The Body as a Musical Instrument: Reconsidering Performances with Biosignals

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Introduction

On the middle of the stage sits a man. Eyes closed, motionless, electrodes attached onto his skull, he is surrounded by timpani and other percussion instruments which suddenly start to resonate, then stop, then sound again … It is 1965. Alvin Lucier is performing his piece called *Music for Solo Performer*. The electrodes on his head measure his brain waves. Practically, Lucier is trying to relax. When he manages to reach a meditative state, his brain produces alpha waves. As soon as those alpha waves are detected by the electrodes, vibrators installed on the percussive instruments are activated and the instruments resonate. This is the way music is being produced. Is Lucier, composer and performer of this piece, p l a y i n g music? Playing music usually implies the use of musical instruments: a physical object that produces sounds when manipulated by a musician. Lucier tries to control his brain activity, but his body is completely still. He is not physically manipulating any musical instrument. Can *Music for Solo Performer* really be considered a musical piece? What is the role of the body in the sound production?

Lucier's pioneering work marked the beginning of a movement in research and creation characterised by the incorporation of biosignals in music[1] and in performative arts in general.[2] Biosignals are signals (i. e. variations of measurable physical

1 Eaton, *Bio-music*, 1971; Brouse, "Petit guide", 2012; Arslan et al., "From Biological Signals to Music", 2005. See also: Nagashima, "Bio-sensing Systems and Bio-feedback Systems", 2003, pp. 48–53; Dribus, "The Other Ear", 2004; Ortiz et al., "Biosignal-Driven Art", 2011.

2 For dance performance, see MacCallum and Naccarato, "The Impossibility of Control", 2015, pp. 184–191; for performance installations: Naccarato and MacCallum, "Critical Appropriations of Biosensors in Artistic Practice", 2017, pp. 1–7.

parameters) naturally produced by the human body. They can be, for example, brainwaves, heart rates, muscular signals, neuron signals, breath. Many experiments have been carried out to sonify biosignals directly, i. e. to turn them into audible soundwaves or to use them in performances as a way to control or influence the production of visual or acoustic content. David Rosenboom is highly significant in this domain as he has worked extensively with biosignals to create musical performances.[3] Since Lucier's time, the advent of computers and digital tools has opened up a new technological age in music and in the arts in general. With these technical developments, sensors have become more efficient and affordable, easy to use and adapt to music practices.[4]

Lucier's seminal work raises questions and challenges our common representations about music – questions about playing music, about what a musical instrument is. One can indeed be puzzled by Lucier's performance. It has been classified as a work of experimental music,[5] but the actions of the performer and his role on stage have been very little discussed.

In this paper, we will examine two particular performances making use of biosignals. Both are recent and noteworthy, using digital sound synthesis with computers. The synthesis algorithms use signals measured from the bodies of the performers. Firstly, I will study Atau Tanaka's performance of *Le Loup* with his instrument called the BioMuse. It is an interface that records nerve signals on his forearms' muscles. The second piece is *DATA_Noise*, a performance by Kasper T. Toeplitz and Myriam Gourfink. He uses a computer; she dances wearing sensors on her body that record movement data. Similar to Lucier's work, these performances propose new ways of playing music that are radically different from traditional music performances. The role of the body and its relationship to sound production are redesigned and this challenges our common understanding and representations of what a music performance is. We will analyse these performances with a particular focus on the role of the human body in order to provide a new understanding of them. The hypothesis is that the body is part of the musical instrument in these performances. I will try to

3 See: Rosenboom (ed.), *Biofeedback and the Arts*, 1976; and Rosenboom, *Extended Musical Interface with the Human Nervous System*, 1990.

4 See, for example: Miranda and Brouse, "Toward Direct Brain-computer Musical Interfaces", 2005, pp. 216–219; Miranda and Brouse, "Interfacing the Brain Directly with Musical Systems", 2005, pp. 331–336.

5 Straebel and Thoben, "Alvin Lucier's *Music for Solo Performer*", 2014, pp. 17–29.

verify this hypothesis through the analysis of the two musical productions. The way in which the body is engaged is novel and specific, therefore, I will also investigate what the new role of the body can entail for the performances.

This paper will start with an overview of what a musical instrument is in the literature. I will present the two performances and analyse them through the lens of the body and its role in the performance, in the sound production and in the staging. From that analysis, I will be able to reflect on and reconsider the role the body plays in these performances. Finally, a conclusion will be drawn about the kind of performances that emerge with the use of biosignals: I will identify if they can be qualified as musical, instrumental performances.

Musical instruments

Musical instruments have long been studied only through organology, i. e. classification and mechanical study. The first attempts to define what a musical instrument is can only be found late in history.[6] Nowadays, when computers and digital tools have pervaded music practices and especially musical instruments, it has become urgent to look for a definition of the musical instrument. Philosophical and technical literature has flourished with many propositions. I will provide a brief overview of this field.

