Bergsland, A. and Wechsler, R. (2016). Interaction design and use cases for MotionComposer, a device turning movement into music. *SoundEffects - An Interdisciplinary Journal of Sound and Sound Experience, special Edition on: Sound and Listening in Healthcare and Therapy.* Vol 5, No 1 (2016).

Manuscript submitted for publication.
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Interaction Design and Use Cases for MotionComposer, a Device Turning Movement into Music

Abstract

The article discusses the ways in which MotionComposer (MC), a newly developed device turning movement into music, engages users of other abilities[1] so as to provide positive psychological and somatic effects. The article starts by describing the philosophy behind the device, emphasizing the importance of dance and music for human well-being. This is followed by a technical description and a section of design principles, including a discussion of two conflicting strategies which must be reconciled: on the one hand the need for clear causality (which implies control, predictability and repeatability), and the need for variation, surprise and adaptability to alternative (unintended) ways of playing on the other. Finally, we discuss some use cases, in which the MC was applied to the needs of persons of other abilities. The article concludes by stating the importance of 1) variance and richness in interaction and music design 2) activity as the central interaction parameter; and 3) openness to the productive aspects of "incorrect" or "unintentional" use in creating meaningful and health promoting interaction for all users.

Introduction

The MotionComposer (MC) is a device that turns movement into music, especially developed for persons with other abilities. It uses video tracking techniques to trace the movements of users combined with sound generating software so that the users' movements in front of the camera are converted into sound and music. While the MC can be applied to professional artistic purposes and general entertainment, it is primarily intended for therapeutic and health care settings. Thus, it is a part of a growing number of devices and applications that have been developed over the last few decades, that use novel sensor and music technology to let all kinds of users play music as a part of a therapeutic or other health-related agenda. Other examples of this kind of technology are the *MIDIGRID* (Kirk et al 1994), the *Soundbeam* (Swingler 1997), *WaveRider* (Paul and Ramsey 2000), the *Movement-to-music* (MTM) system (Tam et al. 2007), *L'orge*

[1] Also called "disabled" or "persons with disabilities".

sensoriel (Picotin 2010), the *MusicGlove* (Friedman et al. 2014), *ORFI* (Stensæth and Ruud 2014), and *Shakers system* (Baalman et al 2016).[2] General purpose video based motion tracking systems like *EyeCon* (Weiss 2008) and *EyesWeb XMI* (Camurri et al 2007) have also been used with success for therapeutic aims (Acitores and Wechsler 2010; Camurri et al 2003) and indeed the MC project has used both systems over the course of the system's development (ca. 5 years).

The Philosophy Behind MotionComposer

Music and dance may be seen not only as art forms, but as deeply-ingrained human behavioral artifacts, common to every human culture and historical period (Brown 1991). Although, they can be learned and mastered according countless traditions, they are also instincts -- children will do them without any role model or instruction whatsoever. That these activities play a role in human health as motivators for movement, creative expression and social interaction is well-established (Stuckey 2010, Four 2002).[3]

Some of the barriers faced by persons with other abilities fall away in the practice of dance and music. The ability to speak, control movement accurately or even think clearly can, with the appropriate tools, be rendered practically irrelevant. Even without interactive technology, dance and music can encourage inclusion. Most music and dance traditions are applied to communal activities where everyone takes part -- children, old people, persons with disabilities -- all find a way to join in (Brown 1991). If applied thoughtfully, digital technology, such as motion sensors, gestural and choreographic analysis, and musical synthesis and composition, can extend the possibilities. Not only do they allow a greater range of body parts and gestures to be used to play music, but they can also contribute "open affordances" -- features that afford a more open form of exploration, where searching, discovering and play are basic afforded actions (Bergsland 2015). The dance and music are still dependent on the users' capabilities, of course, but much less in the form of measurable skills and more relying on sensory and attentive focusing which might be amplified by qualities such as openness, playfulness and creativity.

When we engage in dance and music, it can certainly *feel* good, but in many ways it *is* also good for us; it simply improves our health and well being, both bodily and mentally.

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[2] See also Crowe and Rio (2004) for an extensive review of instruments, application, medical technology and technology-based health music/sound health practices up to that year.

[3] According to the World Health Organization, "Physical inactivity (lack of physical activity) has been identified as the fourth leading risk factor for global mortality (6% of deaths globally). Moreover, physical inactivity is estimated to be the main cause for approximately 21–25% of breast and colon cancers, 27% of diabetes and approximately 30% of ischaemic heart disease burden." http://www.who.int/dietphysicalactivity/pa/en/ (accessed 12.12.2015).

