Modern Technology in the Service of Music Therapy

by

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ABSTRACT

In the last few decades, the rapid development of electronic music technologies has changed the way society interacts with music, which in turn impacts the profession of music therapy. Except for a few cases, music therapy has not extensively explored the integration of new technology. However, current research trends show a willingness and excitement to explore the possibilities (Nagler, 2011; Ramsey, 2011; Magee, et al., 2011; Magee & Burland, 2008; Magee 2006). The project described in this paper intends to demonstrate one of these possibilities by combining modern technologies to create an interactive musical system with practical applications in music therapy. In addition to designing a practical tool, the project aims to question the role of technology in music therapy and to initiate dialogue between technologists and music therapists.

The project, entitled MIST: A Musical Interactive Space for Therapy, uses modern gestural technology (the Microsoft® Kinect®) to capture body movements and turn them into music. It is intended for use in a clinical setting with children with mild to moderate disabilities. The system is a software/hardware package that is inexpensive, user-friendly, and portable. There are two functional modes of the system: the first sonifies specific movement tasks of reaching and balancing; the second is an interactive musical play space in which an entire room becomes responsive to presence and movement, creating a sonic playground. The therapeutic goals of the system are to motivate and train physical movement, encourage exploration of space and the body, and allow for musical expression, play, auditory perception, and social interaction.

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In the last few decades, the rapid development of electronic music technologies has changed the way society interacts with music. This radical paradigm shift inherently affects the profession of music therapy. Music therapy, as defined by Bruscia (1998), is a systematic process of intervention wherein the therapist helps the client to promote health using music experiences and the relationships that develop through them as a dynamic force of change. As a profession, music therapy has not extensively explored the integration of technology into clinical practice, but current research trends show a growing interest in the exploration of technology (Magee, 2006; Magee & Burland, 2008; Magee, et al., 2011; Nagler, 2011; Ramsey, 2011).

The potential therapeutic benefits of technology are wide-ranging across populations and goals. Technology's novelty, multimedia capabilities, and multi-faceted interactions create intrigue and motivation to engage in music therapy. Technology gives access to real-time sound control and therefore increases the ability of musical expression in those with limited movement. Even small or weak gestures can yield a meaningful output, a concept entitled "small input, big output," (Hunt, et al., 2004). For some clients, electronic music technology may be the only means of musical expression available to them, or for heavily dependent clients, their only means of independence (Magee & Burland, 2008). Certain clientele, especially adolescents, may respond better to technology than to traditional instruments (Magee & Burland, 2008; Whitehead-Pleaux, et al., 2011). Technology allows the creation of "new sound worlds" different from traditional acoustic instruments (Hunt, et al., 2004). Overall, this research shows that technology has the capability to expand the reach of music therapy. Therefore, there is a need for both large-scale studies on currently available tools and the development of new technologies.

The project described in this paper is an attempt to fill the latter need. The project has four underlying goals: to illustrate to the field of music therapy the potential of integrating technology into music therapy practice; to demonstrate, through a prototyped system, some basic ideas about how technology could be applied functionally; to recognize the possibilities of merging the two worlds; to lay the foundation for developments to come. The project hypothesizes that simple and inexpensive motion capture audio feedback systems can be effective as a tool in music therapy for both physical and cognitive goals.

History of Technology in Music Therapy

Thus far, the integration of technology into clinical practice has been minimal, though in the past decade or so, there has been a growing demand for greater study in this area and a strong research focus (see *Music and Medicine* publications from Summer 2011). Prior to the turn of the century, there were several accounts of the benefits technology can offer. Crowe and Rio (2004) discuss these accounts in a literature review of all references of the use of technology in music therapy since the first mention of adaptive instruments in 1964. In the 1980s, literature appears on the use of personal computers in music therapy, though mostly for organizational purposes, with minimal mention of direct use with a client. However, beginning in 1990 there are specific mentions of "computer assisted music therapy" applications, including Finale® for music notation and a program called FracTunes, which generates visuals based on MIDI keyboard input (Crowe & Rio, 2004). FracTunes was marketed as entertaining interactive software to explore music and graphics (Rothstein, 1991). In music therapy, this music visualization was used to motivate musical composition and engagement (Crowe & Rio, 2004). The quality and prevalence of music visualization is much greater now and could be implemented in a multitude of similar ways using newer tools.

