Designing Embodied Musical Interaction for Children with Autism

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ABSTRACT

This paper describes the design, implementation, and pilot evaluation of an interface to support embodied musical interaction for children with Autism Spectrum Conditions (ASC), in the context of music therapy sessions. Previous research suggests music and movement therapies are powerful tools for supporting children with autism in their development of communication, expression, and motor skills. OSMoSIS (Observation of Social Motor Synchrony with an Interactive System) is an interactive musical system which tracks body movements and transforms them into sounds using the Microsoft Kinect motion capture system. It is designed so that, regardless of motor abilities, children can generate sounds by moving in the environment either freely or guided by a facilitator. OSMoSIS was inspired by the author's experiences as a music therapist and supports observation of Social Motor Synchrony to allow facilitators and researchers to record and investigate this aspect of the therapy sessions. It converts movements into sounds using Microsoft Kinect body tracking, in the context of an interactive game. From our preliminary testing with 11 children with autism (aged 5 – 11 years old), we observed that our design actively connects children, who displayed a notable increase in engagement and interaction when the system was used.

CCS CONCEPTS

• Human computer interaction (HCI): HCI design and evaluation methods, Interaction paradigms, Interaction devices, HCI theory, concepts and models, Interaction techniques, Interactive systems and tools, Empirical studies in HCI;

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1 INTRODUCTION

Autism Spectrum Condition (ASC) is a neurological condition which manifests in social and communication difficulties, impairments in attention, repetitive behaviors and differences in sharing imaginative play [1] which makes it more difficult for individuals with ASC to predict the actions of others for themselves and other persons. The difference in social cognition has been considered the main impairment in ASC [13], with diverse symptoms ranging from difficulties in social relationships, for example interactive play, to displays of atypical behaviors with respect to their peers. Studies have also demonstrated that children with ASC present motor differences [20], such as postural instability, and poor performance on standardized testing of motor functioning [10]. Furthermore, the significance of motor skills has been highlighted by qualitative differences in early movement behavior which may be among the first biomarkers of ASC [3, 24]. Thus, there is a growing call for thoughtfully designed motor skills interventions which, at the same time, address also the core characteristics of ASC, such as social cognition and communication. In fact, the interplay between motor and social domains makes possible that improvement of motor skills can in turn increase the chances of a child participating in physical activity which has the potential to build social skills [6]. Nevertheless, effective methods to improve the motor skills of children with autism remain elusive.

It is widely reported that people with autism often have similar or superior music processing skills to typically developing counterparts [2]. The effects of music therapy can be powerful. Music can serve as a vehicle of interaction, and social and emotional development, without need of verbal communication, which is often not the preferred means of communication for people with autism [15]. Traditional music therapy generally adopts conventional musical instruments [8] which are frequently not appropriately designed for autistic users due to the cognitive effort required in their use and the need for musical training which is not always available [17].

According to the social model, as opposed to the medical model, disability comes from a lack of accommodation [18] that disables individuals. With autism, which is an invisible disability, assistive music technology (AMT) or accessible Digital Musical Instruments (DMIs) or mainstream adapted devices can be necessary [9] to allow children to communicate and express themselves and overcome barriers they face. Recent technological developments in the field of Human Computer Interaction (HCI) allow the design of 'easy to use' multimodal, multisensory musical surfaces [5] which enable natural interaction for all kinds of special needs, including severe autism, where motor development may be highly compromised [10]. OSMoSIS, presented here, uses the Kinect motion capture feature to support children with autism to creatively compose musical harmonies with their bodies.

2 BACKGROUND

In the last decade there has been a great increase in computer-based interventions, which has touched almost every field from education to therapies. Music therapy has been known for its efficacy with

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Figure 1: Interaction with OSMoSIS environment

children with autism. However, sometimes motor difficulties can limit musical expression through traditional musical instruments, which may present too many challenges for people with motor impairments [17]. Technology can help overcome motor constrains and offer the chance for everyone to create complex musical sounds [23], sometimes even without touching any surface [21]. Music comes as the right combination of sounds expressed in a harmonic sequence of repetitive, organized pattern which generates rhythm. Music evokes emotions and research shows how listening to it prompts movement [16]. The connection between music and movement has been explored by several authors [22]. In one study, [14] the author describes a corporeal expression in music-induced movement made by synchronization, embodied attuning, and empathy.

