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MAMI: A Modular Accessible Musical Instrument

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Exploring music actively can be restricted for someone with cognitive, physical, or sensory impairments. They may face barriers to participation and diminished experiences between their musical expression and the music making means available to them. Technology can be used to bridge these gaps and focus on a person's capability to create personal instruments that allow for active music making and exploration of sound. This doctoral research aims to look at the use of music technology within the school setting and the needs of the users and those around them. Drawing on this and following an Action Research methodology, a tool will be developed following a participatory design process that utilises both hardware and software, in a modular fashion, to provide a flexible and adaptable system to facilitate music making and sound exploration. The desired outcome will be a toolbox that allows users to put together instruments that suit the needs of those playing them allowing access to musical expression.

Music Technology. Tangible Interfaces. Assistive Technology. Children. Software. Hardware. HCI.

1. CONTEXT

Music is essential to most of us. It can light up all areas of the brain (Levitin 2008) and help to develop skills with communication and establishing identity (Burland and Magee 2014). People use music's transformative properties to generate experiences that create meaning and coherence in states and times of adversity (Machover and Ellsey 2008). Music can be explored actively by playing instruments, or passively, such as listening to music and can be used to enter alternative psychological states such as a state of flow (Csikszenmihalyi 2015).

The ability to explore music actively in this way can be restricted for someone with cognitive, physical, or sensory impairments. The barriers they face may cause a diminished experience when using the music making means available to them. Using technology we can focus on a person's capability and create personal instruments that allow for active music making and exploration of sound. Technology can be used to turn tiny movements into huge sounds and tangible user interfaces can be used to investigate the relationship between the physical and digital world, leading to new modes of interaction.

2. BACKGROUND

This proposal shares the doctoral work undertaken so far on the Engineering Doctorate (EngD) at Bournemouth University within the Centre for Digital Entertainment. The research intersects areas of human computer interaction, technology, special needs and disability, music technology, and Action Research, the methodology which it follows. The overriding topic of this research is music technology for users with complex needs, specifically the creation of an accessible system for interaction with music and sound.

The research project will be carried out in conjunction with Luke Woodbury of Dotlib at the Threeways School in Bath, a school for children and young people with diverse range of special educational needs. The scope of the project is to review literature on current commercially available technology, bespoke hardware and software which provide access to music making for those with complex needs, and modular musical instruments. The research will use an Action Research methodology to examine the need and issues for technology in a school setting, and to create bespoke technologies that are flexible enough to be creative but are also accessible to non-technical teaching and support staff. A team of co-researcher

stakeholders, whose practice is directly related to the research, will be put together. This will be an exploratory study using an Action Research methodology that may use a mix of qualitative and quantitative methods within it.

3. RESEARCH OBJECTIVES AND QUESTIONS

Due to the nature of Action Research outlined in the Research and Methodology section below it is not possible to give solid aims and objectives at the start of the research as these develop through an inductive and emergent process during the research and in collaboration with the co-researcher stakeholder team. The initial aims placed here are suggestions given by the author as to areas that have been identified during work set in the same context as this research, previous degree level study, and from the initial review of literature in closely related work.

3.1 Tentative Research Aims

- To explore how technology is incorporated into practices of music creation and sound exploration
- To explore the issues that stakeholders have with current music technology
- To create novel musical instruments and tools that match criteria as specified by stakeholders and address issues as found in the literature review
- To assess the effectiveness of these novel instruments with a view to improving practices
- To propagate the practices, technologies, and methods used to allow for transferability into the wider ecology

3.2 Aims for the system

The overarching aim for the system is to be able to sit down with an individual and spend a short amount of time setting up a new instrument, both hardware and software, that provides the opportunity for them to engage in a transformative musical experience, while still being accessible to support staff. To this end the practical creation of tools has been split into the following objectives:

3.2.1. Software

- Creation of a modular piece of software that allows for bespoke and commercially available controllers to be connected to it
- The ability to choose what types of inputs the user has available (for example 2 buttons and 1 fader)
- The ability to map these inputs to musical outputs within the software and/or send the input to commercially available music software

3.2.2. Hardware

- Creation of modular bespoke hardware that features different types of sensors
- The ability to connect sensors in flexible ways to allow the construction of instruments personal to individuals
- To maintain wireless connectivity where possible
- The ability to incorporate existing commercially available hardware

4. KEY POINTS OF THE LITERATURE REVIEW

> "Music becomes the vehicle for revealing new truths and making new orderings of the world we live in. (Kruger 2007)".