Common Modern Practice

In the literature review, Crowe and Rio (2004) define seven categories of uses of technology in music therapy: (1) adapted musical instruments, (2) recording technology, (3) electric/electronic instruments, (4) computer applications, (5) medical technology, (6) assistive technology for the disabled, and (7) technology based music/sound healing practices. They find that technology in these categories is in use for a broad range of music therapy goals, including developmental disabilities, cognitive and physical impairments, and social and emotional difficulties.

Clinical Applications

MIDI and electronic instruments are pervasive across the music therapy market and are used in therapy similarly to traditional instruments. Related to MIDI and electronic instruments, tools such as the DJX-II Scratch Mixer Box allow clients to quickly create and modify music using pre-composed loops. The client still has room for expression, but is given immediate, affirming musical results with little effort, helping to improve self-esteem (Whitehead-Pleaux, et al., 2011). Loops can be used as an ostinato to facilitate improvisation, which frees the therapist from playing the ostinato to take on other roles (Magee, et al., 2011).

Next to electronic instruments, recording technology is the most prominent use of technology in music therapy. Recording can be done using GarageBand®, a software program from Apple®, and other recording software (Whitehead-Pleaux, et al., 2011). Software such as GarageBand allows teenagers to easily create music to express anxiety and other emotions. Making recordings of these and other musical creations offer keepsakes to help with identity formation, self-esteem, gifts for family members, and lasting ways to assist communication and expression. All-in-one hardware units that record and write directly to CD are popular for their user-friendly interface and fast turn around; therapists can record a session and hand the client a recording of it within minutes. Superscope® is a company that makes such devices; features vary and can include multiple microphone inputs, tempo, volume and key control, and storage to USB devices, SD cards, and CDs (www.superscopetechnologies.com, accessed June 5, 2011).

At times, technology can be more beneficial than a traditional approach in pediatric medical settings. For example, adolescents may be more willing to engage with technology because it is a familiar part of their everyday lives and because traditional instruments can be associated with stereotypes that are off-putting or “socially threatening” to teenagers already struggling with social insecurity (Hunt, et al., 2004; Whitehead-Pleaux, et al., 2011).

Gestural Interfaces for Musical Expression

Based on prior research and this study, I propose another emerging category of technology in music therapy: (8) gestural interfaces for musical expression. This category, part adaptive instrument, part electronic instrument, part computer software, and part assistive technology, includes both motion capture and various types of external hardware that can be used in conjunction with software to create music from gestures. The project described in this paper falls in this category, as do many common tools in music therapy. For example:

Adaptive Use Musical Instruments (AUMI).

In 2007, Pauline Oliveros and Leaf Miller started a project called Adaptive Use Musical Instruments (AUMI). The ongoing project has a goal of giving people with extremely restricted movement the ability to express musically (Heyen, 2009; Platt, 2011). The software uses a laptop with a webcam to translate even the slightest movements directly into sound. The free software, built in MaxMSP, is very user-friendly and is cross-platform (runs on both Mac and Windows). There are five different musical modes provided, including robust options for pitch, scale, and timbral choices, using both midi and recorded audio. The AUMI team also provides support, including one-on-one Skype interviews and workshops to learn how to use the software.

MIDICreator.

The MIDICreator™ is a commercial product developed at the University of York. It is a device with the capability to convert various sensor data into MIDI information (Kirk, et al., 1994). The product released with several "fun" sensors, including a distance sensor, a squeezable foam-filled pad, and an elastic band (MIDICreator User Manual, 2000).

Soundbeam.