Murcia and Kreutz (2012) review a number of studies showing a number of positive health benefits of dance and music: They reduce the risk of physical illnesses as well as mental disorders, develop and enhance fitness indicators as aerobic capacity, balance, elasticity, coordination, reduce stress levels and affect brain health and cognition positively. In addition, they point to the social benefits of dancing on social relations, with benefits for group cohesion and togetherness. Kontogeorgakopoulos, Wechsler and Keay-Bright note how people with other abilities more often face social isolation and reduced physical activity compared to non-disabled (2014). By making people move, dance and make music at the same time, outside or as a part of a therapeutic setting, we regard the MC as a means to better health and wellbeing for its users, independent of physical and mental abilities.

Technical Description

At the time of this article, the current version of the MotionComposer[4] uses an ASUS time-of-flight (TOF) depth sensor, coupled to a CCD ethernet video camera. The next version (now in development) will be based on different hardware and software. The following descriptions pertain only to the current version.

Hardware

In the current version, the sensors are contained in one chassis and the computer in another (see figure 1). The data from the two sensors are combined via custom software. Why two different sensors are used can be understood in this way: the CCD offers the resolution and low latency necessary for the detection of minute gestures with a real-time feeling. Meanwhile, the TOF allows the human figure to be isolated from the background and to be measured in terms of its shape and position in the room.

Figure 1. The MotionComposer 2.0

Software

The high-resolution video images from the CCD along with the 3D data from the TOF sensor are interpolated and fed to the tracking software developed by Simone Ghisio and Paolo Coletta[5] in the *EyesWeb XMI* programming environment. The tracking software applies a number of algorithms to calculate a set of movement parameters, and passes these as data streams over ethernet to the music software via the Open Sound Control (OSC) protocol (see figure 2). Among these 20+ parameters are quantity

[4] The MotionComposer2.0 was sold for a short time in 2014/15 by the German company IMM-Gruppe. The MotionComposer3.0 is currently in development by a different company and will use different hardware and software. More information is available at the website www.motioncomposer.com.
[5] Both work at *InfoMus*, a research institute at University of Genoa in Italy (www.infomus.org).

of movement (also called “activity”), user position perpendicular to the camera direction (also called “centre X”), height, width and arm height for each of the arms. The sound software for each of the six interactive *environments*, which from the technical point of view are characterized by different sound generating algorithms and movement-to-sound mappings, is programmed in Pure Data, Csound and Supercollider. The programs are controlled by the user/therapist from a graphical user interface (GUI) and run using a selected number of the control parameters as input, depending on the specific needs of the environments. The sound software generates the sound output, consisting of synthesized sound and processed playback of sampled sounds, and this is directed to the loudspeakers, and thus made audible to the user.

Figure 2. Software flow-chart.

We have been tempted on numerous occasions to build a software-only system, relying on the cameras built into smartphones and computers, or game controllers such as Microsoft’s Kinect. There would be an enormous cost advantage, and this could bring with it a much wider distribution. The downside concerns the quality of the experience: the built in sensors of consumer electronics and computers have at present time lower resolution and would miss many of the small gestures such as eyes and fingers. Also, the Kinect especially, has considerable latency which detracts from the synaesthetic experience (“I am the music”). Our current thinking is that there may be a place for both products, appropriately priced and marketed. Interest in one may stimulate interest in the other.

Design principles

During the four-year development of the MC, a number of design principles have emerged motivated by three overriding goals:

- Inclusion - the device can be used equally by persons with and without disabilities
- Synaesthesia - the device is both a musical instrument and a dance device
- Artistically satisfying and/or entertaining - a quality experience and not a toy or gimmick

Inclusion has to be seen as our primary goal. We want users with and without disabilities to be able to make music -- alone or with others -- on an equal, or nearly equal footing. While this may sound utopian, it is not. In the simplest terms it means, 1) allowing many different body parts and kinds of movement to be used, 2), the device must be easy to operate, both for user and therapist, 3) it should sound pretty good however it is played, and 4) it must provide highly intuitive mapping and clear causality. *Inclusion* is also the main motivator behind our development of three different interaction *modes*, which we will discuss in detail below.

Synaesthesia refers to the confusion or overlapping of our senses. It is what happens when we “feel the music inside us” when we dance, or when our movements and the sound they cause become one and the same thing (this is discussed below in the section, “Musical Instrument or Dance Device”). In our experience, synaesthesia will strengthen users’ engagement, their feeling of engagement in and focus on the here-and-now and the causal connection between their own bodies and the sounds they hear. There are technical issues that can add to, or detract from a synaesthetic experience. One of these is latency. With a sufficient lag from movement to resulting sound, the user will tend to feel that movement and sound are *two* separated events, instead of one. Single shooter computer games can tolerate quite a high latency between, say, shooting, and when the monster is blown to bits. This is because what is important there is causality and not synaesthesia.

