VESBALL: A ball-shaped instrument for music therapy

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ABSTRACT

In this paper the authors describe the VESBALL, which is a ball-shaped musical interface designed for group music therapy. Therapy sessions take the form of "musical ensembles" comprised of individuals with Autism Spectrum Disorder (ASD), typically led by one or more certified music therapists. VESBALL had been developed in close consultation with therapists, clients, and other stakeholders, and had undergone several phases of trials at a music therapy facility over a period of 6 months. VESBALL has an advantage over other related work in terms of its robustness, ease of operation and setup (for clients and therapists), sound source integration, and low cost of production. The authors hope VESBALL would positively impact the conditions of individuals with ASD, and pave way for new research in custom-designed NIME for communities with specific therapeutic needs.

Keywords

NIME, music therapy, ensemble music making, Autism Spectrum Disorder (ASD).

Figure 1. VESBALL.

1. INTRODUCTION

The authors designed a musical interface called VESBALL for people with mild to moderate Autism Spectrum Disorder (ASD), who received regular music therapy in groups at a government community health center. These individuals ("clients") have reduced co-ordination skills, diminished attention span, and diminished abilities to follow instructions. Typically, simple percussive instruments (such as drums, woodblocks and cymbals) are used in these sessions. Traditional instruments however are not customizable, and therapists are limited in terms of sound by the range of instruments that the facility could afford. Often times, a single instrument is generalized to serve a wide variety of therapeutic as well as musical goals. There is a need for a cheap alternative that is easy to setup, yet customizable in terms of sound and modes of interaction.

VESBALL has been developed for and in close collaboration with music therapy professionals. It is a ball shaped instrument with a soft exterior. Its construction is simple, and is consisted of (1) soft foam form factor, (2) a microcontroller connected to an accelerometer and a piezoelectric sensor, and (3) an embedded loud speaker. VESBALL had undergone several phases of testing over a period of six months in group music therapy sessions for people with ASD, under the supervision of a certified music therapist. It has been designed for ensemble music making. The documented positive effects of ensemble music making on people with ASD include [10]:

- Increased appropriate social behaviors and decreased inappropriate, stereotypical and self-stimulatory behaviors
- Increased attention to task [9]
- Increased vocalizations, verbalizations, gestures, and vocabulary comprehension [4]
- Increased communicative acts and engagement with others [5]
- Enhanced body awareness and coordination
- Improved self-care skills and symbolic play
- Anxiety reduction

2. RELATED WORK

A number of NIME had been developed in recent times for individuals with therapeutic needs. In this section the authors describe several examples that are relevant to their work.

2.1 Skoog

Skoog [16] is a "soft, squeezable object" that responds to a light touch or a compression of its malleable interface. *Skoog* is multi-touch sensitive, and has five color-coded responsive zones. Using physical modeling software developed within Max/MSP, it is possible to dynamically manipulate instrumental sounds though pressing, squeezing, rubbing, stroking, tilting or manipulating the *Skoog*. To play, user has to connect the interface to a computer, which interprets sensor information and also plays the sounds. *Skoog* has been designed for individual exploration in a solo setting.

Figure 2. Skoog Interface.

2.2 Sound=Space

Sound=Space is a webcam-based system that captures the movement of persons in the view of a camera, which is suspended from the ceiling. A musical topology is generated through the analysis of information gathered about the movement of a body, or several bodies, in a “sensorized space” [13]. This information is fed as control variables to a computer executing compositional algorithms. While *Sound=Space* has been used in group music therapy sessions with promising results, the source of sound (speakers) and the object of interaction (the “sensorized space”) are separated.

Figure 3. Children interacting with Sound=space.

2.3 Soundbeam

Soundbeam [14][3] is a MIDI hardware and software system developed by the Soundbeam Project / EMS. Movements detected by a series of_ultrasonic beams are used to control multimedia outputs. *Soundbeam* uses a combination of ultra (sonar) and tangible (foot controller) inputs to generate MIDI messages. Again, the use of *Soundbeam* requires connection to a computer.

Figure 4. Soundbeam.

2.4 Others

Several other NIME for music therapy are briefly discussed below.