Soundbeam® is a gestural device first available in the UK as early as the 1990s that uses a laser beam and midi connection to turn gestures into sounds. The beam detects the distance at which it is interrupted and translates this to MIDI data. Soundbeam 5, released in late 2009, is the latest version of the well-documented commercial product. This stand-alone unit is simultaneously a synthesizer, sampler, amplifier, drum machine, and sound beam. The most notable change to the current version is the addition of an internal, integrated soundchip, which eliminates the need to connect an external midi device (Ayling, 2010). All versions of the Soundbeam have been documented for use with children with special needs. However, at a starting cost of £1,695, it is cost-prohibitive for an individual therapist.

The Beamz Interactive Music System.

The Beamz® Interactive Music System is also a popular commercial product for performance, education and therapy. According to the company's website (thebeamz.com), the Beamz unit plays customizable music when one or more of four visible laser beams are physically interrupted. In therapy settings, the Beamz has been used for physical, cognitive, and social goals because of its intriguing qualities that motivate participation (Vaudreuil, 2001).

Alternative devices.

In addition to these more commonly known tools, there are also devices that have been used sporadically in ways that could be applicable to music therapy. Video games, apps, and electronic instruments offer many ways to address physical goals. Wii music games require the player to shake the controller and extend their arms, actions that address gross movement in the arms, endurance, hand-eye coordination, and synchronized movement. Dance games help the therapist address similar goals but for lower extremities. Music apps on the iPad® and iPod touch® offer a new way to address fine motor skills; in addition, they may be useful in patients with limited strength, little motivation to move, or limited movement in the fingers by providing an incentive to engage with limited physical movement required (Whitehead-Pleaux, et al., 2011). The controllers for popular console games, including Guitar Hero® and Rock Band® have been used as MIDI controllers as alternative instruments in therapy sessions with children (Michael Plunkett, personal communication, May 21, 2011).

Challenges of Technology

As with all interventions, technology has its place. Some clients are less receptive to non-traditional methods than to traditional ones, and some goals are not as suited for technology as others. Trained therapists need to discriminate situations where the use of technology is indicated, just as they decide which traditional interventions to use.

Functional Limitations

Technology is susceptible to a few inherent limitations. It can create a barrier between client and therapist; this occurs on both sides of the relationship when the focus becomes the technology rather than the interaction (Magee & Burland, 2008; Whitehead-Pleaux, et al., 2011). This can also occur if the therapist is unfamiliar with the technology or if there are difficulties with the device. Technology can also provide too much stimulation, especially in cases of acute stress disorder or post traumatic stress disorder (PTSD), and can contain disorienting elements (Whitehead-Pleaux, et al., 2011). The therapist must assess the patient's frustration tolerance with the technology, which likely requires new learning, to be sure that the goal is not unattainable (Whitehead-Pleaux, et al., 2011). In addition, for most technologies to be effective, clients must have the ability to develop awareness of cause and effect (Magee, 2006).

Practical Limitations

There are also practical limitations of technology, including financial, portability, and time concerns (Magee, 2006). Technology can be expensive, and the rapid growth and change of technology means that obsolescence may occur in a few short years. Transportation is also an issue; many therapists work part-time at many different locations, so the portability of the technology important. Setup time of any traveling technology must be minimal because the session time with one patient is often limited. It is important to keep in mind that all of these practical limitations are applicable to traditional interventions as well; musical instruments can be expensive, cumbersome, and take time to set up in a session.

The Learning Curve

Personal accounts show that some music therapists are skeptical of technology (Hunt, et al., 2004; Nagler, 2011), though Magee's systematic investigations show that the problem is actually that they simply do not have access to, training for, or even awareness of appropriate music technology (Magee, 2006). The learning curve of technology requires a time investment on the part of the therapist. The American Music Therapy Association mandated therapy education curriculum just recently added uses of technology as a competency, so was not a mandated part of most current practicing therapists' original education in the US.

Design Foundations to Overcome Challenges

These challenges are presented not to deter any therapist's interest in technology, but rather to clearly explain the obstacles of technology so that they may be appropriately overcome. These challenges defined my design foundations. The system needed to be:

- **Focused on needs of music therapists:** Many systems can be built to create music in novel ways but would not be applicable for music therapy. The design process was inspired and supported by constant feedback from music therapists.
- **Practical**: The tool must be portable, inexpensive, and easy to obtain.