Music is a fundamental human activity. From the moment our senses develop in the womb we are surrounded by sound and vibration. The perception of sound is central to the human condition and provides a unique tool for exploring and expressing our inner states and our connection to the world around us. Sound has musical potential and music in turn has expressive potential. Through music we can communicate and express emotions as well as reflect on our feelings via this universal medium (Ellis and Leeuwen 2000, Swingler 1998). We use music to enhance our mood, provide comfort, and for nostalgic purposes to relive memories (Hunt et al 2004). Making music allows sharing of intimate dialogues through immersive experiences. The act of making music and musical interaction is cross-cultural and enables non-verbal communication.

4.1 Music Making for Individuals with Complex Needs

The term complex needs refer to a spectrum of cognitive, physical, and/or sensory impairments or disabilities, or emotional and behavioural difficulties. The term SLD is used to describe an individual with severe learning difficulties, MLD for mild learning difficulties, and PMLD for profound and multiple learning difficulties. Individuals with severe complex needs can experience "minimal movement, disordered movement, altered states on consciousness, no verbal communication (Magee 2012)". These complex needs can make access to music making difficult both in terms of physically being able to interact with the tools provided, and being cognitively able to understand and use traditional musical systems. This can mean some people face a diminished experience when using music making tools. The nature of the instrument, the physicality of it, and the rigidity in which it has to be played can restrict users. Traditional instruments; acoustic instruments where the physical form is essential to the creation of the sound, require playing in a certain way, which obliges a level of precision in motor skill and

cognitive ability that may be impossible for some individuals. These individuals may have not developed abstractions or sets of mental models with which to base choices that allow such interactions (Kahneman 2011) or who have debilitating conditions of a physical or sensory kind that restrict their interactions with the physical world.

4.2 Technology and its Usage Settings for Individuals with Complex Needs

Music Therapy is an interesting area for music technology as there has been several large surveys (Crowe and Rio 2004, Magee 2006, Cevasco and Hong 2011, Hahna et al. 2012) and other research within this area on developing new technology, how technology has been used and, perhaps more importantly, why it is not used and how it could be used better. The research in Music Therapy also points to some gaps in knowledge and areas of improvement that could be made. Although these are in the arena of music therapy they can be generalised out to provide insight into use of music technology in a school setting with users who have complex needs.

Some of these key points drawn from the literature are:

- A recognised need for training on effective use of technology, perhaps illustrating the idea that technology is not user friendly, and can be complex in its application and clinical integration (Cevasco and Hong study 2011, Magee 2006, Streeter 2007). Cevasco and Hong (2011) suggest making technological tools less daunting and to foster creative use with practical examples of incorporation into practice
- Technology has historically been used as a tool for logging and analysing of musical interactions (Crowe and Rio 2004, Streeter 2007)
- Technology can be used to turn minimal movement into big changes in sound and provide instant interaction often needed to capture attention of those with complex needs, often giving the first experience of control and perception of self-awareness (Swingler 1998, Ellis and Leeuwen 2000, Hunt et al 2004, Crowe and Rio 2011)
- Technology creates a blank sheet offering new sound worlds of possibilities. It offers the chance to look to the individual, to their physical and cognitive requirements, and start from their abilities when constructing instruments (Kirk et al 2002). By breaking apart, the sound and tool coupling, there is space left to explore and cater to the individual at all 3 layers of the instrument. The way the input is given or the data is collected, the mechanism for providing feedback, and how feedback is provided in an attractive way to the user (Nagler 2011). Instruments can be created that can be operated by any part of the anatomy with no wrong or right construction, only that which is appropriate to the individual (Ellis and Leeuwen 2000).
- Musical experiences can have positive impacts on many other areas of the individuals lives and sense of individuality (Magee 2012, Swingler 1998)
- New developments in other areas, such as the hacker movement, the shrinking of technologies, creation of easy to use hardware such as Arduino (Arduino 2016), and new software like Max/MSP (Cycling'74 2016) have led to a boom in affordable tools for constructing bespoke instruments and systems for interaction

4.3 Creating New instruments for Individuals with Complex Needs

> "The ultimate goal in the process is for the player to have a high degree of intimacy such that he embodies the instrument. When the player embodies the instrument it behaves like an extension of him so that there is a transparent relationship between control and sound. This allows intent and expression to flow through the player to the instrument and then to the sound and, hence, create music (Fels 2004, P672)."