One of the continuing challenges we have faced is to create experiences that are *artistically satisfying and/or entertaining*, and which can remain so over time. There are different reasons why a user might want to spend time with a musical environment: one is that, with practice, she or he develops skill and is better able to shape her or his movements to achieve a desired effect. If continuously presenting adequate challenges to a user, the experience of mastery can drive and retain interest and involvement. A second reason is that there is a variety of both music and interaction metaphors to explore. Our take on this has been to develop a set of *environments*, which from the user point-of-view are characterized by each playing different types of sounds and being based on different interaction metaphors. But we have also aimed for that even without switching environments, the musical responses should have variation and interest *by themselves,* so that an identical movement will not necessarily produce an identical sound.[6] For instance, the exact repetition of a sound sample enabled by digital audio technology will quickly feel tiring and even irritating to the user, so introducing variants or avoiding repetition has been important. A third is that the music is beautiful to hear and we are able to make with appropriate-feeling beautiful movements -- in other words, we are seeking *aesthetical experiences*. While it is not always easy to pinpoint what triggers aesthetical experiences in each user, we are constantly aiming for this, thus setting goals that are just as much *artistic* as therapeutic in nature.

Mapping

Mapping deals with how body-movement parameters, as analysed by the tracking software, are linked to sound parameters as a part of interactive design. It is generally divided into two parts: action and output. It is the combinations thereof, which offer their particular efficacy *in vivo*. The body-movement parameters we track are common in video-based interactive systems, and fall roughly into 4 categories:

1. activity
2. shape, including height, width and arm height
3. position in the room (centerX)
4. gesture (particular combinations of the first three, for example, an arm extended quickly overhead, or a jump)

Of particular importance to us are:

1. *Stillness-to-action.* We see this as most basic: movement causes sound and stillness causes silence. Stillness is not a passive experience, as we are almost never still. When we hold still, we tend to listen and this reinforces the causal relationship. It is also a gesture, if I may call it that, that almost everyone can do. The onset of movement/sound after stillness is highly latency critical, whereas the transition the other way around is somewhat less affected by latency.

2. *Small vs. large body-movements.* We have a very different sense when we use finger movements to control sound, as when we use the entire body. Not only are our expectations in the sound world different, but the way we concentrate changes as well. They are based on two metaphors: the musician, who very accurately controls small movements, and the dancer, who uses full-body movement to physicalize an artistic

[6] You will notice that this principle seems to contract the causality principle mentioned above. Clearly a careful balance is needed.

intent. Both seem valid to us, and in combining them we seek a rich and varied user experience.

3. *Body-part extrapolation.* When users hear the sounds that their fingers make, they often, and without instruction, will try out head, torso, feet and other body parts, looking for additional games to play. This sense of exploration through the body is one of the hallmarks of the MotionComposer.

The three modes of MotionComposer

Throughout the development process of the MC, we have faced fundamentally conflicting design criteria. For example, while there is a high priority for simplicity of operation, at the same time, in order to insure the inclusion of truly *all* users, different modes of user needed to be rendered. This became clear to us through workshops with persons of other abilities, including those with quadriplegia, aphasia, dementia and Rett syndrome, to name a few. A one-size-fits-all solution, or a machine that somehow “intelligently” adapts to users, is not easy to implement. Instead, we adopted a compromise design solution in which the MC has 3 modes of use labeled *room*, *chair* and *bed*.

When we started out, the basic mode of interaction was *open* in the sense that we allowed for the user to move anywhere inside the area which was tracked with the camera system. In consequence, most of our environments at that time used the position perpendicular to the camera (*centerX*) as a central parameter in the interaction. Not only are there users who cannot move around the room on their own, but even for those that can, this parameter can be difficult to follow. Thus, although moving around the room is extremely important, and reinforces the dance-is-music metaphor, we also needed a mode of interaction where the instrument could be played from a stationary position -- i.e. a *chair* mode, in which the continuously-variable *centerX* data is transferred to the height of the arms beside the body (only now there are two data streams: left-arm left music channel, right-arm right music channel). The choice of which to use, *room* or chair, is deceptively complex. We tend to apply metaphors when we move to make music. For example, when we hear piano notes, we might extend our arms and wiggle our fingers. Another type of sound may make us feel more like using mouth, head, torso or feet movements.

After doing a workshop at a children's hospital it became clear to us that there are many people who can neither move around the room, nor raise their arms beside their bodies and we developed *bed mode* for them. In *bed* mode, *activity*, or the *quantity of movement*, is tracked in two areas of the body. Admittedly, this mode leaves quite a lot of the musical decisions to the system (i.e. the composer), but we have put a great deal of effort into maintaining variation and interest even for this interaction mode. And indeed, activity, unlike shape or position-based parameters, still retains the powerful component of timing. Thus, activity is thus not only the most trackable of human movement parameters, but is also the most important from the standpoint of physical (dance) and music expression.

Six Musical Environments

Another consequence of our principle of *inclusion*, considering how different people tend to enjoy various types of music, is our offer of varied environments. Consequently, the chances are that most users can find something they find interesting, beautiful or engaging. So, in addition to the three modes of use, the user selects between six musical environments. Each environment offers different mappings and different styles of music. In addition, several of the environments have variants, with several sound banks or other settings, so that the overall musical potential of the device is rich and varied. In terms of musical genres or styles, we have implemented elements from classical, jazz, techno, latin, soundscape and electroacoustic music. We will now give an outline of basic mappings, metaphors and musical content of the four musical environments relevant in this context.

