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MOTIONCOMPOSER: A DEVICE THAT TURNS MOVEMENT INTO MUSIC

MotionComposer: un dispositivo que convierte el movimiento en música

ROBERT WECHSLER
Karl-Haussknechtstr 11, Weimar, Germany
Director, MotionComposer GmbH
www.motioncomposer.org
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Resumen: La utilización de tecnología de captura de movimiento basada en el vídeo permite hacer música sin necesidad de tocar un instrumento musical, sino gestualizando en el espacio. Con un foco en contextos terapéuticos y pedagógicos, el MotionComposer (MC) es una de las herramientas que están siendo desarrolladas en la actualidad, que permite a todo tipo de usuarios participar, incluyendo a las personas con capacidades diversas. El objetivo de MotionComposer no consiste en conseguir un juego fácil, sino investigar en las relaciones musculares-musicales que están en la base de la expresión sana de la danza y la música. Tras describir brevemente el dispositivo, este artículo describe algunos de sus aspectos terapéuticos y pedagógicos de su uso, incluyendo su facilidad de utilización; la posibilidad de uso y adaptación del dispositivo al movimiento a diversas partes del cuerpo; las posibilidades de programar diversos modos de uso; la causalidad que permite comprender la relación entre gestualidad y sonoridad; la posibilidad de tocar músicas estéticamente interesantes independientemente de las capacidades de las personas; y la posibilidad de utilizarse con múltiples usuarios.

Palabras clave: Tecnología musical y terapia; captura de movimiento; danza terapia; música interactiva; danza interactiva.

Abstract: Using video-based motion tracking technology, it is possible to make music without touching a musical instrument, but instead by gesturing in space. With a focus on therapeutic, healthcare and pedagogic contexts, the MotionComposer (MC) is one of a small but growing number of tools being developed today which let all kinds of users participate, including those with different abilities. The aim of the MotionComposer is not just to make a fun trick, but rather to delve into the deeper muscle-music relationships that lie at the heart of healthy music and dance expression. After briefly describing the device, this paper describes some of the therapeutic and pedagogical aspects of its use.

Keywords: Music Technology and Therapy; Motion Tracking; Dance Therapy; Interactive Music; Interactive Dance.

Using video-based motion tracking technology, it is possible to make music without touching a musical instrument, but instead by gesturing in space. With a focus on therapeutic, healthcare and pedagogic contexts, the MotionComposer (MC) is one of a small but growing number of tools being developed today which let all kinds of users participate, including those with different abilities. The aim of the MotionComposer is not just to make a fun trick, but rather to delve into the deeper muscle-music relationships that lie at the heart of healthy music and dance expression. After briefly describing the device, this paper describes some of the therapeutic and pedagogical aspects of its use.

1. INTRODUCTION

The MotionComposer (MC) is a device being developed by a team based in Weimar, Germany (the project was part of Bauhaus University, but is now independent). The team's director, the author of this paper, began this project through his work with the Palindrome Dance Company, which in the 1990's became specialized in interactive performance – using sensors and computers to let dancers create, or shape the music directly through their movements in space. In 2010, Alicia Peñalba, a researcher at Valladolid University, approached him with the idea to use this technology to work with persons with other abilities. This was the genesis of the MotionComposer, which began with a workshop with children at Centro Obregón de Parálisis Cerebral in Valladolid, Spain (reported on by Peñalba and Wechsler, 2010).

By turning movement into music, the MC allows anyone to play music. But to think of this device merely as an "easy-to-play musical instrument" misses a larger point. When music is associated with expressive movement, it triggers deeply-felt sensations and these can play an role in therapy, health and well-being.

Human beings have been dancing and making music for 50,000 years (Higham, 2012), possibly longer than there has been human language. Music and dance involve areas of the brain thought of as more primitive than those used for

speech and cognitive reasoning. Although we may hear music with our ears, it engages us in a deeper way. The Neuroscientist Daniel Levitin writes: "Rhythm stirs our bodies. Tonality and melody stir our brains (...) bridging our primitive cerebellum and our evolved cerebral cortex." (Levitin 2006, p. 263). Or, as Nietzsche said, "We hear music with our muscles." [1]

"I've got the music in me", sings the pop star[2]. This sensation is known to almost everyone and represents a form of synesthesia, a sensory confusion between what is being heard, and what is felt in the proprioception of shapes, movement and rhythms of the body. Though a confusion, it is certainly a pleasurable one! It stimulates us in a way that promotes health, both when we are alone, and as a part of a shared social activity (Stuckey & Nobel, 2010; Four, 2002; Murcia & Kreutz, 2012).

