SOMATOPIA – CREATIVE COMPUTING THROUGH INCLUSIVE DESIGN

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ABSTRACT

The overarching aim of our research has been bridge the gap between emotionally compelling, open source technology innovation and disenfranchised groups who could benefit from the opportunity to engage with such technologies "as themselves"[1]. We have therefore designed a prototype system, Somatopia, which uses the Raspberry Pi[2] computer to create video projections that respond to a variety of gross motor interactions. Our earliest iterations of Somatopia evolved during a series of drama-based workshops with adults with a range of cognitive and physical impairments. Adopting methods that address self-awareness and expressive communication through movement enabled us to participate in activities with the group on an equal basis. The paper describes how the techniques provided a predictable framework for collaboration, which, in turn, directly influenced the design of the interactions.

INTRODUCTION

For many decades, the process of making technology artefacts that have no obvious function other than to encourage people to play and explore has excited creative coders, (Maeda, 1995 – 2011; Levin et al, 2014[3]). The pleasure derived from playful experimentation is highly individual, but closely aligned to the responsiveness of such systems, so that users are drawn to the idea that they, in some way, have influence over how the technology is responding (Montenegro, 2015). These open-ended interactive artworks have been a source of inspiration for this project as they offer a route for exploring how to make technologies more inclusive - whilst the artist is responsible for creating the

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[1] Author's emphasis
[2] https://www.raspberrypi.org/help/what-is-a-raspberry-pi/
[3] http://www.flong.com/

interface, this is conceived as an opportunity to co-create; without user input the interface remains benign (Edmonds, 2010).

For many years we have taken this approach to our work, exploring how simple, iconic interface elements that behaviourally map user interest, can be confidence building and a source of joy for people with a range of complex disabilities (Keay-Bright, 2007 – 2016). Fundamentally, the interaction must be direct, so that the user senses that his or her control through repetitive exploration that rewards with meaningful feedback. Our earliest work, and subsequent iPad applications, permitted direct manipulation through touch (Keay-Bright, 2007 – 2011); whilst the benefits of tangible interaction are well documented, (Ishii, Hornecker, etc) for individuals with gross motor impairments, there is a danger of latency and feelings of failure when the touch input relies on precision. For this reason, camera - based interaction provides a more accessible platform for exploring causality between a person and the interface. It must be noted, however, that manipulation through gesture is perceptually less direct and is thus most effective when the interaction is amplified on a large screen. This has the added benefit of being palpable to other people, making it possible to mirror user action and move in resonance, whether sharing in the interaction in real-time, or by observing.

All of our technology interfaces have been designed in user settings, including school assembly halls and adult learning centres. Feedback from skilled observers (teachers and support workers) has confirmed that when the user is aware that they are being observed, their interaction becomes more dynamic and communicative. For many of our participants with complex learning difficulties, the perceived desire for communication emerging from an increased sense of self and feelings of creative flow (Csikszentmihalyi, 1978) can be the first step toward independence.

TECHNOLOGY AND INCLUSION

As stated in the introduction, our overarching goal is to bring exploratory technology innovation closer to people with complex needs. For this reason we have begun to experiment with the Raspberry Pi computer, which is widely acknowledged as a valuable tool for teaching creative computing to learners of all ages. The Raspberry Pi community includes creative technologists from around the world -from novice to expert - ensuring that the hardware, operating system, software and peripherals are continuing evolve, supported by robust technical documentation.

The benefit of the Raspberry Pi is that it is affordable, however, the disadvantage is that for people with no experience in computation – and no funding for technical support - the idea of having to learn some basic programming commands is completely alien. In this sense, there is a noticeable gap between the many creative pioneers that populate the Raspberry Pi community, and those who are in most need of technological innovation.

Somatopia is addressing this gap by making the Raspberry Pi a device that is not only attractive because of its affordability, but also that the software we are creating is simple to use and meaningful for a range of users. This next section of the paper will draw on six key points that encompass our method story for developing the first iteration of the Somatopia software, followed by a short description of the 5 applications resulting from this process.