Classical definitions focus on acoustic instruments. Bernard Sèves defines them in his philosophical study of musical instruments as technical objects, built by humans, manipulated by the body so as to produce musical sounds.[7] The physical energy of the body used for the movement is partially turned into sound energy. In Claude Cadoz' definition, the continuous energy transfer from the human body to the instrument and then into sound is essential.[8]

This applies to acoustic instruments. However, many instruments using digital sound synthesis have been developed in today's digital age. These instruments are

6 The first definition of a musical instrument in the literature appears in the 18th century. Before this, scholars were more interested in classifying musical instruments and organology than in the ontology of instruments. See Le Bouteiller, *Digital Instruments and Music Performances*, 2020.

7 Sève, *L'instrument de musique*, 2013.

8 Cadoz, "Musique, geste, technologie", 1999, pp. 47–92.

generally composed of a gestural interface, a computer and speakers. The interface, also called a digital music interface, is an object manipulated by the musician. Various types of sensors can extract data from the gestures performed by the body. These data are sent to the computer, where an algorithm synthesizes a signal accordingly and speakers deliver the sound output. These digital instruments do not comply with the traditional definitions cited above. New definitions, adapted to digital contexts, have consequently been proposed. In Joseph Malloch and colleagues' definition, a musical instrument is a sound-producing tool, controlled by and reacting to human gestures.[9] It is composed of a sound generator, a control interface and a computer programme that establishes the connection between gestures and sounds. Amidst a vast variety of digital tools in music, some definitions aim at providing a set of conditions to be met in order to recognise a tool as a musical instrument. According to John Croft or Sarah Hardjowirogo, for instance, a musical instrument has to be recognised as such by the audience. This implies that there must be a physical object handled by the musician and that the sound response to gestures must be immediate. There is a perceived causality between gestures and sound, and the body can show expressivity.[10]

The common thread between all these definitions, old and recent, is the fact that a musical instrument is or contains a physical object, handled by the musician and visible to the audience. This object is either self-contained or needs to be connected to a computer and speakers so as to produce sound. The musician's role is to manipulate the instrument or interface to produce and control sound. The musician's gestures are linked to the sound he or she intends to produce. Skills and techniques are refined in order to have better control over the sounds produced. However, it can be quite different in performances with biosignals: the presence of an object handled by a performer is not effective. I will now turn back to those performances and analyse them to identify how they can exemplify a new type of musical instrument.

9 Malloch et al., "Towards a New Conceptual Framework", 2006, pp. 49–52.

10 Croft, "Theses on Liveness", 2007, pp. 59–66; Hardjowirogo, "Instrumentality", 2017, pp. 9–24.

Biosignals in performance – Atau Tanaka's *BioMuse*

The BioMuse is an interface that measures electrical signals from muscle activity in the body. It was developed by Hugh Lusted and Benjamin Knapp in the 1980s for Tanaka, who started using this interface in the early 1990s and has performed with it ever since. Tanaka composed *Kagami*, his first piece for the BioMuse, in 1989.[11] The interface consists of two armbands equipped with electromyogram sensors. The latter are able to measure the electrical signals emitted by the nervous system to trigger muscle contraction.[12] The data measured are being transmitted to a computer on which software generates the sound signal; output is by speakers. The software consists of different Max/MSP patches[13] for data processing and sound synthesis. One of the patches can contain the structure of the piece: it can be programmed to trigger temporal changes in the sound material. On stage, Tanaka moves his hands with great precision, concentrating on small wrist or finger motions. In the piece *Le Loup*, for example, created in 2017, the sound production is based on a recording of a wolf's cry that is being processed and modified throughout the performance.[14]

The interface is attached to Tanaka's body. The sensors detect a signal when he moves his hands, wrists or arms, and even when he contracts his muscles without moving. Indeed, the BioMuse records muscle contractions and not movement. It can be played without moving, just by contracting muscles – even though it is not a technique that Tanaka generally uses. Tanaka moves his hands and arms while playing without holding anything. He explains that it is as if the instrument had been removed and only the gestures remain. He also says that the control is not deterministic.[15] On the one hand, he has acquired a very fine control of his arm and wrists movements; on the other hand, one specific gesture is never associated with the control of one specific parameter. The same gesture can have different consequences in the sound

11 Ortiz et al., "Biosignal-driven Art: Beyond Biofeedback", 2011.

12 Tanaka, "The Use of Electromyogram Signals (EMG) in Musical Performance", 2014. See also: Tanaka, "Sensor-based Musical Instruments and Interactive Music", 2009, pp. 233–257; Tanaka and Ortiz-Perez, "Gestural Musical Performance with Physiological Sensors", 2017, pp. 422–430.