Similar music-based intervention to OSMoSIS include Soundbeam Imitation Intervention (SII) which is an ultrasonic beam, perceived as an invisible keyboard, that plays sounds each time the user moves the body or the fingers [7]. More recent studies like BendableSound [4] use an elastic display encouraging children with autism to be more coordinated when touching a fabric to play sounds. Microsoft's Kinect, an integral feature of OSMoSIS, offers opportunities to study motor coordination [12] and increase the engagement of children in educational games. Kinect has been used in projects such as the 'Pictogram Room' where the system aims to teach self-awareness, body schema and postures, communication, and imitation. In the Pictogram Room [11], the child works through educational activities and games, controlling a virtual avatar with his or her movements. OSMoSIS does not use an avatar or any objects, but instead focuses on the relationship between the child and facilitator, teacher, or caregiver. Our study using OSMoSIS is closer to studies where there is an interactive sonification of the children's spontaneous movements [23].

3 PROTOTYPE DESIGN

The synchrony of movements and sounds is of central focus in this research as it represents one of the key measurements of the success of the interaction between the facilitator and the child. The system indirectly supports synchronicity through the facilitator's action and the use of third-party software, just for analysis. The software is also designed to support the analysis of the child's motor patterns during the activity, which gives further insights for outcomes analysis. Movement analysis is widely used in the diagnosis and treatment of autism [20, 24]. OSMoSIS aims to support researchers and therapists in conducting movement analysis, easily and unobtrusively with touchless motion capture, while children are having fun (Figure 1). Specific instrument sounds were selected to support the child's expression and self-affirmation in choosing between different sounds. Currently the instrument sounds supported are guitar, marimba, woodblock, water drops and flowing water. The use of different instruments also provides the opportunity to address different motor features. For example, the melodic guitar allows focus on upper body movements compared to the use of flowing water which elicits movements like rolling onto the floor which gives back a full proprioception of the child's body in contact with the floor surface. The design also aimed to stimulate the child's imagination through pretending to play different instruments.

The prototype incorporates a bespoke piece of software that processes and transform the stream of data generated by Microsoft Kinect which captures the body movements of one or more individuals, into sounds. The software and the Facilitator GUI (Figure 2) are built using mainly JavaScript libraries such as ReactJS to render the UI, NodeJS for the back end and SoundsJS and Tone.js to generate the sounds. The GUI provides, on the left, 3 toggles map body-part to instrument sounds, and sliders to customize sounds. The circles in the 'Bodies Monitor' pane represent the distance between the key joints and the body center. This diagram represents only the tracked body. The Mode functions below switch OSMoSIS between Demo and Tracking modes. When in Demo mode, the system generates the sounds using a previous recorded body's telemetry data (allowing the operator to showcase the system to parents and other researchers, or experiment with new settings). The radio buttons on the right side of the screenshot allows the facilitator to select which body's stream of data should be processed by the system (the software can track up to 3 bodies). The processed data is then used to generate sounds before being finally stored for further analysis. Once a body is selected is labelled with red dots, representing the 25 body joints. The system stores anonymized data on the cloud using MongoDB. The current study uses an early research prototype, though the long-term objective is that OSMoSIS be deployable in homes and schools.

3.1 Evaluation

The evaluation took the form of a four-week study with 4 sessions each lasting 30 minutes, with the researcher acting as the facilitator. A within-subject design was used to explore differences in interactions with and without OSMoSIS.

3.1.1 Participants. 11 participants were recruited (2 female), aged between five and eleven years old (M age = 8.27; SD =1.42) with a diagnosis of Autism Spectrum Condition. Participants were voluntarily enrolled in the study, and all parents gave informed consent for their children to take part in the study.