1. 1. Product history and current status

The MotionComposer2.0 was built by IMM Electronics GmbH and sold from 2015 until July 2017. Approximately 20 units were sold to institutions and centers for persons with other abilities. Together with frequent workshops, these "test users" are providing information about its use and potential markets. Current work is focused on the development of the next version of the device, the MotionComposer3.0, whose release it to the open market is planned for early in 2019.[3]

1. 2. Comparable products

Over the past decade, there has been an increasing interest in motion tracking technology for therapeutic, healthcare and pedagogy-oriented fields. For Assisted and Augmented Communication (AAC) applications, a number of remarkable new tools have emerged, for example, those based on tracking eye-movement as a way of controlling a computer, which is then used to trigger the playback of sampled speech, essentially enabling speech through eye movement. (The dominant company building such devices is Tobii (Levine, 2012).

Other examples of movement-into-sound technologies directed towards persons with other abilities include Soundbeam (Swingler, 1998), L'orge sensoriel (Picotin, 2010), MusicGlove (Friedman et al., 2014) and the Shakers system

[1] Oliver Sacks attributes this quote to Nietzsche on page 11 of "Der einarmige Pianist: Über Musik und das Gerhirn", Rowohlt, 2008. weltwoche-ausgabe-372012.html.
[2] "I've Got the Music in Me" is a song by The Kiki Dee Band. It was written in 1973 by Bias Boshell, https://en.wikipedia.org/wiki/I%27ve_Got_the_Music_in_Me, accessed 28.12.17.
[3] See http://www.motioncomposer.com. The author of this article is the project's leader.

developed at STEIM by Baalman et al. (2016). MIDIGRID (Kirk et al., 1994), ORFI (Stensæth & Ruud, 2014), WaveRider (Paul & Ramsey, 2000) and the Movement-to-music (MTM) system (Tam et al., 2007) are examples of other tools that turn movement into music (using non video-based technologies).

General purpose video-based motion tracking systems like EyeCon (Weiss, 2008) and EyesWeb XMI (Camurri et al., 2007) also enable movement-to-sound interactive environments, and have been used with success for therapeutic purposes (Peñalba & Wechsler, 2010; Camurri et al., 2003a). Indeed the MC team has used both systems extensively[4].

What the MotionComposer offers uniquely, is an extremely low entry fee – it can be set-up within minutes, and played satisfyingly by virtually anyone. It offers high resolution -- the blinking of the eyes is sufficient to play sounds – and has intuitive mappings and a wide range of high-quality sound worlds.

1. 3. Workshops and studies

Between 2010 and 2017 the MC team conducted around 50 workshops with persons 4 to 90 years old, and including those with a variety of abilities, including persons with Rett Syndrome, Cerebral Palsy, Alzheimer's, Parkinson's, quadriplegia, blindness, deafness, autism and others.[5] Some of the accumulated experiences have been written about[6], and numerous video excerpts are available on-line.[7]

One study has been conducted by Peñalba and associates concerning "several types of interaction achieved through MC in individuals with differing characteristics in terms of age, disability, gender, training background, experience, etc., by focusing on both standardization and diversity." (Peñalba et al. 2015; Peñalba, 2015, p.1).

2. DESIGN PRINCIPLES

Bergsland and Wechsler (2017) identify certain design principles used in the MC. These can be summarized as follows:

2. 1. Inclusion

[4] Ibid.
[5] Ibid. There is a list of workshops at http://www.palindrome.de/sites_MC.
[6] http://motioncomposer.de/#section-what-is-mc.
[7] https://vimeo.com/album/3993460

Inclusion is the primary design principle of the MC (Bergsland & Wechsler, 2017). The designers are dedicated to assuring that users with all sorts of abilities are able to make music, alone or with others, and on an equal or almost equal footing. In other words, the project is aligned with concepts such as 'universal design' and 'design for all', which ultimately rest on philosophical/ethical ideas of equality and democracy (Iwarsson & Ståhl, 2003, p. 61).

