OSMoSIS: Interactive Sound Generation System for Children with Autism

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Abstract

This paper reports on the design and pilot evaluation of a system that uses movement, music and sounds to support playful interactions for children with Autism Spectrum Conditions (ASC). OSMoSIS (Observation of Social Motor Synchrony with an Interactive System) is a musical motion-based game. The design was inspired by previous research that suggests that music and movement can be helpful in fostering communication and expression skills, and the first author's experiences as a music therapist. OSMoSIS converts movements into sounds, using a Microsoft Kinect-based system which provides full body tracking. A recently conducted evaluation with a group of 11 children with autism aged 5– 11 years old showed positive engagement with the system, and some instances of imaginative play. In our discussion, we highlight implications for the design of future music and movement systems to support learning in children with autism.

Author Keywords

Autism; movement; music; motion based touchless interaction; data analysis; log data; interaction.

CSS Concepts

- Human-centered computing: Human~computer interaction (HCI)~Interaction techniques~Gestural

input~Auditory feedback~HCI design and evaluation methods~User studies.

Introduction

Autism is a neurological condition which manifests in social and communication problems, impairments in attention, repetitive behaviors and difficulty in sharing imaginative play [1] which makes it more difficult for people with autism to predict the actions of others. The difference in social cognition has been considered the main impairment in ASC [10], 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 impairments such as clumsiness, abnormal motor coordination, postural instability and poor performance on standardized testing of motor functioning [6]. Furthermore, the importance of motor skills has been highlighted by qualitative differences in early movement behavior between children who later received the autism diagnosis and typically developing children, suggesting movement may be among the first biomarkers of ASC [17].

Due to the importance of motor skills, there is a growing call for thoughtfully designed interventions which address not only the core characteristics of the autism condition, such as social cognition and communication, but also extend their beneficial effects to motor skills to develop better interaction skills. The 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 [4].

Previous studies have highlighted that people with autism are commonly sympathetic to sound, though often demonstrate problems processing auditory information [12]. Music therapy, as a component of other occupational therapy interventions, has shown great success in improving children's communication and expression [9]. Music can be helpful as it can serve as a vehicle of interaction, and social and emotional development, without the necessity of verbal communication [11]. However, music therapy for autism usually involves traditional musical instruments which are often not appropriately designed for autistic users due to the high cognitive load and requirement for musical training, which is not always possible [11]. However, recent technological developments are making it possible to design 'easy to use' multisensory musical surfaces which enable natural interaction for all kinds of users, including those whose motor development may be highly compromised [2].

We developed the OSMoSIS system which enables children to generate sounds simply by moving (freely or guided) in the interactive environment. The system uses Kinect motion capture without the use of any wearable devices. Our overarching research questions are related to whether children's interactions with a facilitator change when using the system and how, through observation and data logging, we can investigate the enjoyment of children during their interactions within the OSMoSIS environment. In this paper, we first describe our prototype design, and then present findings from our preliminary testing with 11 children. The main contributions of the paper are:

- We present empirical evidence indicating that autistic children's interaction with the facilitator

Figure 1: Interaction with OSMoSIS setting. OSMoSIS does not use an avatar, but instead focuses on the relationship between the child and facilitator, peer, teacher or caregiver. Therefore, OSMoSIS does not present the child with a User Interface for interaction and we avoided the use of avatars or any invasive tools or sensors which could divert the child's attention.

changes when the interaction occurs within the OSMoSIS system.

- We illustrate the changes in activity and social cues as indexes of enjoyment of children with autism during their interactions within the system.
- We provide a preliminary analysis with an initial high-level summary of video data, which show the increase in interactions between the child and the researcher.

Background

In recent years, a rapid growth in the use of digital technologies has improved the quantity and quality of educational and diagnostic tools in autism research [8]. A small number of these tools use sound and music to interact with children, though little research has been carried out during music-based interventions.

One notable research tool is BendableSound [2] which uses a Kinect sensor, speakers, and an ultra-short throw projector placed behind a spandex fabric, encouraging children with autism to be more coordinated when touching the elastic fabric to play sounds. Although it has potential benefits, BendableSound reveals some limitations related to tailoring the selection of music to each child's preferences [2]. Microsoft's Kinect, with its motion capture capabilities, offers opportunities to study motor coordination [8] and increase the engagement of children in educational games. Kinect has been used in projects such as the 'Pictogram Room' [7] where the system aims to teach self-awareness, body schema and postures, communication and imitation. In the Pictogram Room, the child works through educational activities and games, controlling a virtual avatar with his or her movements. It uses Kinect and an Open Scene Graph

(OSG) shader that facilitates combining the objects and the user's movements and integrating them with the virtual world. Other studies explored the relationship between movements and music [15] employing sonification techniques using wearable technologies in order to give users feedback on their own movements. [5]. Sigrist and colleagues [16] found that the use of sounds affects the way children move and interact. Our study using OSMoSIS is closer to studies where there is an interactive sonification of the children's spontaneous movements.

For her Master's dissertation, the first author developed an earlier prototype with similar aims and found that water sounds were calming and relaxing even when children showed signs of distress [13]. However, there is still no evidence to show how such sounds may be beneficial in support of therapies [5].