O'Modhrain (2015) sees interactions with instruments as being mechanically complex, ergonomically complex, and temporally nuanced. Each of which can be effected by any sensory, cognitive, or physical impairment, and each of which technology can be used to support. Physically disabled individuals could use newly created technological tools as extensions of themselves and for playing music with augmented instruments as well as novel instruments, individuals with sensory impairments can use other senses such as touch and sight to partake in musical activities. There is also the ability to scaffold a person's cognitive ability by providing varying levels of support depending on their needs, made configurable using technology. All of the above could be utilised to create tools that fit to the needs of the person, focusing on capability and allowing freedom of expression and communication within the music through the tools. Developing personal instruments that configure to the person, whilst going against the usual process of learning a ready-made instrument, allows for the above issues to be addressed and for workable solutions to be developed.

5. PROBLEM STATEMENT

Technology can be extremely helpful in breaking down barriers to participation and enabling users with complex needs to access music making and sound exploration experiences however there is not wide uptake of the use of such technologies when facilitating users with complex needs. Technology is often deemed hard to use, not relevant to the practice, and expensive to implement- both in monetary and time-to-learn terms.

Although there has been research and commercial development within music technology for users with complex needs; notably Soundbeam (Soundbeam 2016) and Skoog (Skoogmusic 2016), many of these systems are expensive and require a trained 'techie' person to facilitate their use or are only created for the purpose of research and not as something to be left behind or supported within the school. Bespoke systems can be developed in ever easier ways due to the advancements in computing and tools for interaction. Expanding processing power in smaller form factors, cheaper technology available, and networking tools (both systems and people creating online resources) have pushed pockets of development, however combining these to create something usable in a school setting still requires a level of resources (expertise and time) not typically available to many schools, and not typically aimed in the direction of music and the arts.

There needs to be development of a system that is easy to use, flexible in its application, utilises new methods of human computer interaction, and does so in a manner that is relevant to the context and users that it is aimed at.

6. RESEARCH APPROACH AND METHODOLOGY

The methodology that this research will follow is Action Research (AR). AR is an overarching framework that allows for the use of other quantitative and qualitative data collection methods within it. AR sees participants as co-researchers aiming to create a democratic atmosphere allowing for all aspects of the research to be considered by a team. The team is created from stakeholders in the research, anybody who that research could affect, or anyone who can contribute expert opinion to the research problem. Rather than a methodology it is an "orientation to inquiry (Reason and Bradbury 2008 p1)" that allows for human flourishing through people working together to address problems that are key within their community (Reason and Bradbury 2008). This approach demands flexibility and responsiveness to adapt the research agenda and methods as the project unfolds (Hayes 2011), something which is important when dealing with delicate situations and with users who might have difficulties in sticking to rigid schedules and rigid goals.

Action research (AR) is carried out in a participatory way in collaboration with community partners and all stakeholders within the research project with the aim to open up communicative spaces within which dialogue can flourish (Stringer 2007). Whilst the definition of AR varies according the the level of emphasis put onto empirical and logical problem solving (Reason and Bradbury 2008) there are core values and principles that identify research as AR and offer guidance for the conducting of this type of social enquiry (Hayes 2011). AR has at least 3 common features (Gray 2009 p313); the participants are co-researchers (Burian et al 2010) engaged in a democratic partnership with the researcher, the research is "seen as an agent of change" (Gray 2009 p313), and there is a direct relationship with the co-researcher participants which leads to data.

The AR methodology allows for the flexibility needed to adapt to the needs of the participants and stakeholders as co-inquirers (Dick 2001). It also allows the participants and stakeholders to take ownership of the research outcomes, with the aim to leave behind a solution that works in context but more importantly solutions that are used and expanded on in a more autonomous fashion- led by the participants and stakeholders.

7. INITIAL RESULTS

The research is still in the early stages. Presented here are some general themes gathered from meetings with stakeholders. Also presented here is the current status of the MAMI (Modular Accessible Musical Instrument) system which has started development, drawing on feedback from stakeholder meetings, as well as previous sessions run by the author within the Threeways School and its electronic orchestra, which uses technology to explore playing music and exploring sound.

7.1 Stakeholder Meetings Initial Findings

On The Methodology-

(i) Action research is a research model which offers benefits within a school setting, especially for the children involved, offering a flexibility to allow for the responsiveness needed within the setting.