Tonality

The prevailing metaphor used in this environment is that of playing an instrument, and for most users, one that they are familiar with. The choice of instrument -- in the current version you can choose between piano, vibraphone and harpsichord -- can be set by the user or the therapist in the GUI (sitar, guitar and a moog-like synthesizer will be added to the next generation of the device). When it comes to the *choice* of notes from these instruments, it comes about through a combination of user input and features built into the system: Although the user chooses the approximate note value, or whether the notes are ascending or descending, the *exact* selection is controlled by the system, using algorithms to ensure that the notes are in accordance with an underlying musical logic and thus rendering a strong sense of tonality. On top of this musical intelligence, the user affects the dynamics (soft/loud), pitch range, whether chords are played or single notes and various kinds of articulation (arpeggios, scales, chords). The result is an environment that is ”musical” in a relatively traditional manner that can remind listeners of music in the classical and jazz idioms, but where the user can also feel that s/he is in some sense “playing” the music.

Particles

The Particles Environment is perhaps the most sonically most complex of the six. It is based on four sound worlds, each consisting of a large number of short samples, in which the user can orient him/herself in that the user’s movements in different zones trigger the sounds.[7] Within each sound world, the samples are organized so that sounds sharing a similar characteristic or belonging to the same source category are contiguous. Moreover, the transitions between different groups or categories of sounds are made continuous, so that even if there is a pronounced change in quality, this change will still come about as a smooth and sonically continuous transition. The nature of the different sound worlds from which the user can choose, suggests different metaphors. In one, *materials*, the user can play the sounds of materials like glass, metal, water, wood and skin by navigating to different areas of the interaction space. In another sound world, *Songshan Mountain*, the user plays vocal sounds from a Chinese opera singer. The environment generally reacts in a very dynamic manner letting the size of movement control the density of the samples so as to vary from playing single particles, to chained sequences or even dense clouds. These loud masses of sound render a relatively abstract quality that can be far removed from the original. All-in-all, the large number of sounds gives the environment a sonic richness that can evoke interest and curiosity.[8]

Techno

This environment is based on a contemporary popular dance metaphor, where the user is given an underlying beat to which s/he can dance. The system reacts to the user's movement by making the music more active and engaging, so as to invite the user to keep dancing. This takes place in a few ways.

One of the most basic aspects of the techno genre is the groove. While it must never stop, at the same time it must be modulated and these modulations can be user-activated. When the user stands motionless before the MotionComposer a beat is heard, but when they "groove to the music" the kick (bass drum) comes in. This effect generally keeps the user in motion, bobbing up and down or shifting weight between legs. By bending low the music becomes low-pass filtered, a recognizable effect from the techno genre. Stretching high similarly offers a high-pass effect. Finally, melodic layers can be added and removed by extending the arms.

Fields

This environment is relatively diverse since it includes both metaphors of narrativity/ impersonation, as well as playing a musical instrument and causing sonic events. The logic of the environment rests on a division of the interaction space into two side-by-side zones that can be preset by the user/therapist. In some of the fields the user plays animal sounds, thus enabling a game of impersonation or role-playing where the user

[7] See Bergsland & Wechsler 2013; 2015 for a more in-depth description of mapping and sound design in the *Particles* environment.

[8] The *Particles* environment has also been used to create interactive dance performances. See Bergsland and Wechsler (2015).

"becomes" the animal. In others, the user can "play" different instruments or objects like drums and glass, or weather phenomena like "wind" and "rain". Musically, this environment therefore has affinity with soundscape composition and an expanded notion of what sounds can be musical.[9] The division of the interaction space into two distinct areas, which can be played simultaneously by two users, makes this environment ideal for duets, enabling, for instance, a "conversation" between a chicken and a frog. Actually, developing *Fields* made us aware of a number of benefits of having more than one user, something we will discuss further below.

Fields, as mentioned earlier, is based on the human movement parameter we call *activity*, which we consider to be the most important. Derived from the continuous activity parameter we do an additional analysis of which of four levels it falls into:

1. very small, discrete movement, such as fingers or eyes.
2. typical gestures of the hands, head, shoulders, feet, etc.
3. bursts of large, high-energy movement.
4. jumps, where both feet leave the floor.

Here, levels 1,3 and 4 are Boolean (on/off triggers), while 2 is a continuously variable controller.

These levels are used when choosing among four categories of sounds in the *Fields* environment following the logic that small movement cause small events, creatures or objects to be heard, whereas large movement will cause big ones. For instance, in the case of the bird sounds:

Activity level 1:	plays individual chirps, or tweets
Activity level 2 in low range:	plays a trill, or continuous singing of one bird
Activity level 2 in high range:	plays more than one bird, volume also increases.
Activity level 3:	plays a larger bird, such as a crow
Activity level 4:	plays the sound of how we imagine an archaeopteryx would sound like

Thus, even if this follows a "logic", this logic is interpreted in a creative, playful and sometimes joking manner. For the frog, for example, level 1 will render gentle "quacks", while when the user moves really large thus reaching level 4, a "splash" will be heard suggesting for the user that the frog has jumped in the water. Each kind of sound requires a unique strategy for its implementation.