SIX KEY POINTS FOR OUR METHOD STORY

The first phase of co-designing Somatopia took place in January 2015 and occurred over a period of six weeks, in which we ran four workshops that culminated in a live performance in a major arts venue in London, UK. The workshops ran for 3 hours on Sunday afternoons and were undertaken with 11 young people with learning and physical disabilities, aged 18-22.

The structure of the workshops employed many techniques from our experience of working in inclusive theatre. These methods respect each person as an individual with distinct interests, abilities and needs. As a project team (of three people) we joined in all of the sessions as equal partners, but used our skills as organisers and designers to structure the sessions so that each individual had an opportunity to flourish.

Positioning the impairment

The participants had a diverse range of disabilities, including autism, Down's syndrome, hearing and physical impairments. An overarching difficulty was poor concentration, which, if not managed appropriately, could cause anxiety for individuals and disruption to the group. For this reason, each activity was kept short and instructions were minimal, always demonstrated by one of the research team.

Some participants were disinclined to use verbal communication and were offered templates for drawing ideas; we also encouraged the use of iPads, phones and cameras for capturing interesting actions. Siblings or carers were invited to work with us, however only one took up this offer, and chose not to attend the remainder of the sessions.

We always began our activities in a circle, taking the opportunity for face – to – face communication and to create a sense of self within a shared space. By way of introduction we stated our names and how we were feeling at the current moment. Then we placed a tall drum in the centre of the circle and made a sound to express these feelings, so that those who did not express themselves verbally had an opportunity to use sound and gesture. Everyone in the circle took turns to do this. We all acted out sign names, using large movements so that that they could easily be mirrored. As this was a popular activity we repeated the warm up each week and only introduced new challenges when the warm up was complete.

Aiming for equivalence

Whilst the warm-up acknowledged each person as an individual, it was equally important to encourage collaboration and respect for others, therefore we extended ideas for self-awareness by inviting participants to explore the whole of the drama studio space and to experiment with how we greet people. We each chose how we wanted to move around the space, noticing speed and direction, and particularly how we respond to other people when they enter our space - what signals and gestures do we use. As design researchers were interested in how the participants perceived the affordances of the space, and how this affected the flow and synchronicity of movement. We also observed how this changed in relation to other people, for example were we attracted or repelled by the proximity of another person, did we begin to anticipate the presence of another?

We understood from previous work how important it is to enable participants to join in when they feel ready, and not to rush towards a conclusion. For this reason, the participants set the pace of this activity; we were particularly keen to observe the changes in movement dynamics as the space became more familiar. We also wanted to observe changes that the participants themselves introduced when the activity became repetitive. In order to bring the moving to a natural conclusion we invited everyone to reform the circle when they felt they were ready. Coming back together as a group in a circle enabled us to signal the start and end of an activity.

We structured each workshop to include a short break for refreshments. Following the break it was important to bring focus back into the workshop and so set up a camera and projection system to provide a focal point for the next stage of the workshop - gesture-based interaction. We used one of our previous software applications Somantics, to draw attention to the shapes that we can make with our bodies. All the participants enjoyed this and were able to extend their movements beyond their normal range, either by stretching or by combining their body shape with the shape made by a partner.

Balancing of viewpoints

In order to elicit a range of creative ideas, where no one feels judged, or concerned whether they are right or wrong it was vital that each person could openly express their viewpoints. For this reason the activities were designed to be confidence building by virtue of being simple, repetitive and rhythmic. We employed turning-taking routines, using our names, sign-names and drumming to ensure that everyone felt involve. We optimised on mirroring techniques, both with and without technology, to help concentration and empathy without the need for “theory of mind” or social imagination, (Godoy & Leman, 2010; Foster, 2005).

