, or impact on acceleration of the shape. Movement can cause the shape to cluster, spin, and trace the child's body position. When the child perceives the circle on a projected surface - in the MAGIC room this is the wall, or on the iPad it is the screen - the visual sense distinguishes it as different from the background space. The circle becomes more meaningful when it responds to input, moving as the child moves or makes a sound.

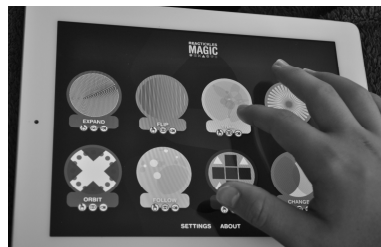


Fig. 1. ReacTickles MAGIC interface on the iPad

3.1 Physical Directness

ReacTickles MAGIC combines a number of sensory inputs which are behaviourally and perceptually coupled with visual outputs [10]. Each input action is mapped to an instant graphical representation, affording physical directness through cause and effect. This notion of physical directness is of interest to interaction designers as it impacts on the level of cognitive processing required by the user to navigate an interface. Beaudouin-Lafon [11] describes three aspects of physical directness. Firstly, the *degree of indirectness* refers to the temporal and spatial distance between input and output, or cause and effect; secondly, the *degree of integration* refers to the

degree of freedom between the input tool and the level of interaction afforded, and, lastly, the *degree of compatibility* refers to the similarity or match between actions with the input device and the reactions the manipulated object. Within the design of ReacTickles MAGIC, there are varying degrees of physical directness, which were explored during the iterative cycle of development.

4 Participatory Design Methods

The Participatory Design movement has been 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 [12].

4.1 Participants

Participatory design for ReacTickles MAGIC was cohered around the involvement of a group of 6 boys aged 15 years with low functioning autism (LFA) and three of their teachers. The boys used no functional verbal language and had very poor concentration. Prior to setting up the project and the MAGIC room, we undertook familiarisation activities with them, blending into the classroom routine, in order to become accepted by the group and to avoid unwanted distractions during the study.

We began the process of developing ReacTickles MAGIC with a four day design workshop, which included the design team - two programmers, a designer, a researcher - the 6 boys and the teachers. Early ideas coming from staff were based on non-digital cause and effect activities that the boys were known respond to. We demonstrated how the motion sensor worked, that it didn't respond to touch and then storyboarded some ideas based on circles that flocked around the user as they moved in front of the Kinect sensor. These became our first ReacTickles MAGIC experience prototypes. Experience prototyping [13] was considered the most effective method for iterative design as it would enable the design team to evaluate whether or not the proposed technology concepts could interest the boys before refining them.

The 6 boys were first introduced to these early ReacTickles MAGIC prototypes as a group. When the ReacTickles shapes tracked their movement, they showed no interest whatsoever. With so much movement in the room the cause and effect was very hard to follow, they were also were distracted by the light from the data projector. They displayed stereotypical behaviours such as hand flapping, erratic movement, and vocalisation, and took only fleeting glances at the projections on the wall. However, the teachers really enjoyed the experience and felt that given time the boys may begin to interact. They suggested that they boys would benefit from being introduced to the room one by one, rather than in a group. The design team responded by rethinking the interface, reducing to one shape that could be controlled by sound. Even though each child's vocal repertoire was limited to very few sounds, we took those as an indication of communicative ability. We progressed our concepts on the basis that if vocal actions or sound inputs provided the trigger for cause and effect, the

children may become more aware of their own locus of control, and from this emerging sense of awareness we would gradually introduce more complex responses.

Over the next three days we created prototypes that varied in the degree of physical directness, with the motion sensor offering the least physical directness and the sound inputs offer the most. In relation to this we also varied the complexity of visual feedback, from one monochromatic shape change to a sequence of different shapes and colours, which enabled us to explore the degrees of compatibility necessary to support the children in maintaining interaction beyond the initial experience of discovery.

Periodically, in between intense sessions of programming, the boys came into the room. At the suggestion of one of the staff team, ReacTickles MAGIC was introduced to a group of 4 more verbally able children with Asberger Syndrome. This group were confident in articulating their thoughts and ideas, but were noted as having challenging behaviour and difficulty with concentration, organisation and flexible thinking. For the designers, having the opportunity to observe this group provided real insight into the diversity and complexity of the autism condition. This group became highly animated at being able to control the system through their movement intrigued by the power they seemed to have over the system. They very quickly realised that if they didn't move, they would be able to stop any visual effects, and the motion sensor would make them "invisible". This led to an unprecedented degree of turn-taking as they challenged each other to create and control the visual interface. By the end of the Lab, ReacTickles MAGIC was running from one interface menu and was fully installed in the room on the school computers so that teachers and classroom assistants could continue to use the system.