2.4.1 BrainFingers

A headband fitted with sensors detects electrical signals from facial muscles, eye movements, and brainwaves. The Software converts signals into computer controls or "Brainfingers," which are used to control MIDI software [1]. Individuals with ASD have used BrainFingers in performance [6].

2.4.2 BCMI-Piano System

BCMI-Piano system converts EEG signals to MIDI data that drives music software. BCMI system allows individuals with disabilities to generate music with their mind [7]. This system could potentially be used in music therapy to reinforce attention and focus.

2.4.3 MidiCreator

Another MIDI interface commonly used in music therapy sessions across the UK, consisted of a range of sensory inputs that send data to a computer to produce sounds [7].

2.5. Comparison with VESBALL

A significant drawback of the instruments listed above is their high cost of production and maintenance. Many are also difficult to set up, especially for music therapy professionals with little to no technical background. The majority of music therapy centers are not-for-profit entities funded by foundations and/or charitable organizations that cannot afford expensive equipment or technical personnel. These facilities lack access to storage, high-end computers, and high fidelity audio monitors, making many of the aforementioned NIMEs impractical. Designs that require connection to a computer are also not ideal, as clients with reduced motor skills and/or co-ordination could accidentally dislodge and damage expensive computer equipment.

Additionally, the majority of these NIMEs cannot be used to support "active music therapy" (with the exception of *sound=space*) that calls for a range of bodily motions as well as group interactions, which is a common music therapy approach especially with children [2]. VESBALL is robust, portable, requires no computer and no power cable, can be thrown around, and is cheap to produce. Authors estimate that cost of producing each of these would be around 50 to 60 USD, which is significantly lower than the above-mentioned instruments. Additionally, the source of sound (speaker) is embedded inside of the interface, which makes for a motion-to-sound relationship that feels natural to the clients. This design also eliminates audio setup time, and makes for better sound blending in ensemble music-making situations.

3. DESIGN AND CONSTRUCTION

3.1 Hardware organization

VESBALL's Hardware is organized into three units as follows.

3.1.1 Sensing unit

The sensing unit has an accelerometer and a piezoelectric sensor. The data from the two sensors is received by the micro-controller when the ball is hit, tilted or moved. Based on the program and the input from the mode switch, the microcontroller sends MIDI data to a tone-bank (VS1053 IC), which then plays the sounds through the speaker.

3.1.2 Main unit

A 2200 mAh lithium ion polymer battery powers an Arduino Uno. The battery is rechargeable through a micro USB inlet on the surface of the ball. The string toggle switch is used to toggle between play modes.

3.1.3 Sound synthesis unit

The musical instrument shield sonifies MIDI data coming from the Arduino Uno. The VS1053 chip contains two large tone-banks that include such sounds as piano, woodwind, brass, synth, SFX and percussion. The audio output is connected to an amplifier breakout board, which is powered by the Arduino. The amplifier drives an 8-ohm speaker that has been carefully positioned at the center of the ball.

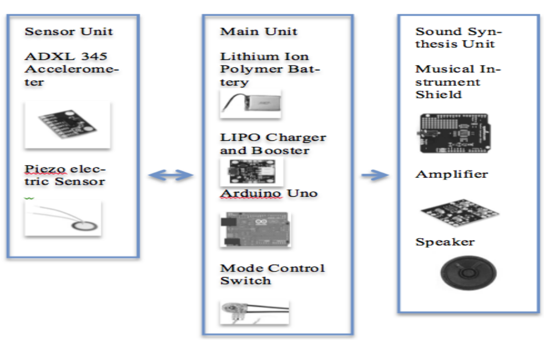

Figure 5. VESBALL: hardware organization.

3.2 Construction

The speaker is attached to a circular fiberglass frame, and this frame also physically supports all the electronic circuitries. The frame is protected by EVA foam that has openings for a power switch, a mode-changing toggle switch and a port for battery charging and communication with the micro-controller. A soft fabric jacket covers the EVA foam.