With consent from the participants and their guardians we filmed the activities and offered cameras so that they could film each other. At the end of each session, we collated the footage and brought the group together around a large table to watch the video. In order to stimulate reflection and idea generation, we stopped the video at the point when someone in the group made a comment and invited others to add their own thoughts. The immediacy of this process elicited further feedback and enabled us to consider which particular aspects of the experience were meaningful to individuals, rather than make our own assumptions.

In addition to video observations, we created a paper-based template for encouraging the group to share interesting things about themselves, which we called the Somatopia passport. The idea for the passport came from the need for personas that we could help us to reference user preferences throughout each iteration of the design. However, we wanted the personas to be created by the participant, rather than the researcher, hence we choose the term passport. The sections of the passport were modelled on ideas from Jordan's work on the design of pleasurable products (2000) but included a specific reference to communication preferences. For some of the participants the form was too complicated, but parents were happy to help completing the information.

Dealing with ethical challenges

The ethical challenge when working with young adults with learning disabilities is to ensure that they are made aware of the nature of their involvement in the project, so that they are able to give informed consent. Although their parents and guardians are required by law to give consent, we wanted to ensure that the participants themselves were given the choice whether or not to take part. To this end we worked in collaboration with the arts centre and devised an information and consent form for parents and guardians, plus a separate one for participants with a simple consent form that used symbols to try to convey the fact that we wanted to use video during the workshops and that this would lead to a live performance, which would also be recorded. We also explained this verbally at the start of the project. At the end of each session, we collated the video footage and showed to the group, using it as a prompt for reflection and idea generation. At the end of the performance we made a DVD for each of the participants showing their involvement in co-creating Somatopia as well as clips from the performance itself.

Data collection, analysis and interpretation

We were keen to invite the participants to draw their ideas. There were some in the group who enjoyed drawing, so we provided simple 4 frame blank storyboards to try to capture sequences of movements. We explained to the group that we use this method in our own professional design work; reducing the action to 4 frames helps us to focus on key positions or interactions, which can provide the structure for interface design and programming. This provided a valuable source of data for cross-referencing our ideas with those of the participants.

In order to organise the feedback gathered during each session (as described above), and to manage the workflow, we decided to interpret the different the data at the end of each workshop into 4 themes, and selected one theme to explore each week. These themes were inspired by modern dance and games research that evidences a link between exertion, effort and social communication (Mueller et al, 2010; Mueller et al, 2009; Lindley et al, 2008). The choice of names for these themes later became the names for the applications themselves: *Call and Response*, *Mirror*, *Space* and *Flow*.

Each subsequent workshop followed a similar format, starting with the warm up activities, focusing on one theme and trying out one prototype to discover many possible interpretations. Each session concluded with the participant review using video to share experiences. In the final two workshops we introduced the idea of a live performance, repeating the successful interactions as an opportunity to rehearse and fine-tune our interactions for an audience other than ourselves. For one of these sessions we were able to use the actual theatre space for rehearsal. This made a big difference to the participant engagement and it became clear to us that Somatopia could be a conduit for shared creative experiences, and it was particularly useful as a visual cue for turn-taking.

Adjustment of codesign techniques.

Each of our previous projects had used video review as a form of codesign, in most of these cases the analysis of video footage was undertaken by professionals, for example teachers, therapists and programme administrators, the reason being that our participants were more profoundly non-verbal. The Somatopia project gave us an opportunity to invite the participants themselves to comment on aspects of the workshop activities that they enjoyed and thus provided the inspiration for the core interactions within the system. This project was also different for us in that the output would be a live performance, so the codesign was less about refining the technology and more about ensuring that each participant had a meaningful cue, or trigger, for the performance.

For example, we used clapping to cause names to appear and change on a backdrop, when participants saw their name appear they would prompt each other to take a position centre stage. However, we noticed that when more than one person was providing the input it could be very difficult for participants to notice the effect of their actions. When we used a drum, only one person could make a sound, so we used this to cause a photograph of one of the participants to appear. We created a routine that when a photograph appeared that person would come into the centre and perform a movement, which everyone would then mirror, then he or she would be given the drum to cause a new photograph to appear, and so on. This kept everyone focussed and involved. We also experimented with photographs and names appearing simultaneously, this encouraged participants to call each other's names and to create a movement. Importantly, one sound equalled one effect.