5 Discussion

Over the following eight weeks the same 6 boys took part in one ReacTickles MAGIC session per week with their teachers and the researchers. The sessions were timetabled at the request of staff, who had seen positive changes in behaviour for each child over time, and a significant reduction in *unwanted* behaviours in the children who were frequently challenging in the classroom. Each child has responded in highly individual ways. One boy, noted as having the most challenging behaviour, enjoyed a clapping game which generated a new small circle with each clap, the circles form a pattern of circles in the shape of a clock and on reaching the twelfth circle, the pattern changes to a square. The application had a clear start and end point to a sequence and the *degree of compatibility* between his actions and the response of the shapes provided a focal point for his attention. The child was observed to need proprioceptive stimulation, he was continuously jumping around and bumping into people. We experimented with offering him a large exercise ball to give him an opportunity to continue to stimulate his proprioceptive sense whilst interacting with the applications. This proved highly motivating for him, he used the ball to interact with the motion sensor, observing how he could change the flocking of circles. He also used the ball as a drum, changing patterns through the volume of sound. Movement and sounds afforded by the ball as an input device enabled a *degree of integration* that was important for his child. After three

sessions in the room, his playfulness and flow of concentration increased, he became calmer as he observed his movement and sound projected on the wall. During the 4th session, he began to verbalise shape names. He pointed to his classroom assistant for guidance and verbalised all the shape names in the system: *circle*, *square*, *triangle*, *heart*, *cross* and *hexagon*. At the most recent session he controlled the interface by altering sound patterns, he articulated the shape names and added colour names. He has also started to use the iPad version of ReacTickles MAGIC, seamlessly transferring his knowledge onto the new platform.



Fig. 2. Exploring the circle of shapes in the iPad

The other boys have made less progress, however, each one is showing signs of individual ability through being able to predict the sequence of interaction. The teaching staff confirmed that some of the reactions observed (copying, observing, participating, taking turns) may seem insignificant to the casual observer, but they represent huge milestones for students with more severe ASC. The data collected during this phase has been used as formative evaluation to ensure that the technology is robust, useful and desirable. The next phase of the project will be to undertake studies that evaluate the effectiveness of ReacTickles Magic in supporting expressive, functional communication. Our hypothesis is that when the child with autism is happy, relaxed and confident in their own ability - through being able to predict a sequence and explore through rewarding interactive play - communication with others may be more desirable. To this end, we are developing methods for observing and analysing highly nuanced experiences in a meaningful, systematic manner. Specifically, we will look for instances of increased concentration and flow, initiating and choosing a sequence of actions, initiating a bid for attention and sharing attention with another person [2] [5]. We are creating a coding scheme for micro-ethnographic analysis using a systematic video performance tagging software tool [15]. Capturing data from multiple angles, we will use the system to observe and monitor children's interactions within each session and over time. This will be complimented by more freeform analysis and interviews with teaching staff.

6 Conclusion

This paper has aimed to provide some insight into the creation of a software interface, ReacTickles MAGIC. From our early observations and from interviews with teaching staff we have noted that the playfulness and predictability of ReacTickles has assisted

children in gaining interest and independence through their explorations of the interface. For many children, simply being able to touch, move or make a sound and have that action reflected through the simple abstract graphical output has been motivating. As the possibilities for interaction are discovered through repetitious cause and effect, the children's engagement has increased and become more dynamic, expressive and creative. In adopting a highly responsive, participatory design approach the creators of ReacTickles MAGIC have learned some valuable lessons on designing for this population. Co-designing in the user setting provides vital clues in the early stages of design, but for novel concepts to become usable and desirable, children with autism need more time than their typically developing peers to process new information, and for this new information to gradually become predictable and a source of reassurance. The implementation of new activities needs to be carefully introduced through more familiar routines, which requires the researchers to work at the pace of the children and with the guidance of teachers. Designing in this way we have become interested in the ways in which the whole environment impacts on the children's experience, and realised that interaction with the technology plays a relatively minor role. The other people, physical objects, sensory information, as well as less tangible aspects such as the time of day, all make a difference. Many of these aspects are hard to predict, and in response to this we are developing new artefacts that provide additional physical triggers to provide predictability and to assist interaction. We will continue to work with a number of schools, therapy centres, and with families to identify ways in which real world playful interaction can lead to positive long-term outcomes for individuals regardless of developmental ability.

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