Single vs. Multi-User

[9] See Drever (2002) for a discussion of soundscape composition and acousmatic music.

Even when we do them by ourselves, music and dance are in some sense concerned with performance; sharing the experience heightens the enjoyment. In the current version of the MC, only one of the six music environments, *Fields*, is implemented for multiple users. Based on positive experiences with having two users together in an environment in many of the later workshops, we have seen the need for porting the *two-person* mode to all environments, and this is currently in development.

Allowing two-person interaction also has the advantages of creative social and musical interaction, either involving a friend, colleague or therapist. As Eide (2014) points out, the dialogical perspective in music has become important to music therapists in recent decades, emphasizing *co-experience* and *co-creation* (p.122). In our work, we have experienced that games of imitation, mirroring and dialogue heighten the enjoyment for many users. The challenges that two-person interaction present to users -- most often this relates to problems of hearing *who does what* -- are often easily solved through focus and conscious guidance, and might offer the pedagogical benefit of making space in the interaction and listening to the other.

Gathering Experiences

Beginning in 2010, the MC Team has been seeking support to the claim that interactive digital movement-to-music technologies can play a role in affording dance and music engagement among highly diverse users, including those with severe disabilities. The work has taken place in the form of 28 workshops in 7 countries. A total of 242 persons with disabilities took part, as well as 119 therapists, teachers and caretakers.[10]

The types and severity of disability varied widely, as did age and demographics. Disabilities included Rett Syndrome, Autism (Autism Spectral Disorder), Cerebral Palsy, Quadriplegia, Parkinson's, Alzheimer's and others. Most workshops also included "non-disabled" participants (including, in some cases, professional dancers and musicians).

The workshops were organized through institutions for persons with disabilities and participation was free. Sessions alternated individual and collective exercises, beginning with a group warm-up lasting ca. 30 minutes. This was followed by a demonstration of the interactive system, which gave participants the chance to have an individual taste of the experience. Next, we divided into smaller groups of 3-6 persons where each participant had more time to experiment. In this part the needs of individual participants guided the workshop, which included storytelling scenarios and little performances. At the end we would bring everyone together for a finale, which was followed by a debriefing or discussion, where the focus was on the experiences of the participants of other abilities.

[10] See: http://www.palindrome.de/ad_sites.pdf. Accessed 12.12.2015.

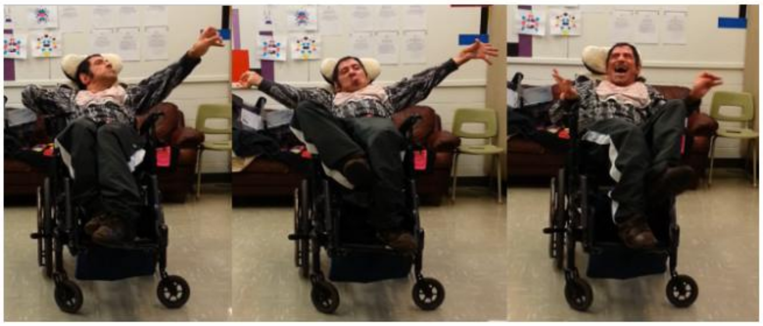
User Interaction Case Studies

From the big number of individuals that we have worked with over four years, we have chosen a small number of uses cases, which have highlighted one or several themes we find interesting. Our accounts of these use cases are partly based on our own notes from the workshops, communication with relevant close others and studies of video recordings of the events.[11] In that sense, they are anecdotal by nature, but still refer to general principles which we have observed repeatedly through all of our workshops. The names of the users are anonymized.

Frederick

Fredrick (adult male) made a particularly strong impression during a workshop playing the *Tonality* environment in the *chair mode*. The music he generated in the interaction with the system projected a musicality and sense of dynamics and phrasing that was surprising, even for the members of the project team who knew the potential of the *Tonality* environment well. This seemed to transcend the pathological view of Fredrick's movements, a perspective in which his movements could be characterized by a high degree of muscle tension and stiffness due to Cerebral Palsy, also affecting motor control and movement patterns. Half-laying, half-sitting in his wheelchair, he had several moments with high energy movements where all extremities were in constant motion for a period of 10-15 seconds. This included arm movements in big circles to the sides and lifting both legs/knees alternately in an almost rhythmical manner (see figure 3). Then he could have periods where either his left or right arm moved up and down in a bouncing manner while the rest of his body remained relatively still. Frederick's lowest levels of activity as they were tracked by the system, however, were far from what most people would perceive as bodily stillness. Still, the differences between his highly active periods, and the periods with less activity generated beautiful and highly dynamic piano music, with arpeggios running up and down, melodic trills and alternations between high and low voices, all varying from soft and sparse sections to dense sections with high energy and a fast pace.[12] For us, this illustrated the importance of the activity parameter, and how in fact a user with less motor control than most of us, still can express himself musically through the dynamics of his movements.