- **Unassuming**: Neither its use, nor its physical setup configuration (i.e. cords and equipment) should be a distraction to the therapist or client, nor should it interfere in the client/therapist relationship.
- **User-friendly:** The entire system must be easy to set up and use.
- **An improvement upon traditional interventions:** No technology is worth creating if its purpose can be better accomplished using traditional means.
- **Adaptable:** Client needs differ from day to day and person to person, so the technology must be robust enough to respond to these changes.

The Project

What Is It?

The project in tangible form is primarily a piece of software called MIST, A Musical Interactive Space for Therapy. MIST is an immersive, interactive sonic system that allows people of all ages and abilities to make music with just the movement of their bodies. It runs on a Mac® or Windows® computer, and requires one small piece of commercial motion-capture hardware from Microsoft®, called the Kinect®. Together, with a third-party software called Synapse that helps interface with the Kinect (see synapsekinect.tumblr.com), they create a system that is capable of turning any ordinary space into a highly interactive sonic space able to respond to any human movement. This effectively turns the body into a musical instrument. The sounds occur in response to various movements of the body, including location and amount of motion. What does that mean? It means that a wave of the arms can be a twinkling magic wand, a chorus of birds, a splash of the ocean, or an orchestra of whales. It means that a child can play an imaginary drum set that surrounds their body. It means that a child's physical presence and movements can actually impact an imaginary world. It means that any classroom, clinic, hospital room, or living room can become a sonic forest, a space station, or the ocean floor with just the touch of a button.

The original concept for MIST was as a tool for music therapy meant for children ages five to twelve who have mild to moderate developmental disabilities. Interaction with the system is meant to encourage exploration of space and the body, create motivation to move, provide an avenue for musical expression, and provoke imagination and abstract thought. These capabilities allow it to be useful in a number of goal-based interventions. The audio feedback of the system gives accurate, real-time knowledge about the state of the body, which not only provides body and spatial awareness, but also motivates continued movement. As a therapy tool, it is designed to motivate specific movements, so that the therapist can work on individual movement goals for each different client. These physical goals can include gross motor movement, synchronized movement, endurance, muscle tone, muscle control, and balance. In addition to physical goals, the system is also designed for cognitive goals such as spatial awareness, proprioception, musical expression, and improved auditory processing.

Background and Related Research

Alan Lem and Garth Paine at University of Western Sydney recently developed a system that sonifies gestures using motion capture with a IEEE-

1394a video camera and MaxMSP (Lem & Paine, 2011). Their intent was to provide physically disabled adults with a way to improvise musically using just the motion of their bodies. The results of the small-scale study showed enthusiasm from the six participants, and the promise that mobile (not wheelchair bound) physically disabled adults change their movements based on the sonic possibilities presented to them. In another project, researchers at Arizona State University and the Center for Computer Research in Music and Acoustics (CCRMA) worked on a project called Pendaphonics that used another game controller, the GameTrak (Freed, et al., 2009; Skriver Hansen, et al., 2009). Though not meant specifically for music therapy, the project shares elements of musical play, motivational environments, and occupational therapy. Adaptive Use Musical Instruments (AUMI) from the Deep Listening Institute, as mentioned above, is also related in its use of motion capture and audio feedback.

The Hardware

Released in late 2010 and widely popular, the Microsoft Kinect is an Xbox 360® add-on that contains next-generation 3D motion sensing technology to allow the player to control games using only gesture and voice, with no tangible controller. The Kinect is a small device that includes an RGB camera, an infrared camera, and microphone (Naone, 2011). It can be connected via USB to a computer to control many types of software it was not originally intended for, such as MIST.

Some technology equipment is easily breakable and expensive, and other types have cables and other devices that could potentially be distracting. This could be an issue for children with attention deficit hyperactivity disorder (ADHD) or autism spectrum disorder (ASD), who typically have impulse control and hyperactivity issues. Because of the Kinect's limited cables and small size, the therapist can easily hide the cables and the technology so that just the room itself becomes the interaction space. The cost is relatively inexpensive compared to other available technology; at only $150, it is much more affordable than the Soundbeam (upwards of $3000) and infrared motion tracking systems (also upwards of $1000). The system allows for any light level, and unlike some other motion capture systems, it will not break if multiple children were to move about the space simultaneously.