In order to facilitate inclusion, the MC should:

2. 1. 1. Be easy to use

Both for the player, the teacher and the therapist or teacher, the MC must be easy to use. It should work effortlessly and off a minimum of buttons to press[8]. In addition to choosing one of six "musical environments", and the selection of Mode (mentioned above), the user interface offers a slider to control volume and one to control sensitivity. The sensitivity slider controls how much movement is needed to play the sounds. Thus, persons who move a lot, can achieve a similar result as those who move very little.

2. 1. 2. Be possible to play using different body parts

The MC allows many different body parts and kinds of movement to be used. The philosophy, which is inspired by the work of Cage and Cunningham, is that all sounds have the potential to be music, and all human movement has the potential to be dance[9]. Movements as different as blinking one's eyes, shaking one's head, moving one's hips, waving an arm, finger movements and falling to the floor can render interesting musical results with the MC (Bergsland & Wechsler, 2016). This opens up the possibilities of expression for persons with a limited movement range and control, for example due to dementia, paralysis, hypertonic or hypotonic cerebral palsy or limited motor control.

This flexibility is made possible by using Quantity of Motion (QoM), a common and easily calculated parameter in video tracking involving frame

[8] Since most users want ease-of-use, the normal MC3 will be a „closed system", offering very few control options to the user. However, since some users want the power to modify the system, for example to use the MC's motion tracking to control their own music-making devices or software, a more powerful "Pro-version" of the MC3 will also be available.

[9] These are well-recognized principles in the oeuvres of composer John Cage and choreographer Merce Cunningham. The author was a student of Cunningham and Cage in New York in the 1980's (http://motioncomposer.de/#section-our-team).

subtraction (the comparison of consecutive video images) which represents the dynamic qualities of many kinds of movements (Camurri et al., 2003b; Camurri & Moeslund, 2010, p. 247). As the term implies, the parameter refers to the amount of movement in the field-of-view of the camera, rendering small movements into small values and large movements into large values. The MC music software, then further refines this analysis through mapping. For example, a small movement might be interpreted as a small sound, let us say the chirp of a bird. As the QoM increases, the same chirp sound might become *louder*. But alternatively, we might also hear *more birds*, or indeed the sound of *a larger bird*, such as a crow instead of a sparrow. Such complexity in sounds and mapping can improve the intuitiveness of the user experience and, in this way, result in greater pleasure and longer use-sessions, or at least so it is hoped.

2. 1. 3. Be playable in different 'modes of use'

The MC allows for different modes of use. For example, for users who can move through the room, one can select a mode in which the notes of a piano are played *across the room*, with the low notes on the left side of the room, and high notes to the right. Alternatively, one can choose a mode in which notes are arranged vertically, with low notes close to the floor and the highest notes overhead. Of course, many persons can neither move through the room, nor raise their hands over their head, thus there is a mode in which the piano is played purely by movement, or QoM. In this case, the melodies that one can play are similar to the other modes of use. The difference lies in the musical features that the player can control. For example, although the QoM mode does not allow for a precise selection of notes, one can nevertheless change the key and scale of the music by making pauses of different lengths. Also, the timing of the notes and chords remains completely under the player's control.

The key issue is not how *much* control a player has, but rather that whatever control they do have is convincing (see the section on causality, below) and musically significant.

2. 1. 4. Provide clear causality

It is important that the player get the sense that his or her movements are causing the music – with no explanation required – despite the fact that there is no physical contact between the user and the instrument. This may sound like a small matter, but in fact it is not. Unless the motion tracking, mapping, and sound choices are made with care, the sense of causality can be lost. There are a number of issues causality, some could be described as psychological, some artistic and some technical.