[11] These use cases are also described in Wechsler et al (2016), but in the present article we have generally expanded and adapted our discussion to cohere with the themes presented here.
[12] To hear a recorded sample of Frederick's playing, go to http://www.palindrome.de/frederick.



Site 7. Video 100141, 4:51-6:23.

Figure 3. Video stills of Frederick, face blurred

In several parts of his session, Frederick's arms weren't necessarily reaching out to the sides so as to be adequately tracked by the system, but would often be positioned in his lap, pointing towards the camera or backwards away from it. This would frequently make the system replace the user input with "default" values -- in this case, the absence of one or both arms for the tracking software would generate a value corresponding to minimum arm height (arm way down). This affects the environment so that the choice of notes will be from the low pitched end of the piano. When he had only one arm to the side, something which happened quite often, the insistent bass voice would be accompanied by a voice in the treble range of the register. Together, this was in fact one reason why Frederick's playing occasionally took on the flavour of late romantic piano music, à la Chopin and Liszt. Fredrick's non-adherence to the "rules" of the interaction highlighted for us how "glitches" of the design or "mis-use" could infact have aesthetically pleasing results. Together with similar incidences, we have come to embrace faults and failures of different sorts as a positive thing that can lead to new design innovations and new ways of thinking about movement, technology and interaction.[13]

Lastly, it has to be mentioned that Frederick seemed to have a great time during his session. His face and vocal utterances expressed many positive emotions during his performance session: immense joy, well-being, concentration and pride.

Daniel

Daniel (male, 26 years) participated in a full-day workshop together with a small group. Daniel loves music and dance, especially latin and classic, which he enjoys on a regular basis. People who know him characterize him as active and full of humour, although he can be timid and need time to adjust to new sensory impressions and social settings. Daniel can react in a pertinent manner in various situations, but has problems with

[13] See also the discussion in Wechsler et al (2016).

comprehension and communication, especially on the verbal level, and his abilities in that area can be compared to a 3-4 year old.

What was most striking with Daniel was that he got very absorbed in the music and in the exploration of his body's role in the interaction. In his first session he was playing the *Fields* environment together with a close other. At first he acted a little insecure, seeking the safety of eye contact with his close other, but after a little initial hesitation he seemed to gain confidence and started to engage actively in the interaction. When he moved and made sound he seemed at first quite surprised that he was actually producing the sounds with his body. After he had established the causal relationship between his own movements and the sounds, he started to explore what parts of the body corresponded with what sounds (see figure 4). Whereas his movements moments earlier had seemed quite stiff and limited, he now began to stretch his fingers, rotate his arms, use foot movements and even small jumps. Perhaps most striking, however, were the pauses he employed, freezing in place to delineate the effect that he was having on the music. Precisely this freezing and moving again is maybe the strongest way of establishing the causal relationship between movement and sound, at least when the system responds without noticeable latency. While many users need overt instruction and a bit of training to do this, Daniel, seemed to this spontaneously. Subsequently, he would smile broadly in satisfaction of realizing the effect he was having on the music.

Site 27, video 100456, 12:01-14:32.

Figure 4. Video stills of Daniel.

All the time he seemed to listen intensely and respond immediately to the sounds he was making. We learned from his close others that this stood in stark contrast with how Daniel responds verbally in everyday communication settings - he can sometimes answer a question or request after as much as 30-40 seconds. The psychological absorption, acuity and presence we observed in Daniel suggests a state of mind thoroughly described and studied by Csikszentmihalyi, called *flow* (see e.g. Csikszentmihalyi 2014). In this state, there is a "merging of action and awareness; a concentration that temporarily excludes irrelevant thoughts, feelings from consciousness" and there is a clear feedback in the interaction (*ibid.* 215-16).

Aneta

We met Aneta at a children's hospital in Italy. She cannot speak but does make some vocalizations. After moving in an environment in which her movements triggered verbal sounds, she began to make vocalizations in response. Her mother told us the next day that her vocalizing had continued on into the evening and that this was very unusual for her.

Site B. Video 100145, 45:12-45:31.

Figure 5. Video stills of Aneta

Anna

Anna (girl) participated in a relatively long session at one of our workshops with dominantly non-disabled participants. She had her parents and her therapist present during the session, where she was playing the *Tonality* environment in chair mode using the vibraphone sound bank. Anna has Rett syndrome and is dependent on wheel chair. In the beginning of the session Anna did not move very much by herself, except the twisting and rubbing of the hands, characteristic of Rett. When one of the MC team positioned himself behind her, and began moving her hands for her, she seemed to respond positively to the gentle vibraphone notes this movement generated. After some minutes, she began to make slow rocking movements back and forth, thus producing music by herself. In the de-brief following Anna's session, we learned from her parents and her therapist that this type of self initiated physical response was very unusual for her. We have found this method -- first assisted, and then alone -- useful in cases where verbal instructions are not possible.