Implementation

There are two modes of the system. The first was originally based on Thaut's (2005) theory of Patterned Sensory Enhancement and sonifies two specific movement tasks. Its goal is to motivate action, enhance movement, and retrain the brain. The second mode is an interactive musical play space that reacts to movement within the space in direct but not immediately obvious ways. It is meant to encourage play, movement, musical expression, social interaction, and exploration of space and the body, and to improve proprioception and auditory perception.

Mode 1: Goal-based motion.

Patterned Sensory Enhancement (PSE) is a technique in neurological music therapy that uses music as a cue for specific movements. The musical cues can be rhythmic, melodic, harmonic, and dynamic and provide not only temporal cues, but also spatial and force cues. PSE is commonly used to improve balance and posture and increase physical strength, endurance, and functional motor skills (Thaut, 2005). According to the practice of PSE, musical features are generally mapped to movement in the following way: tempo to timing of movement, dynamics to force of movement, pitch to direction (and/or space) of movement.

The hypothesis in applying PSE to this project is that accurately mapping movement directly to musical cognitive cues using motion-sensing technology could improve learning of motor tasks. In addition, the technology would take over the task of musically matching the movement, therefore allowing the therapist more hands-on work with the client. The novelty and engaging nature of the interaction should motivate participation. The current iteration of the system intends to sonify two specific chosen goal movements, an upper extremity extension (Reach mode), and a horizontal sway of the torso (Balance mode).

Reach mode (upper extremity extension).

The goal of the Reach mode was to use accurate motion sensing data to elicit audio feedback that is directly related to the size and arc of the motion, thus providing the subject with real-time feedback on how their current motion compares to the goal motion. For example, if the client's motion motion is not fully extended throughout, the volume of the sound output is lessened.

As the hand(s) reach up, they trigger "approach" ascending sounds that encourage further upward motion. When the hand(s) reach the vertical extension goal (set by the therapist), a success tone is played. A scale is played over the length of time set by the therapist, indicating to the client how long to hold the hands at this goal length. When the time goal is reached, the hands are given "instruments," meaning that constant musical output is mapped to the speed and location of the hands. MIDI notes are triggered; pitch ascends as hands ascend, volume goes up as hands extend from body, and notes are played depending on hand speed. As this MIDI musical output takes place, the system looks for the hands to reach a horizontal extension goal. The client has four seconds to reach this horizontal extension. If it is reached within the four seconds, a congratulatory tone is played. If it is not reached, the instruments fade and the client can try again to reach up to the top.

The sound for this mode is meant to be whimsical and engaging and loosely based in the theme of a magical forest. The instrument attached to the hands is one of the 128 sounds found in the traditional midi collection, called Music Box. The therapist can change this instrument, or choose the scale (chromatic/pentatonic/major) if they desire. The "approach" sounds are modified steel drums that slide upward and appear in ascending pitches. The success tones are pan flute melodies created by the author.

Balance mode.

The goal of the Balance mode is to work on muscle tone, awareness of body position, timing, and symmetry of motion on both sides. The design gives the client active control over the sound output in two similar modes. In both, the client sways back and forth, looking for the torso to meet given distance goals. In the first mode, Rhythm, one bar of a rhythmic loop is played when the distance goal is met. They must reach their torso to the other side to trigger another bar of the loop. If they sway at the correct tempo, the rhythm is maintained as one bar after another is triggered. If the sway is too fast, the loop sounds choppy because it restarts too soon. If the sway is too slow, there is a break in the sound. There are three rhythmic loops to choose from; each of these can play in five tempos. The therapist can control which loop and how fast it is playing with the << >> and + and – buttons on the Apple controller, or by presetting it before the game. Feedback from the focus group indicated a minor change to this design, which yielded the second mode, Rhythm Hold. Rhythm Hold instead plays the chosen rhythm loop as the client holds the body on either side, focusing directly on muscle control and tone.