13 A Max/MSP patch is a piece of software that is designed to perform a specific task. It takes a signal and parameters as input and outputs a new signal.

14 Tanaka, *Koncert, 20.10.2017* <https://www.youtube.com/watch?v=VwUngn4N-4A>.

15 According to an interview with the author in London, UK on 6 April 2017.

output, depending on the software configuration and the moment in the piece. Consequently, the performer often does not know exactly what the sound response to his/her gesture will be – hence Tanaka's non-deterministic approach. Tanaka, along with his team of developers, can implement the software so as to decide, firstly, what sort of sounds are possible to play in a performance and, secondly, the way to produce and control these sounds, i. e. how gestures will transcribe into sound variations. The software will be different for each different piece. It can also change several times during one performance. As a result, one gesture is never associated to one type of sound or control.

Utilising the BioMuse, the body performs movements that provide data to the software programme which, in turn, synthesizes sounds. The nervous system produces electrical impulses to control muscle contraction. Therefore, the human body creates the prime oscillation that will be used for the sound production. The body and the instrument form one technological system together in the BioMuse.[16]

Biosignals in performance – *DATA_Noise*

DATA_Noise is a piece by Kasper T. Toeplitz and dancer Myriam Gourfink, premiered in Karlsruhe, Germany, in 2013.[17] The stage is dark; it displays two tables lit from below. Toeplitz stands behind one table, facing a computer screen. He controls the sound by producing algorithms from the computer. Gourfink performs very slow movements on and around the other table. She wears sensors on her body (mostly accelerometers). The data recorded by the sensors are sent to Toeplitz' computer, where they serve as an input in the sound production algorithm. The sound production is based entirely on live synthesis; no sample or pre-recorded material is used. The data produced by the movements of the dancer influence the sound synthesis; they introduce noise into the signal which is otherwise perfectly controlled by the computer. Toeplitz controls the sound production algorithms according to the instructions given by the score, but the signal coming from the dancer introduces light variations to the sound. The music consists of very slow evolving sounds

16 Tanaka and Donnarumma, "The Body as Musical Instrument", 2018. See also Tanaka, "Musical Performance Practice on Sensor-based Instruments", 2000, p. 389–405.

17 Toeplitz and Gourfink, *DATA_Noise*, 24.11.2013, <https://www.youtube.com/watch?v=uFWTn3g0mbU>.

– coming closer to noise music. The piece is about 50 minutes long. The music to be synthesized and the choreography are entirely composed and written down.[18]

According to Toeplitz, *DATA_Noise* is a piece for two "musicians", one of them being a dancer.[19] Indeed, both performers participate in the music production. But Toeplitz also considers Gourfink to be an instrument, along with his computer: her movements are used as a source for the sound material synthesis.[20] Thus, the role of the dancer is ambivalent. She dances; what she performs foremost is dance, but not only that. She participates in the process of sound production, almost unintentionally since the data is taken from her body without her voluntarily producing them. The music is a by-product of her dance.

Data_Noise, *Le Loup* and other performances with the BioMuse offer new ways of playing music, and performing and presenting it on stage. A particular way of experiencing music appears to the musicians and their audience. The next section will be dedicated to a more in-depth analysis, leading to the characterisation of these performances.

New instruments, new performances

It can already be noticed in these two performances that music is being produced without there being any musical instrument to be seen on stage. The performers do not seem to be 'playing music' in the ordinary sense: they are not holding nor manipulating any sounding object. Performers are, nonetheless, performing movements: Tanaka is moving his forearms and hands, being visibly focused very much on his movements. This is even more obvious for Gourfink, who is executing a choreographed dance. Tanaka is not; nevertheless, his gestures also come very close to dance movements. He obviously pays great attention to his arms' movements, which are the main point of visual focus for the audience. However, in both cases, the purpose of the movements is not only dance. It is also to produce a vibration that will be captured by sensors and turned into sound or used in the sound production by the software. The body produces a signal that is used by the algorithms to produce sound.

18 Toeplitz, "L'ordinateur comme instrument de concert", 2002.

19 Toeplitz, "Questions for Avopolis", 2014. See also: Toeplitz, "Interview Kasper T. Toeplitz", 2003.

20 Toeplitz, "DATA_Noise", 2017.

The gestures are not producing the sound directly, as would occur with acoustic instruments. The sound signal is created by algorithms, and those take the body signals as input. By changing a patch or a parameter in the code, one can change the sound material that is available to the performer and, thus, also the way gestures trigger and control sounds. The dancer in *DATA_Noise* does not have a conscious control over the sound produced by the computer. Her movements influence the algorithm to modify the sounds produced, but she does not perform a certain gesture in order to produce a certain sound or sound effect. The choreography she executes is not written in order to produce certain desired sound effects. The movements influence the sound through small variations. The dancer has, therefore, an unintentional impact on the music production. Tanaka has a closer control over the sound: with a lot of practice, he can anticipate the sound consequences of different types of hand motions. However, these are piece-dependent, since every piece works with a different bit of software (or different patches), the relationship between gestures and sounds is redefined for each piece – and often within same piece when the software changes during the work.