One technical issue is latency, meaning the amount of time that passes between making a gesture, and hearing the resulting sound. There is research showing how temporal contiguity affects the perceived causality between two events (Gruber et al., 1957; Mäki-Patola & Hämäläinen, 2004a). More specifically, latency in the form of a delayed auditory response, can negatively impact musical tasks, for example the ability to synchronize with an external beat (Aschersleben & Prinz, 1997) or another player (Chafe & Gurevich, 2004), the ability to maintain a steady pulse (Pfordresher & Palmer, 2002; Dahl & Bresin, 2001) or the ability to match a target pitch (Mäki-Patola & Hämäläinen, 2004b)[10]. Furthermore, latency in new electroacoustic instruments can lead to the functionality of the instrument itself being interpreted as 'late' (Tarabella & Bertini, 2004), thus detracting from the performance quality of the music.

Causality, which can be described as a "Sense of Agency" (SoA) has important implications in cognitive psychology. "[SoA] is the experience of controlling both one´s body and the external environment" (Limerick et al., 2014, Front. Hum. Neuroscience), and can be seen as "the sense that I am the one who is causing or generating an action" (Gallagher, 2000), or "the experience of controlling one´s own actions and, through them, the course of events in the outside world" (Haggard, 2017, Nature Reviews Neuroscience).

2. 1. 5. Sounds good no matter how it is played

To play a violin, players need to acquire a basic level of skill in order to have stable dynamics and proper intonation. Thus the violin, like many instruments, requires considerable practice before a pleasant result can be expected. There are, however, instruments (including the MC) that have what is called a 'low entry fee'; this means that they can be played with little or no practice (Wessel & Wright, 2002). By basing the sound production on high-quality digital sampling, the perceived audio quality is independent of the user's skill in playing. Also, the MC uses algorithmic composition software to effectively pre-select the notes that will sound good together.

A technique known as "quantizing" is also used. This helps the player to play rhythmically by correcting errors in her or his timing. For example, if the player plays a note too early, then the sound is delayed slightly so that it occurs "in-beat" – at the time when it would be expected. If, on the other hand, the player's gesture is late, then software will either filter out the "wrong" note, delay it all the way until

[10] This review of research concerning the perception of latency is from Bergsland & Wechsler (2017).

the next upbeat, or simply play it anyway, even though it is off-rhythm, on the assumption that an occasional wrong note will not destroy the overall rhythm. Thus, the resulting music always has a good beat.

2. 2. Dance is it!

The MotionComposer is based on the principle that movement expression, or dance, is as important as musical expression. This should not be a stretch – in many music and dance traditions, there is an overlap between the two. Capoeira, for example, is a practice in Portuguese-speaking countries and it is as much a movement tradition as it is a musical one[11].

When playing a traditional musical instrument, the player usually moves his or her extremities (fingers, hands and feet) to make the sounds. And yet, "The playing gesture itself may have fewer expressive qualities than the sound it produces. Dancers, on the other hand, move in response to the music. They express themselves through movements that are sound-accompanying rather than sound-producing. In combining these modes of expression, a feedback loop is implied: Movement generates music, and music generates still more movement" (Bergsland & Wechsler, 2017, p 28).

For the MC, this means mapping torso movements as well as extremities. Movements involving the center of the body, the so-called 'core muscles', are of great importance in dancing and indeed are sometimes seen as the source of its puissance. Finally, there is the importance of a strong pulse. A good groove tends to make people want to dance. In the MC, three of its six musical environments are based on or contain rhythmical music.

2. 3. Multiple users

Dance and music are activities we like to share – either to perform in front of others, or to do in a group. One can point to the benefits of dancing in social relations, creating a sense of group cohesion and togetherness (Murcia & Kreutz, 2012, pp. 128-129). For the MC, however, this presents a challenge: when there are multiple users, causality becomes difficult, since it is difficult to perceive who is doing what. Nevertheless, some of the musical environments do offer two-person mode. As long as the music sounds are very different, there can be a communication-though-sound with the resulting benefit of increased social activity and fun.

[11] https://en.wikipedia.org/wiki/Capoeira.