Mode 2: PlaySpace.

The goal of the PlaySpace is to encourage exploration of space and the body, musical expression, play, movement, auditory processing, and social interaction. It is an immersive sonic environment in which a child's movement creates sound, eliciting imagination, abstract thought, and the illusion of a magical environment. Research suggests that interactive multisensory environments that offer mediated ways to express and communicate may be beneficial to those with disabilities and their families (Williams, 2008). Garth Paine (2008) defines immersive sonic environments as occurring when one's presence in an architectural space influences the sonic space in some intelligible, designed way. When the subject notices the room has changed because of their presence, it becomes an invitation to explore.

The PlaySpace sounds are themed to encourage imagination and play. The system makes a room become a responsive environment, with hidden layers of interaction that encourage the subject to continue exploring. The PlaySpace is an interactive space approximately 15ft x 15ft in area. There are currently two sound environments that are functional with plans for a third. The first is an enchanted forest, and the second is underwater. Each sound environment, or sound world, follows the same basic structure. There is a base soundscape track that constantly loops as long as the space is turned on. There are three sound areas that have specific interactions within them. Both current worlds have a bird area, in which many birds can be heard and shaking the left and/or right hands makes even more birds fly. The forest birds are tree birds; the underwater world birds are seagulls, and are also accompanied by the sound of waves hitting the shore, as if the subject has ascended to the surface of the ocean.

The second sound area in each sound environment is a moveable area, meaning that when the subject finds the sound, they can pick it up and move it to another area in the space. Giving the subject the ability to move the sound allows them the ability to actually impact the environment, making them an active participant rather than a passive experiencer playing by the set rules of the game. It provides motivation and structure that is more than superficial. To pick up this sound, the subject must put his/her hands near the ground and bring them back up to the torso level. A notifying tone is played, and the moveable sound gets noticeably louder until it is placed down again wherever in the space the subject chooses.

The last sound area encourages large motion. In the forest, it is drumming elves, and underwater, it is an "orca-stra" of whales. The system looks for overall motion of the body and adds layers of rhythm to the elves' drumming the more the subject moves. A greater amount of overall hand motion causes more whales to start singing. Each of these areas also contains a timed incentive sound. If the subject remains in the area for a given amount of time (default twenty seconds), excerpts of fitting Disney songs or whatever the therapist decides to include begin to play.

There is also one main interaction for when the subject is not in one of the three sound areas; in the underwater world, hand movement outputs a sound of hands rushing through water as if the subject is swimming. The forest world is similar, except the resulting sound is of midi instruments and is meant to feel like a musical magic wand. The same mappings used are the same as in the Reach mode. The wand only appears if the hand reaches far enough away from the body center, such that the client has to reach out and grab the wand, encouraging upper extremity extension. The wand then disappears if the overall speed of hand motion falls below a certain level.

The Study

Method

The system design was evaluated through qualitative research in the form of an anonymous survey, in-person interviews, and a focus group. All research subjects were trained music therapists. Because of the novel nature of the project, the scope of this first pilot study was not to test the technology with the clients it was designed for. Rather, the goal was to evaluate its potential from the perspective of the experts who would eventually implement it. An on-going online anonymous survey was distributed to approximately fifteen music therapists at the beginning of the design process. The purpose of the survey was to get an idea of what technology might be most useful to music therapists. There were two respondents.

The same email used to distribute the survey included a request for people to participate in one-on-one interviews. The interviews were for the same purpose as the survey, but to facilitate a more creative dialogue. Four people participated in interviews. On September 7th, 2011, after the first iteration of the system was designed, a request was sent to approximately ten local music therapists to participate in a focus group. The purpose of the focus group was to provide an engaging forum for creative dialogue concerning the actual project, and through this, critique and evaluate the current system design in the context of functional applications to music therapy. Three therapists were able to attend the session.