3.1.2 Procedure. Each session was 1:1, where the facilitator interacted with the child. At all times, either a caregiver or a teaching assistant was present in the room in an unobtrusive way. At the start of each session the facilitator began to interact with the child

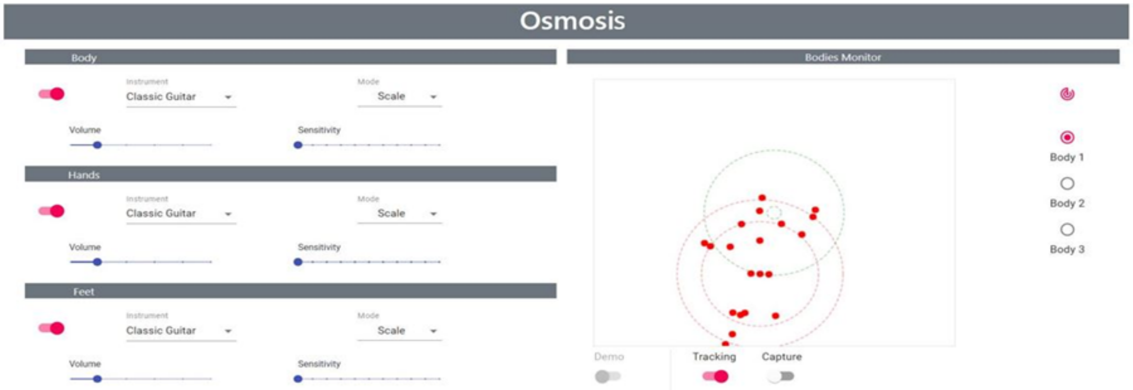

Figure 2: Software Graphical User interface

by singing a 'welcome rhyme' with the child's name and inviting them to imitate her, while performing some movements such as 'hopping' or 'marching'. Afterwards, the facilitator proposed four movements/activities associated with four sounds in a random order. For instance, the facilitator might present the 'water drop' sound, elicited by a hopping movement or the 'woodblock' sound associated with marching. Each sound condition lasted no more than 3 minutes. Towards the end of the session, the facilitator sang a farewell song to conclude the activities. Each session was video recorded, with the camera positioned unobtrusively to capture the child's movements.

3.1.3 Preliminary analysis and findings. An initial analysis of the video data has been conducted, with the researcher making notes on children's levels of engagement in the activities during the different stages and activities and examining one case study in more detail. In the first part of each session, when the facilitator was inviting children to copy her with no music in the background, children typically did not show high levels of engagement or interest in interacting. Once the software was activated, children appeared to be keener to copy the facilitator's movements or freely explore the different possibilities that their bodies had to generate sounds. The mother of one of the children who took part in the study explained that her son had been diagnosed with autism with a high level of need but without learning difficulties. His mother was not sure he would attend the sessions because he often shows resistance to changes. Eventually, the child attended all of the 4 sessions. In 2 out of the 4 sessions he was not feeling well, so he stayed in his mother's arms in the first part of the sessions (when there were no sounds in the background). However, when OSMoSIS was activated, he jumped up and began to interact, especially when the flowing water sound was activated.

4 DISCUSSION AND FUTURE WORK

This study provides preliminary evidence of the possible benefits of such a tool, with a notable increase in engagement at the point in which the system was switched on. However, a more systematic analysis is required before wider conclusions can be drawn, and further investigation is needed to determine whether this was due to other factors such as children relaxing as the session went on. The next step will be to use a software application, Motion Energy Analysis (MEA) [19], to count the number of Social Motor Synchrony instances within the interaction between the researcher/facilitator and the child at different stages in the sessions. An analysis of the logged Kinect data is also planned, including measurement of the distance between facilitator and the child.

5 CONCLUSION

We have described the design and evaluation of OSMoSIS, which supports children generating sounds through bodily movements. In our preliminary analysis of the data collected, we found that OSMoSIS is engaging, showing its potential as a platform for motivating children with autism to consciously generate sounds by movements. We noticed increased engagement and interaction when the system was introduced, which needs to be investigated further.

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