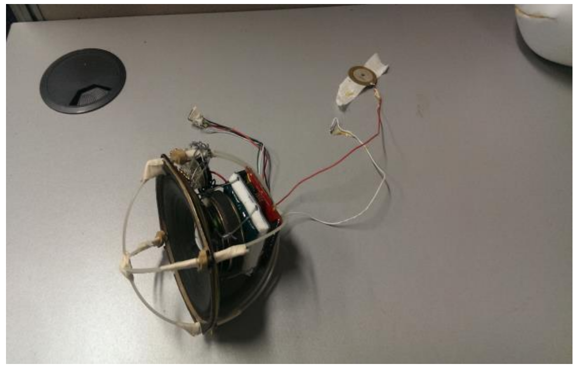

Figure 6. The speaker, microcontroller, sound chip and other components inside the fiberglass frame.

Figure 7. The EVA foam.

Figure 8. Soft fabric jacket.

4. MODES AND SOUND SYNTHESIS

VESBALL operates in two modes:

4.1 Percussion mode

In "percussion mode" user triggers sounds by moving or hitting the object. By default, moving the ball in a fixed direction with speed triggers the cymbal sound and hitting it would produce snare drum sound. Other sounds and input triggers may be set using a simple software interface. In music therapy, individuals lacking in musical knowledge often find it easier to produce satisfying results with simple percussive instruments [8]. It has been noted that highly structured interventions, such as following strict rhythmic patterns, can lead to successful developmental gains for people with ASD [12]. These benefits are especially prominent in modifying maladaptive behaviors, shaping self-help skills as well as linguistic skills [15]. With traditional percussive instruments, sounds are produced through the striking of surfaces. With the VESBALL sounds are triggered through motions and striking actions. Therapists using VESBALL can drill simple to complex physical gestures and motion patterns, while urging the players to keep a steady tempo.

4.2 Melody mode

In "melody mode" the user changes notes or modulates the pitch of the notes being played at a fixed tempo by tilting or moving the ball. The pitches are set to the intervals of a major pentatonic scale. This mode is most suited to free play and improvisation. Free improvisation has also been widely used in music therapy to provide the players with sensory stimulus and means of self-expression. Improvisation also promotes on-the-fly decision-making [11].

Table 1. Comparison of the two modes.

"Percussion mode"	**"Melody mode"**
Piezo-electric triggers snare drum sound by default when hit (tone generated may be changed). Sensitivity may be adjusted.	Play the notes of the C major pentatonic scale by default when tilted (pitches generated may be changed).
Accelerometer triggers crash cymbal by default when acceleration along certain directions is higher than some threshold value defined by the user.	Pitch-bend by varying the acceleration speed of the object.

5. VESBALL IN THERAPY

5.1 Development cycle

5.1.1 First prototype

The initial prototype of VESBALL was developed over a period of three months. During which, the design team noted the needs of the clients as well as the music therapist through interviews, therapy session observations and regular meetings. The initial construction consisted of an air filled ball with a wireless audio transmitter, accelerometer Arduino Uno and a VS1053 chip. The construction was robust, however use of an external speaker meant it was difficult to use multiple balls together as each had to be connected to a separate speaker. It also made the interaction with the instrument unintuitive for the clients

5.1.2 Second prototype

In the second prototype the developers moved the source of sound inside the ball. The inflated ball was replaced by a foam covering. A piezo sensor and string switch to change the mode was included to make the instrument more versatile. 2nd stage prototype was tested in a series of music therapy sessions over a period of six months. During prolonged period of testing the developers observed that different groups responded differently to the instrument depending on their age and severity of their condition. Thus the developers began working on an easy to use software interface for therapist to customize the functionality and usability of the ball. Work on the software interface is currently ongoing.

5.2 Therapy sessions

Therapy sessions took the form of "musical ensembles" comprised of individuals with ASD led by a certified music therapist. Activities included passing the VESBALL around, "play-along" in which the clients attempted to perform timed percussive events, and group improvisation. Clients learned to switch between modes. These sessions resulted in a group performance directed by the music therapist.

Figure 9. Group improvisation (faces of clients masked out to protect privacy).

Figure 10. Clients learn to pass the ball around.

6.CHALLENGES

One of the major challenges of designing NIME for music therapy is to strike a good balance between practicality and functionality. When dealing with people with special needs it becomes all the more difficult to strike a balance between the two because their physical and mental capability depends on the severity of their conditions. A single design solution cannot be generalized to serve different therapeutic needs. Thus it is important for the music therapist to have a level of control over ease of play, and to be fully integrated in the design process.

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