Prototype Design and Development

One of the key requirements of OSMoSIS, drawn from the first author's experience as a music therapist, was to help the child maintain focus on the facilitator's movements in order to build skills, such as copying her movements. OSMoSIS (Figure 1) is an interactive musical system which tracks body movements and translates them into sounds using the Microsoft Kinect motion capture system. OSMoSIS generates sounds in synchrony with the child's movements with the aim of encouraging them to interact with the facilitator. The current study used an early prototype of the OSMoSIS system, though our long-term objective, following test

analysis procedures, is that OSMoSIS be usable in homes and schools.

The system required the development of software that processes the data from a Microsoft Kinect (Figure 2) camera capturing the body movements of one or more individuals. The software transforms movements into sounds, generating their pitches and speed by computing the distance between body parts and their position relative to the body center. The software is built with open-source JavaScript web technologies React, SoundJS and Tone.js, and captures and anonymizes the data using back-end technologies Node.js and MongoDB. The facilitator's User Interface (Figure 3) has two sections: one controls the generation of sounds and the other the capture of movements of up to three participants, who are represented by skeletons.

Prototype testing

We conducted a four-week study with 4 1:1 session each lasting 30 minutes. The design of the study is a within-subject design, examining interactions with and without OSMoSIS. Participants were 11 children aged 5-11 (M age = 8.27; SD =1.42) with a diagnosis of Autism Spectrum Condition. Participants were voluntarily enrolled in the study, and their parents/ caregivers gave informed consent to the study. The study took place in a mainstream primary school and a special needs primary school. A further three participants were recruited through a parent-support group, and we ran the study in their activity space room.

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. The facilitator began each session with

a 'welcome rhyme' with the child's name and invited them to imitate her, while performing some movements such as 'hopping' or 'marching'. Afterwards the facilitator introduced OSMoSIS and proposed four movements/activities associated with four sounds in a random order. For instance, the facilitator might have presented the 'water drop' sound, elicited by a hopping movement or the 'woodblock' sound associated with marching. Each sound condition lasts no more than 3 minutes and the whole session no more than 30 minutes. Towards the end of the session, the facilitator sings a farewell song to conclude the activities. Each session has been video recorded, with the camera positioned unobtrusively to capture the child's movements.

Preliminary finding and discussion

We use descriptive methods to analyze the data collected from the video observation. The current paper does not contribute a coding scheme, which is under development. However, the empirical data collected in this study shows potential enhancement of social interaction and motor skills.

Engagement

Almost all participants expressed interest in interacting with the system. There was a notable increase in engagement between the first part of the session in which the researcher invites each child to copy and collaborate with her, presenting some movements without the use of the system, and the condition in which the movements elicit different sounds from the system.

Enjoyment

All the participants expressed enjoyment of the system through smiles, eye contact and other social cues. Some of the verbal children expressed their willingness to

continue the session even after the planned 30 minutes were completed. Most of the children were physically and vocally enthusiastic while interacting and keen to help the researcher and her team with the implementation of the system, suggesting useful tips.

Figure 3: Facilitator's User Interface. The sound generation section allows the facilitator to choose between different sounds: guitar, marimba, woodblock, water drops and flowing water. Each sound can be linked to (1) the whole body, (2) the right and left hand, (3) the right and left foot.

Pretend Play

Initial observations revealed increased instances of pretend play during the interaction within the interactive environment, when compared with the facilitator-only interactions. For example, with the water sound the facilitator proposed swimming-like movements which led children to pretend they were under the water or pretending to dive into the water. Also, the woodblock sound elicited movements like hopping or marching. Interestingly, in discussion the verbal participants recalled situations or movements whenever they listened to the sounds. This aspect may be considered a further exploration and validation for future research.

Social Interaction

In most of the sessions there were instances where the child initially had no interest in interacting with the researcher but suddenly became quite engaged and enthusiastic, when the OSMoSIS environment was enabled. In addition, motor skills such as acceptance of imitation have been observed and show promise for the future development of the system.

Sound Issues

With the current prototype we encountered a few limitations regarding the quality of certain kind of sounds which some participants reported as being annoying or reminiscent of negative personal experience. More research needs to be carried out regarding the most appropriate sounds to better encourage children and

foster interaction. Although we made considerable efforts to provide a spectrum of pleasant sounds for the synchronic interaction, several children had issues with some of the sounds.

Conclusion and Future work

We presented the initial prototype design of OSMoSIS, a sound environment which provides children with an interactive musical environment elicited by the child's 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 social interaction when the system was introduced, although further investigation is needed to determine whether this was due to other factors such as children relaxing as the session went on.

Further research is needed to improve the OSMoSIS soundscape to make the experience in the environment as positive as possible. There also remain several open questions on how we can improve our design to achieve a better synchronization between the interacting bodies and the sounds generated by the system. The next step will be to use a software application Motion Energy Analysis (MEA) [14] to count the number of social motor synchrony instances within the interaction between the researcher/facilitator and the child. The analysis of the logged Kinect data also needs further work as our current calculation of the distance between facilitator and the child is not yet reliable (the continuous movement and frequent overlapping of bodies makes this a complex calculation).

We would also like to explore whether OSMoSIS could give children on the spectrum more chance to engage in movement/sport activities with their peers. A pressing issue now is the lack of sport activities tailored for children with autism, which leads to further isolation.

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