Past Technology and New Tool Creation-

(i) Tools have been created via research within the school in the past but have been taken away when the research is over.

(ii) Technology, with its growth of multiuse tools such as the iPad, has enabled more manageable portable music making possibilities, however tools that require set-up time, space needed to store and set-up, and technical knowledge are often abandoned.

(iii) There is interest in exploring where technology is and isn't necessary.

(iv) Access to participation can be provided by technology by judging situations as they occur in practice and adapting equipment as needed.

(v) Involving the children and others in the school that are actively incorporating technology into practice, will allow for a more authentic picture of what's happening and issues to be exposed.

(vi) There should be a scope for improvement over time when using any tools to give ownership and intimacy with the tools used.

(vii) The shape, texture, feel, and feedback of the instrument should be used to create a multisensory experience whilst minimising the need for configuring instruments in ways that are not accessible to those using them.

(viii) Plug-and-play is the ideal end goal using low cost self-contained units that feature the ability to incorporate natural interactions that make sense to the users.

7.2 MAMI Development

7.2.1. Software

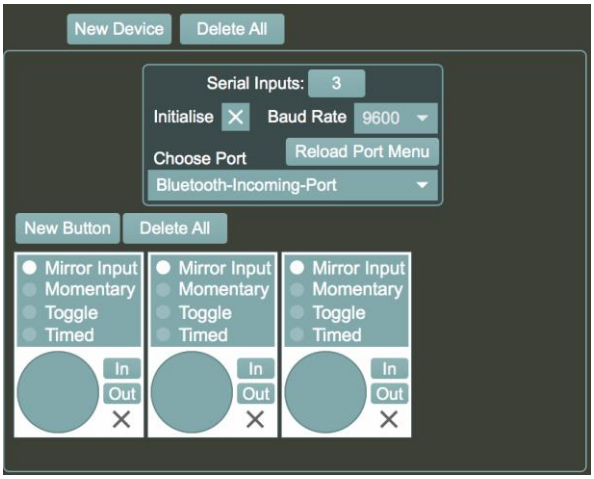

Figure 1: *MAMI Software Serial Instrument*

One of the key areas recognised as underdeveloped by the stakeholders and the literature review is available software for use with accessible instruments. Any hardware used, bespoke or off-the-shelf, unless self-contained, has to be connected to software to explore its sonic possibilities. This is often a sticking point. MAMI is offered here to provide a modular system that can be adapted to any piece of hardware connected to it. Most hardware is button and/or fader based, using either switch style binary inputs or continual inputs that move through a range of values. With the MAMI system the user can select the amount of inputs they have with their device, the type of device they have (for example Wiimote, MIDI controller, or bespoke device), and then connect and map these inputs to musical outputs within the software, or run them through to commercially available software using communication protocols that are common in music technology- such as MIDI or OSC.

7.2.2. Hardware

Figure 2: *MAMI Hardware Jack Sensors*

Many sensors are available that offer different modes of interaction with potential to facilitate capabilities in users that face barriers when playing traditional musical instruments. There are also low cost methods, such as Arduino boards (Arduino 2015), of transferring this data to the computer for mapping to musical output. To this end a range of sensors for capturing expressive data from the users will be explored to create a plug-and-play modular hardware system which can connect to the MAMI software system. In this way bespoke devices can be created based on a user's motor, cognitive, or sensory needs, and the system can provide the flexibility needed to put together tools that tailor to the individual, in a short amount of time, and with as little expertise needed as possible.

8. MAIN CONTRIBUTIONS

The cross- disciplinary nature of the research could allow for potential contribution to knowledge in several fields depending on the route the research takes. This work has potential to provide new systems for human computer interaction, looking at how we use technology for those with disabilities, and combining music with technology whilst maintaining the effectiveness of such systems

within the context of use. New pieces of technology will be developed alongside methods for using them, assessing the effectiveness of them, and knowledge and designs will be passed on to the wider community using an open source philosophy. The methodology followed also offers the chance to contribute to the field of Action Research.

9. REFERENCES

Arduino. (2016). Main Page. www.arduino.cc/ (Retrieved 15th March 2016).

Burian, P. E., Rogerson, L., and Maffei III, F. R. 'Skip'. (2010) The Research Roadmap : A Primer to the Approach and Process. Contemporary Issues in Education Research, 3 (8), pp.271–286.