Results

The results of the survey, though limited, were positive. Both participants described a significant amount of technology already being used in current practice, and both agreed that technology would work well with clients who were already interested in technology. However, one also postulated that technology could serve as a good tool for geriatrics because "incorporating technology can be a process of growing and understanding and may also facilitate shared experiences with younger folk." One of the survey questions asked, "In what context might you see a gestural device benefit music therapy?" Both respondents provided ideas, and one respondent replied, "I wonder if clients could use gesture on something like the Kinect to play a series of notes or chords."

An early interview yielded the idea that musical cues could help incentivize side-to-side balanced movements in clients with cerebral palsy, which inspired the design of the Balance mode. Thus, it may have potential with children with cerebral palsy or who need to work on changing direction of movement. The interviews proved successful in providing feedback at multiple states of development, so that the project development adhered to the needs of music therapists.

The overall results of the focus group were highly positive and indicate that the system has potential to be successful in treating physical goals such as muscle control and extremity extension, and cognitive goals such as spatial awareness and auditory processing. The participants spent two hours viewing and interacting with the system and engaging in dialogue loosely guided by a set of research questions provided by the investigator. The group was particularly excited about the "potential" and the "imagination," and that "anybody can do it." In comparison to other technology, one participant said, "This is truly interactive in a way that I can't say I've ever really experienced with a piece of technology in the music therapy world," and that "it's quality feedback." In terms of specific applications, they said it "could be great for a kid you're trying to have more physical activity," and "it's really great with auditory processing and the sensory and the spatial awareness, motor movement, all that stuff."

The participants suggested changes to the program in places where the goal could be modified to be more applicable to music therapy; for example, the reach and balance modes' experiential goals were modified to include a "hold" in the motion to better address muscle tone and control. A user-interface was added to give the therapist control over the length of the arm-extension goal, as was the opportunity to add in client's favorite songs.

Even more importantly, the discussion yielded many ideas about functional applications of the current system. Most were ways the therapist could structure interaction with the system; for example, an intervention working on instruction following and auditory processing, "When I play this instrument you have to go to the frog, but if I play this instrument you have to go to the drums." They also discussed using the system for structured storytelling, having the child act out the story with the sounds in the space. They stressed the importance of the therapist imposing structure on the interaction.

While discussing functional use, the therapists noted that using this technology with groups of children would be difficult, because only one person can be tracked at a time. Even if more users could be tracked by the system (a capability that is coming in the near future), it would get chaotic trying to discriminate which sounds came from which user. Another practical challenge addressed was the space availability in classrooms; the thought was that some classrooms may not have a space large enough to accommodate the system. Neither the setup time nor the requirements for a computer, power source, and speakers seemed to pose a problem to the participants.

The focus group generated many new ideas for future versions of the system. These included, but are not limited to: adding the possibility of saying "hello" and "goodbye" to the room; designing more moveable sound spaces in the PlaySpace; adding the capability to track multiple bodies to facilitate social interaction; giving the therapist the option to focus the feedback on a different body part, such as the torso, head, or legs, tracking tangible objects in the space; and modifying so that it can be used for more traditional musical performance.

Conclusion

The project originally set out to prove that simple and inexpensive motion-sensing audio feedback systems can be an effective tool in music therapy for both physical and cognitive goals. The preliminary assessment of the project shows promising data that this hypothesis is true. This promising feedback leaves a wide-open road for development. The next steps will be to set up a study to evaluate the system with actual clients. During this process, development of the system will continue and will focus on added variety of sound choices, improved quality and breadth of interaction, targeted movement goals using the head and lower extremities, the development of a performance-oriented mode, and research into expanding the system to make it suitable for group applications.

The project was built on four underlying goals: to illustrate to the field of music therapy the potential of integrating technology into music therapy practice; to demonstrate, through a prototyped system, some basic ideas about how technology could be applied functionally; to recognize the possibilities of merging the two worlds; and to lay the foundation for developments to come. It is the author's hope that these goals have been met, that the project may encourage meaningful dialogue between music technologists and music therapists, and that this will promote innovation in this important research avenue. Collaboration and discussion are vital to successfully integrating technology into music therapy practice, an important addition that will expand the scope of the profession.

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