Site 14. Photo courtesy of International Rett Syndrome Foundation (www.rettsyndrome.org).

Figure 6. Girl with Rett Syndrome[14]

Conclusions

In designing music-movement tools for persons with disabilities, we face large, but also very interesting challenges. This user group is not only incredibly diverse, but also incredibly open. One of our main challenges has been to ensure *inclusion* for users with all abilities, so that *all* types of movements can in fact render musically interesting and pleasing results for the user. The overruling strategy we have taken in that respect has been to strive for *variation* and *richness* in mapping strategies, interaction metaphors and in sound and music. Simultaneously, we have maintained *activity*, being something truly universal across abilities, as the central parameter for all our environments. For both Frederick, Anna and Daniel, feeling the music follow their activity level seemed to be sufficient to generate a rewarding experience. We have realized that its counterpart, *stillness*, is also very important, and as for Daniel, can be a crucial component in perceiving the causality between movement and sound.

We have made many surprising revelations in our workshops as users would play the MotionComposer "incorrectly", and in doing so discover brilliant creativity, inventiveness and musicality. To wit Frederick (described above) played the *tonality chair* environment, in which arm height along the vertical axis is tracked. But Frederick was almost horizontal in his special wheelchair and thus his arm movements did not follow the intended trajectories. This lead to unintentional, yet interesting consequences. Other examples include persons who reach both arms to one side of their body (fairly common), twist around in their wheelchairs, or who reached towards the floor or towards the audience instead of upwards. From a choreographic standpoint, these ways of playing are expressive and completely justified even though the logic of the system *as a musical instrument* is not what was intended.

[14] Photo courtesy of International Rett Syndrome Foundation (www.rettsyndrome.org).

The question for us, then, is how to design dance-music systems which offer "rules" for their control, and yet for those cannot or choose not to follow those rules, allow alternative mappings and modes of playing. This dichotomy -- rules and freedom -- cannot be resolved through compromise. A system that sometimes does what you want, will always be frustrating. The question is how to accommodate multiple modes of playing. They can be concurrent or alternating and if the latter, where there is a switching back-and-forth, how is the choice made of when to switch?

- by the therapist (or other person pressing the buttons)
- by the user (for example, through a particular gesture)
- randomly
- via an intelligent system, which analyses the style, range of movement, etc. of the user

Finding good answers to these questions depends on amassing experiences with users who appropriately reflect a broad range of abilities. Disabilities Studies professor Devva Kasnitz spoke up during a seminar we gave at University of California at Berkeley[15] to say, "we are not interested in having you develop tools for us, but we do want you to develop tools *with* us" (Block 2015). Different users can contribute to the development in different ways, some more actively and directly with own suggestions and ideas, and others more indirectly, through showing what they like and what they don't like so much.

We believe that if we follow this advice in our design process, that technologies such as ours can herald a new era for creative expression among persons of other abilities -- rendering positive effects for health and well-being, and that society at-large will benefit in ways we can hardly imagine.

Acknowledgements

This project was supported in part by the EU Commission through the project "MetaBody", under the subproject "Affording Difference".   Please see www.metabody.eu for further details.

[15] "Media, Embodiment and the Politics of Indeterminacy", University of California Berkeley Department of Theater, Dance and Performance Studies, Symposium, Zellerbach, Room 170, May 7-9, 2015. http://tdps.berkeley.edu/events/media-embodiment-and-the-politics-of-indeterminacy/

References

Acitores, A.P. and Wechsler, R. (2010). Danza Interactiva con Ninos Paralisis Cerebral. *XXVII Congreso de la Asociación Española de Logopedia, Foniatría y Audiología, 7, 8 y 9 de julio de 2010, Valladolid, Spain.*

Baalman M., Lussana, M., Lavau, D., Palacio, P. Reus, J, Wechsler, R. (2016). Touch Matters*. Proceedings of International MetaBody Forum (IMF), Madrid, 2016.*

Bergsland, A. (2015). Aspects of digital affordances: Openness, skill and exploration. *Paper presented at the International MetaBody Forum (IMF), Weimar, March 2015.*

Bergsland, A. and Wechsler, R. (2013). Movement-Music Relationships and Sound Design in MotionComposer, an Interactive Environment for Persons with (and without) Disabilities. *Proceedings of Re-New Conference of Digital Arts, Copenhagen, 2013.* Retrieved from http://issuu.com/re-new/docs/re-new_2013_conference_proceeding

Bergsland, A. and Wechsler, R. (2015). Composing Interactive Dance Pieces for the MotionComposer, a device for Persons with Disabilities. *Proceedings of the New Interfaces of Musical Expression NIME2015, Lousiana State University, 20-24.*

Block, P., Kasnitz, D., Nishida, A. and Pollard, N. (2015). *Occupying Disability: Critical Approaches to Community, Justice, and Decolonizing Disability.* Springer Publishers, New York City.