Movement effects were much harder for the participants to perceive, being less physically direct than clapping or drumming. For this reason we needed the participants to spend more time attending to the screen on their own. For mirroring activities we tried to facilitate a three-way interaction whereby one participant would create a movement in front of a projected mirror, and all of the other participants would mirror that person's action. This proved highly engaging, particularly when the person performing became more dynamic as a direct result of seeing his or her own actions mirrored by the interface. Mirroring has been an important codesign activity for this project as it offers a neuronal basis for understanding how people can understand each other's intentions without having to rely in building a mental representation, or needing to construct a theory of mind (Gallese, 2005; Gallese & Goodman, 1998).,

The live performance took place in a large theatre, with over 100 people in the audience (also with disabilities). During the performance the technology provided both a visual cue for the performers and a back-drop that amplified their movements. This had the added benefit of facilitating audience participation, motivating them to also mirror the movements of the performers.

Following the performance we set up Somatopia for an "open mic" session in the dance studio. At the end of the performance we gathered feedback on the workshops and performance using an emoticon form, however, more qualitative analyses of participant experience were made on the basis of visitors to the open mic sessions as many of the participants returned for this session, bringing friends with them.

REFINING SOMATOPIA

Using the experience of the workshops to inform the design of the system we tested Somatopia in other performing arts activities with fifteen young people with disabilities who were regular attendees of a theatre group. Audio feedback transcripts were collected alongside and large paper based mind-maps. This group had experience of performing together but had difficulty concentrating. This meant we tended to focus on the applications that had the most responsive cause and effect. They responded well to sound triggers, but at times the noise could be overwhelming, particularly for two of the participants with Down's Syndrome and Autism.

By April 2015, the software was robust enough for us to test out some of the ideas we had for making the source code available and so we hosted our first Somatopia RPi Lab at the FabLab, Cardiff Metropolitan University. Four SEN teachers, covering ages 4-18, two pupils with a diagnosis of ASD and a technical demonstrator joined us for a rich mix of acting, gestural interaction, paper prototyping and storyboarding based on the Somatopia applications. Everyone learnt how set up his or her own Raspberry Pi, Pi camera module and microphone. After experimenting with the existing Somatopia applications, all of the participants were shown how to use openFrameworks to create a range of interactions triggered by sound and motion. As well as demonstrating the capacity for creative coding we also introduced the idea of paper prototyping, this process enabled one of the pupils to contribute his idea for an emotion recognition game, which was highly original.

In August 2015 we included Somatopia in a performing arts workshop with a social enterprise charity that offers training for people with learning needs. During the workshop participants were shown how to assemble the Pi, launch Somatopia and select different options to use as backdrops for their public performance. An interesting feature of this experience was just how much enjoyable some of the participants found assembling the Raspberry Pi. We created a case using Lego bricks, and the Pi instantly became a prop in its own right.

In the following section, we describe the current design of the Somatopia,system and provide a brief technical specification for the work to date.

SOMATOPIA

Somatopia is first and foremost intended to support inclusion. Whilst we recognise that there are some truly innovative and inspirational ideas emerging through the Raspberry Pi community, we are aiming to enable people worldwide, regardless of age or ability, to experience the pleasure of building, playing with, and developing bespoke gesture-based interactions. Offering a choice of possible graphical displays is intended to encourage experimentation with different software representations and their effect on body movement and gesture.

From a technical perspective, data originating from the movement of the participants is captured by the Pi Camera and microphone, transformed and fed back into the environment using openCV in openFrameworks. With the Raspberry Pi connected to a monitor or projector, the feedback becomes highly visible having an observable effect on the participants. When more than one person interacts the artwork is something that emerges in the interactions between the participants as a result of introducing the feedback mechanism.

