HeadSphere:
A musical instrument for people with limited mobility

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ABSTRACT
HeadSphere is a research project and prototype that explores development of a wearable musical instrument for people who have limited range of motion. The prototype is a device worn on the head that generates sounds and musical tones based on the wearer's head gestures. The objective of HeadSphere is to understand the needs of a potential user population -- children in Music Therapy-- and create an instrument that can be performed by them, as novice musicians with a limited range of physical and cognitive abilities.

After qualitative research and basic user testing, it seems that such a wearable device could be useful in the context of music therapy.

Keywords
Children, music therapy, physical impairment, cognitive impairment, wearable instruments

INTRODUCTION
Musical instruments are traditionally designed for people with 'typical' physical and cognitive abilities. Any given instrument in its unaltered state (for example a guitar, keyboard, or drum) would require the use of at least one hand and arm, and mobility from the waist up. In the United States alone, there are at least half a million people who do not have full mobility above the waist. [1]

Music therapy is a form of treatment used for a variety of physical and psychological conditions. Within the practice there are several approaches, but most involve the patient playing an instrument accompanied by a therapist. For patients with limited mobility, traditional instruments must be adapted to their needs in order for them to participate.

PROCESS AND PROTOTYPE
HeadSphere was conceived and developed over the course of a semester. Due to the compressed period of time, development began before research was completed. Future iterations will incorporate the learning from this and future rounds of testing.

Interviews
On site and phone interviews were conducted with therapists at three separate facilities in the New York metropolitan area. General practices of music therapy were discussed as well as the specific needs and issues of patients with limited mobility. From these conversations it was determined that initially the device should be musically simple, rely on simple head gestures and provide a clear cause and effect between action and outcome. With a new device such as this, it was suggested that a more complicated experience would be confusing or frustrating for patients, particularly those with cognitive impairments. [David Ramsey, interview April 6, 2004.]

Observations
Two of the facilities, The Foundling Hospital, and the Nordoff-Robbins Center at NYU, allowed observation of their sessions. Both facilities treat primarily children patients with a combination of cognitive and physical impairments, and had at least one child patient with very limited physical mobility. In cases where children did not have functional use of their limbs, the therapists engaged the children using their range of head motion to play instruments. Chimes were used in most cases, as a subtle head motion quickly generated a pleasing sound. This observation supported the idea that a device relying on head motions could be applicable to this kind of environment.

The HeadSphere instrument worn by the author

Prototype

The current prototype served as a proof of concept and was used for initial testing with music therapy patients. It consists of the wearable instrument and a screen-based interface.

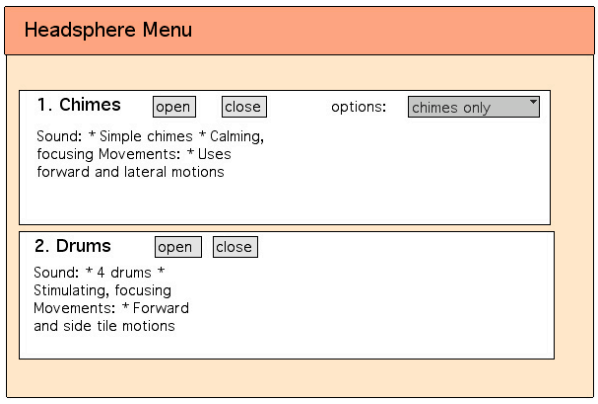
Instrument

HeadSphere consists of a sensor cluster embedded into a furry red headpiece connected to a headband to keep the device securely in place. The sensor cluster has an accelerometer and a digital compass, which measure the head movements. These sensors are mounted to a circuit board, which is wired via Ethernet to a circuit containing power/ground, a BX-24 microprocessor and a MIDI out connection. (Please see the previous page for image of the device.)

Musical Mapping & Interaction

Gesture mapping (the relationship between gesture and musical outcomes) was kept simple based on the recommendation of music therapists. For this iteration, there are two instrument modes – chimes and drums (shown in screenshot below). Each instrument mode has two main gesture mappings – forward/backward and lateral motion. In chime mode, movement forward and backward generates notes on a C major I chord (C, E, G). Lateral motion (like shaking the head 'no') generates the same notes, one octave higher. In drum mode, forward and backward motion trigger a beat of 3 different drums depending on the direction of motion (slightly forward, far forward, and backwards). Lateral motion generates cymbals (left) or claps (right).

Therapist Interface



Screen interface for therapists

Since HeadSphere is intended for a therapist-patient environment, a simple interface was designed for the therapist to operate and adjust the instrument set up. For this iteration, a screen-based interface allows the therapist to turn the instrument on or off and select the instrument sounds (chimes or drums). Ultimately a physical interface could be created, with switches operated on the device or remotely.

Testing

One hospital allowed testing of the initial prototype with their patients. (Visual documentation is not available, as none of these patients had releases signed.) Two children tried the instrument, both of which had cognitive and physical impairments such that it was not possible to clearly verbally communicate the purpose of the instrument or test. The first child actually refused to wear the device, and it was later revealed that a sensory tactile sensitivity that may have caused his inhibition. The second patient entered the room in an agitated state, flailing her arms and not focusing visually on her surroundings. After some initial therapy using traditional drums, we placed HeadSphere on her head. She became and remained nearly still for several minutes as chimes sounds played. The therapist and I discussed the possible causes for response this but were inconclusive.

ASSESSMENT AND FUTURE DIRECTION

User Testing needs to be more extensive to understand the issues and potential for this device. While conversations with therapists have been encouraging, actual use will provide another level of input and direction. It may also be necessary to test with a broader range of patients, including those who have the communication ability to provide feedback about the device. As of this writing, the author is seeking a research facility to partner with for ongoing research and testing of HeadSphere.

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REFERENCES

1. Estimate based on the number of people with severe spinal cord injuries, plus children with Cerebral Palsy. In all likelihood the number is greater, however I could not find research to show a thorough count. Spinal Cord Injury Statistics: http://www.wheelweb.com/facts.htm C D C : http://www.cdc.gov/ncbddd/dd/ddcp.htm