Brown, D.E. (1991). *Human Universals.* New York: McGraw-Hill, 1991.

Camurri, A., Mazzarino, B., Volpe, G., Morasso, P., Priano, F., & Re, C. (2003). Application of multimedia techniques in the physical rehabilitation of Parkinson's patients. *The Journal of Visualization and Computer Animation*, *14*(5), 269-278.

Camurri, A., Coletta, P., Varni, G. and Ghisio, S. (2007). Developing multimodal interactive systems with EyesWeb XMI. *Proceedings of the 7th International Conference on New Interfaces for Musical Expression, New York.*

Cappelen, B., & Andersson, A.-P. (2014). Designing four generations of 'Musicking tangibles'. In K. Stensæth (Ed.), Music, Health, Technology and Design (Vol. 7, pp. 1-20). Oslo: Norwegian Academy of Music.

Crowe, B.J. and Rio, R (2004). Implications of Technology in Music Therapy Practice and Research for Music Therapy Education: A Review of Literature. *J Music Ther. 2004 Winter,* 41(4), 282-320*.*

Csikszentmihalyi, M. (2014). Toward a psychology of optimal experience. In *Flow and the Foundations of Positive Psychology* (pp. 209-226). Dondrecht: Springer Netherlands.

Drever, J. L. (2002). Soundscape composition: the convergence of etnography and acousmatic music. *Organised Sound*, 7(1), 21-27.

Eide, I. (2014). 'FIELD AND AGENT': Health and characteristic dualities in the co-creative, interactive and musical tangibles in the RHYME project. In K. Stensæth (Ed.), *Music, Health, Technology and Design* (Vol. 7, pp. 119-140). Oslo: Norwegian Academy of Music.

Four, G.D. (2002). Decades of music therapy behavioral research designs: a content analysis of Journal of Music Therapy articles. *J Music Therapy*, 39(1), 56–71*.*

Friedman, N., Chan, V., Reinkensmeyer, A. N., Beroukhim, A., Zambrano, G. J., Bachman, M., & Reinkensmeyer, D. J. (2014). Retraining and assessing hand movement after stroke using the MusicGlove: comparison with conventional hand therapy and isometric grip training. *J Neuroeng Rehabil 11*(76).

Kirk, R., Abbotson, M., Abbotson, R., Hunt, A. and Cleaton, A. (1994). Computer Music in the Service of Music Therapy: the MIDIGRID and the MIDICREATOR systems. *Medical Engineering & Physics 16*(3), 253-258.

Murcia, C. Q., & Kreutz, G. (2012). Dance and Health: Exploring Interactions and Implications. In R. A. R. MacDonald, G. Kreutz, & L. Mitchell (Eds.), *Music, health, and wellbeing*. Oxford: Oxford University Press.

Paul, S., & Ramsey, D. (2000). Music therapy in physical medicine and rehabilitation. *Australian Occupational Therapy Journal*, *47*(3), 111-118.

Peñalba, A., Valles, M., Partesotti, E., Castanon, R. & Sevillano M. (2015). Types of interaction in the use of MotionComposer, a device that turns movement into sound. *Proceedings of ICMEM – The International Conference on the Multimodal Experience of Music, University of Sheffield, England, 2015.*

Picotin, R. (2010, December 28). L'inventeur de l'orgue sensoriel récompensé. *Sud ouest.* Retrieved from http://www.sudouest.fr

Ruud, E. (2010). *Music Therapy : A Perspective from the Humanities*. Gilsum, NH, USA: Barcelona Publishers. Retrieved from http://www.ebrary.com

Stuckey, H.L., and Nobel, J. (2010). The Connection Between Art, Healing, and Public Health: A Review of Current Work. *Am J Public Health. 2010 February,* 100(2), 254–263.

Swingler, T. (1998). "That Was Me!": Applications of the Soundbeam MIDI Controller as a Key to Creative Communication, Learning, Independence and Joy. *Paper* *presented at California State University Northridge Conference on Technology and Persons with Disabilities 1998.*

Tam, C., Schwellnus, H., Eaton, C., Hamdani, Y., Lamont, A., & Chau, T. (2007). Movement- to- music computer technology: a developmental play experience for children with severe physical disabilities. *Occupational therapy international, 14*(2), 99-112.

Wechsler, R., Bergsland, A. & Lavau, D. (2016). Affording Difference : Different Bodies / Different Cultures / Different Expressions / Different Abilities. *Proceedings: International MetaBody Forum (IMF), Madrid, 2016.*

Weiss, F. (2008, April 08). EyeCon. Retrieved January 21, 2016, from http://eyecon.frieder-weiss.de/.