The current Somatopia applications represent different types of gestural interaction:

i) manipulation – using sound input to change names, shapes and images in a rotating circle (*Sound Wheel)*;

ii) rhythm – using visual patterns and mirrors to encourage the co-creation of sequences (*Call and Response, Mirror);*

iii) expression - using flocking to draw attention the body in movement and stillness (*Flow);*

iv) empathy – using mirrors and cubes to test the boundaries of space (*Space*).

Somatopia Applications

Sound Wheel is based to the concept of causality, action and reaction. Users simply make sounds to cause changes to shapes. Names can be added using a simple line of code, and images added using a built in interface option to use the Pi camera. The shape, name and image will change in response to sound.

Call and response offers a playful, rhythmic activity, enabling participants to experience feelings of exertion by experimenting with volume to alter the speed and direction of graphical shapes.

Flow: when interacting with *Flow*, coloured dots flock around the body and leave a trail following movement, the greater the movement the faster the lines appear. Stillness will cause them to fade, but rapid movements with several users could potentially fill the screen with colour.

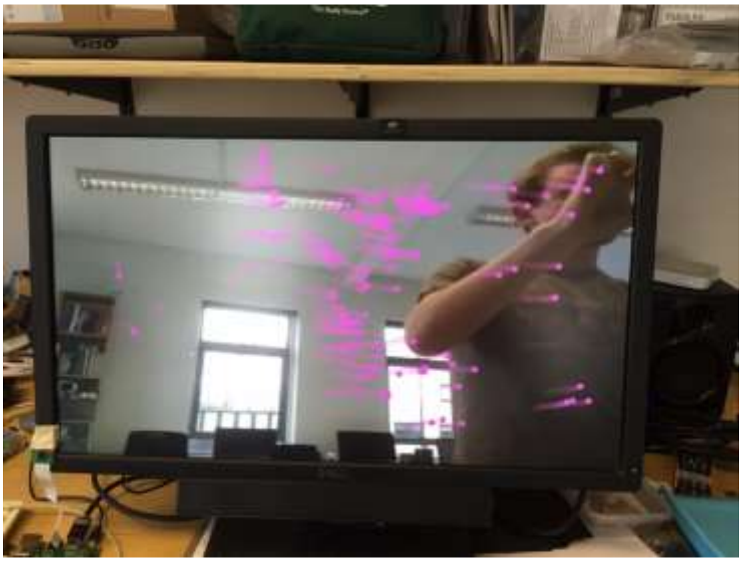

Figure 1 Flow

Space: promotes the exploration of the three-dimensional area around you. The current prototype generates blocks of translucent colour in response to movement, creating spatial patterns that can settle or be distributed in space.

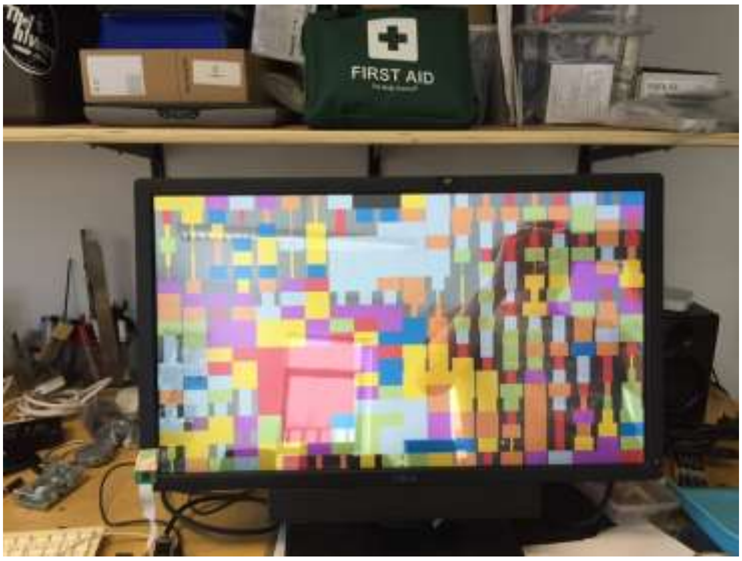

Figure 2 Space

Mirror: this generates kaleidoscopic patterns, which can be altered using the computer mouse. It provides an opportunity to explore naturally occurring bodily rhythms or compose a collective rhythm.