To summarise: the musician's body performs movements without manipulating any musical instrument. Using these movements, the body produces vibrations that are captured by sensors fixed directly onto the body. This signal is used to produce sound by the computer programme. Finally, the sound is produced by the computer together with the performer's body.

The conclusion that can be drawn from these observations is that the body is part of the musical instrument. The musical instrument is constituted by the whole system that leads to the sound production: from the first oscillation generated in the body to the speaker emitting sound waves. It comprises the computer and its programme, the speakers, the interface and sensors, along with all cables, connections and conversion units. Therefore, the instrument can be considered a new type of "assemblage", as introduced by Georgina Born.[21] In the music performances considered here, music can only emerge through the interaction of the body with a set of devices, hardware and software, through a constant flux of data from the body to the computer. Not only does the music performance emerge from an assemblage of a musician and a musical instrument, but the musical instrument itself can also only exist through a combination of the human body and technological tools.

21 Born, "On Musical Mediation", 2005.

Therefore, the role of the body in these performances is manifold. It is, foremost, to perform an action: dance, or simply gestures, or even solely muscle contractions. It is a bodily action, made visible to the audience, that requires skill and concentration. Secondly, the role of the body is to play music. Indeed, the final aim of the movements is to produce music. Thirdly and finally, the role of the body is also to 'be played': the body emits a signal that is being measured by the sensors and used by the algorithms to produce sound signals. It is as if the system was 'playing the body': extracting the waves that it produces to turn them into sound – similar to the way in which the string of an acoustic instrument oscillates, transmits the wave to the bridge and the sounding board, so as to finally let the sound resonate. The role of the body is, therefore, threefold: it is to perform movements, to play music and to be played – as being part of a musical instrument.

This special role of the body I have identified has implications for the performances. Let us observe first that the gestures in both *DATA_Noise* and Tanaka's performances are not determined by the sound production, as it is with acoustic instruments. Bodily movements are performed while playing an acoustic instrument in order to control the vibrations of the string, membrane or air column. In the performances considered here, gestures are not contingent to acoustic sound production; they are completely free and can be composed with no other constraints than what the body is able to perform. Gestures are composed: it is clear in *DATA_Noise* where Gourfink's choreography is written. It is less obvious in Tanaka's performance, but gestures are still being selected as a set of movements that can be explored during a performance, among all possible hand movements. The body is, thus, liberated from the sound. Bodily movements are not contingent to sound production but stand for themselves. Therefore, they have their own performative value, and they shape the visual aspect of the performance. The resulting performances have a prominent visual character.

This leads to the conclusion that the performances produced with biosignals are music performances of a new type: their visual component is essential. They are very close to dance performances, but music remains the main material of these artistic performances and is being produced in real time (as opposed to a pre-recorded musical track). In that respect, they are music performances. Furthermore, our analysis allows us now to affirm that they are instrumental performances as well, i. e. music produced thanks to musical instruments, but instruments of a new and specific genre.

The musical performances I considered here present a visual component that is of primal importance. Consequently, the composition of such pieces implies composing gestures (in the form of a choreography or a definition of a set of possible gestures), developing algorithms (in which the sound material is prepared) and utilising a whole system which encompasses sensors, computers, cables, connections, processing units and speakers. In addition to sound composition, staging is an important part of the performance and the composition process of the piece.

Conclusion

Since the time of *Music for Solo Performer*, biosignals have been used in many artistic and music performances. I hope to have brought a significant insight into this area, so far left unexplored on the theoretical ground, through the study of these two particular pieces. My conclusions result from an analysis of two specific music performances using biosignals and from an interpretation derived from the discourse of the musicians themselves. Even though every performance in the experimental music field has to be examined individually, my conclusions can be generalised to other music performances using biosignals. My analysis of *DATA_Noise* and *Le Loup* shows that the body is part of a complex musical instrument which does not correspond to traditional definitions of musical instruments. The performer's body does not manipulate a physical object (instrument or interface) but is itself a part of the musical instrument. The role of the body is threefold: it is to perform an action (gestures), play music and be played as part of a musical instrument. This leads to music performances that are instrumental productions in a new sense. The musical instrument comprises the body, the computer and its sound synthesis programme, the speakers, and all connections and conversion units. The distinctiveness of these performances is their prominent visual character: the visual components of these musical pieces are not contingent on the physical behavior of an acoustic musical instrument; therefore, they are virtually unlimited and need to be composed. This defines a new area of creativity in music performances.

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