A method used by workshop-leader Josepha Dietz, is to assemble a group in front of the device and have all move together. Then, she asks the group to freeze – to stop moving – and the music stops. Next, she will have one person and then the next dance solo, while the group remains still. Finally, she returns to the beginning, where all are moving at once. In alternating group movement and solos, she is able to build a "group energy" while at the same time having enough moments of *clear causality* to deliver the feeling that the users, collectively, are controlling the music (Dietz, 2016).

3. HOW IS THE MC USED IN THERAPY AND EDUCATION?

There are many answers to this question. Both for persons with and without disabilities, music and dance take on many forms. Dietz (2016) and Bergsland & Wechsler (2016 and 2017) offer anecdotes (some documented with photos and videos) to describe how the MC can used. Some typical examples include:

3.1. Crossing the room

Workshops often begin with playing a musical scale by crossing the room. Everyone can do this, even persons who must be pushed in a wheelchair. This serves two functions: 1) it introduces the rather unusual phenomenon that one's body in space can play music, and 2) it makes a performance in front of others, one in which all can succeed equally well, i.e. everyone can play every note on the scale, equally well. The scale in the MC can be changed; e.g. it is easy to hear the difference between a blues scale, a flamenco scale. The next step in the workshop might be to control the speed of playing (with the speed of moving), experiment with changes of directions, or add accents (chords or other instruments) by extending the arms or legs.

3.2. Movement to the floor

Going to the floor and up again requires the large muscles of the torso and legs. Setting the mapping so that the music responds to the player's height is an good way to get players to move in strong and expressive ways. Persons who cannot do this movement might nevertheless be able to reach up from a mat on the floor and hear a similar effect. (Or, as described above, there are alternative ways to play the MC).

3.3. Reaching out hands, controlling arm height

One of the most effective ways to work with persons with severe movement disabilities is to use extended arm movements to play sounds. The workshop leader

will often work by repeatedly moving the player's hands for them – helping them to play the sounds. After a period of time, it is not uncommon for the player to begin to make the same movements by themselves, in order to play the same pretty sounds that they just heard. This has been applied to persons with Rett Syndrome, for example, with remarkable results.

3.4. Bobbing, shaking and swinging movements

Almost any sound can encourage movement based on QoM. Movements that repeat, like swinging, bobbing or shaking, will generate sounds that match the movement, and will thus have a clear causality. This, in turn, is often fun for the player, and encourages continued movement. By changing the sounds over time, the environment can be kept interesting (even while the mapping remains the same).

3.5. Stillness and melodic timing

It is through the use of silence that music has some of its strongest expression (Williamson, 2011). Players can easily generate dramatic pauses in the music simply by being still. This has been observed with children with Autism.

4. RESULTS

It is well-established that movement is important to health and well-being (Laforge, 1999; Armstrong, 2009). It is also true that persons with disabilities disproportionately face social isolation and reduced physical activity as compared to their non-disabled counterparts (SGUN, 2010). Since the joy and stimulation of dance and music encourage movement (Stuckey & Nobel, 2010; Four, 2002; Murcia & Kreutz, 2012), it is easy to see how a device like the MotionComposer can bring a health and well-being benefits to persons with different abilities.

The effect of dance and music on the spirit is perhaps more subtle and difficult to quantify, but anecdotal evidence seems to suggest that using the MC can be beneficial to mood (Bergsland & Wechsler, 2017; 2016; Dietz, 2016).

5. CONCLUSIONS, QUESTIONS AND FUTURE PLANS

The MC stands out as a tool that can be used with broad inclusivity – including with persons with severe disabilities. These users include those who, for a variety of reasons, cannot express themselves verbally, but their engagement can nevertheless be judged on their facial expression and in other ways. Particularly once the MC3.0

is completed in 2019, systematic studies of its effects on users over longer periods of time are encouraged and would be supported by the developers.

It would, for example, be interesting to look at how regular, repeated use might be beneficial in ways that go beyond the benefits of 'increased movement'. For example, can users with low verbal or cognitive ability, nevertheless develop their musical abilities? Could we see improvements in expressivity of gestures and responsiveness? How then might the device be modified to allow for and encourage such development?

Not only could this be deeply satisfying for the player, but it could be interesting and beautiful for their friends, care-takers and for the public at-large.

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