Figure 3 Mirror

Each of the applications can be accessed via a graphical user interface. One click on the icon will select the application, and the S key will return to the Somatopia interface.

In addition, the Options Menu allows for the video image to be turned on or off and enables the use of the camera to take still images. Still images can be saved into the Somatopia folder on the Raspberry Pi interface and added to Sound Wheel.

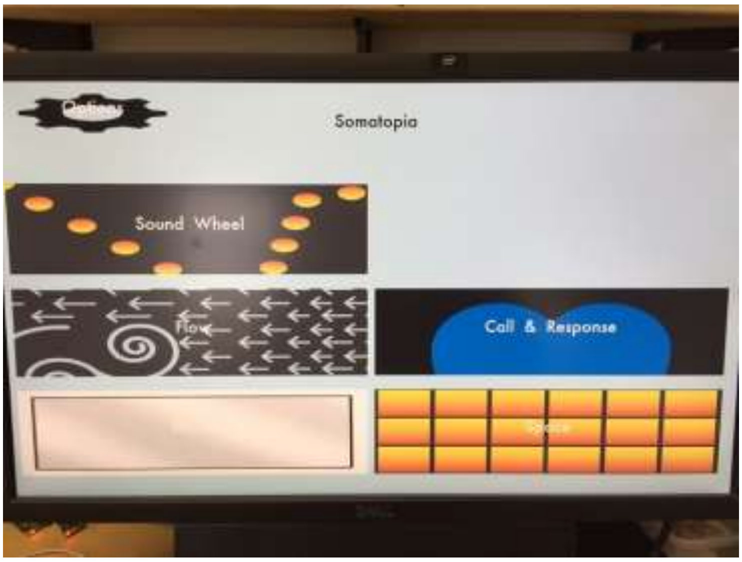

Figure 4 Somatopia Interface

SUMMARY AND FUTURE WORK

As a research and design team we have been successful in our endeavours to include people with some of the most profound disabilities in co-creating and using gesture-based technologies. In 2012 we released our first iPad and Kinect projects created in openFrameworks. Whilst the software has always been free and openly available to use, until the Raspberry Pi was released, we have not been able align with a system that is affordable and usable in social and health care communities, in particular, those who experience extreme financial hardship.

Somatopia as a technical system is made up of three parts that span hardware, software and paper based tools. The Raspberry Pi hardware is low cost, supported by a community of enthusiasts with a desire to share innovation. We are using our expertise in inclusive design and open source software to contribute to this community, but with a very clear goal. That is to bridge the gap between genuine innovation and end users who are disenfranchised through perceptions of disability and lack of resources (human and technological).
By developing in openFrameworks - an open source C++ framework for creative coding – we are bringing novice and experienced coders closer together to address this need.

With this in mind Somatopia is aimed at three groups of people:

1. those with the disabilities, particularly within disabilities services, who would enjoy opportunities for gesture-based interaction, together with their friends, families and care-givers;
2. novice computer users, or those wanting to learn to program;
3. seasoned computer users who want to see their software skills used for more positive outcomes than the traditional domains of financial, military or other (likely closed source) commercial software.

Our vision is for Somatopia to become a widely adopted inclusive design toolset. By appealing to enthusiasts with expert knowledge, and those who enjoy making and tinkering with technology, and connecting them people who could benefit from such innovation who are currently ignored, we believe there will be positive outcomes for all.

To this end, we are currently designing a Somatopia starter kit, to include hardware and other prototyping materials for teaching inclusive design through creative coding. We are also looking for partners interested in conducting joint research in autism and technology.

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