Burland, K., Magee, W.L. (2014). Music Technology and Identity in Therapeutic Contexts. In: Magee, W.L. (eds). Music Technology in Therapeutic and Health Settings. Jessica Kingsley Publishers, London.

Cevasco, A. & Hong, A. (2011). Utilizing Technology in Clinical Practice: A Comparison of Board-Certified Music Therapists and Music Therapy Students. Music Therapy Perspectives, 29(1), pp.65–73.

Crowe, B.J. & Rio, R. (2004). Implications of technology in music therapy practice and research for music therapy education: a review of literature. Journal of music therapy, 41(4), pp.282–320.

Csikszentmihalyi, M. (2015) Flow: The Psychology of Optimal Experience. Nightingale Conant. USA:

Cycling'74. (2016). Cycling'74 Max. https://cycling74.com/products/max/ (Retrieved 13th March 2016).

Dick, B. (2001). Action research theses. http://www.aral.com.au/resources/arthesis.html (Retrieved 13th March 2016)

Ellis, P. & Leeuwen, L. Van. (2000). Living Sound: human interaction and children with autism. Music in Special Education, Music Therapy and Music Medicine, pp.1–23.

Fels, S. (2004). Designing for intimacy: Creating new interfaces for musical expression. Proceedings of the IEEE, 92(4), pp.672–685.

Gray, D. E. (2009). Doing Research in the Real World. SAGE Publications LTD. London.

Hahna, N. D., Hadley, S., Miller, V. H., and Bonaventura, M. (2012). Music technology usage in music therapy: A survey of practice. Arts in Psychotherapy, 39 (5), pp.456–464.

Hayes, G. R. (2011). The relationship of action research to human-computer interaction. ACM Transactions on Computer-Human Interaction, 18 (3), pp.1–20.

Hunt, A., Kirk, R. & Neighbour, M. (2004). Multiple media interfaces for therapy. IEEE Multimedia, 11, pp.50–58.

Kahneman, D. (2011). Thinking, Fast and Slow. Penguin Group. London.

Kirk, R., Hunt, A., Hildred, M., Neighbour, M., North, F. (2002). Electronic Musical Instruments-a role in Music Therapy? In: Fachner, J., Aldrige, D (eds), Music Therapy in the 21st Century: Contemporary Force for Change. MusicTherapyWorld.Net, Oxford.

Krüger, V., 2007. Music as Narrative Technology. Voices: A World Forum for Music Therapy, Available from: https://normt.uib.no [Accessed 10th May 2015].

Levitin, D.J. (2008). This Is Your Brain On Music. Atlantic Books, London.

Machover, T., Ellsey, D. (2008). Inventing instruments that unlock new music. http://www.ted.com/(Retrieved 15th March 2015).

Magee, W. (2012). Music and Medicine: Applications of Electric Music Technologies in Addressing Psychic Pain. https://www.youtube.com/watch?v=u9-OJs93naA (Retrieved 20th November 2014).

Magee, W.L. (2006). Electronic technologies in clinical music therapy: A survey of practice and attitudes. Technology and Disability, 18, pp.139–146.

Nagler, J.C. (2011). Music Therapy Methods With Hand-Held Music Devices in Contemporary Clinical Practice: A Commentary. Music and Medicine, 3, pp.196–199.

O'Modhrain, S. (2015) "Once more, with feeling: Revisiting the role of touch in performer-instrument interaction." NIME2015, Baton Rouge, June 4-7

Reason, P., and Bradbury, H., 2008. Introduction. In: Reason, P. Bradbury, H. (eds). The Sage Handbook of Action Research Participative Inquiry and Practice. SAGE Publications Ltd, London.

Skoogmusic Ltd. (2016). Meet the Skoog. http://www.skoogmusic.com/skoog (Retrieved 10th October 2015).

Soundbeam, (2016) Soundbeam. http://www.soundbeam.co.uk/ (Retrieved 16th March 2016).

Streeter, E. (2007). Reactions and Responses from the Music Therapy Community to the Growth of Computers and Technology - Some Preliminary Thoughts. https://voices.no (Retrieved 10th March 2015).

Stringer, E.T. (2007). Action Research. SAGE Publications, Inc, California.

Swingler, T. (1998). “That Was Men Applications of the Soundbeam”. CSUN conference Technology for Persons with Disabilities. Los Angeles, March 1998.