

# Creating Interactive Multimedia Works with Bio-data

Claudia Robles Angel  
Freelance Media Artist  
Dürenerstrasse 176 – 50931 – Cologne - Germany  
+49 221 27783325. [www.claudearobles.de](http://www.claudearobles.de)  
[post@claudearobles.de](mailto:post@claudearobles.de)

## ABSTRACT

This paper deals with the usage of bio-data from performers to create interactive multimedia performances or installations. It presents this type of research in some art works produced in the last fifty years (such as Lucier's *Music for a Solo Performance*, from 1965), including two interactive performances of my authorship, which use two different types of bio-interfaces: on the one hand, an EMG (Electromyography) and on the other hand, an EEG (electroencephalography). The paper explores the interaction between the human body and real-time media (audio and visual) by the usage of bio-interfaces. This research is based on biofeedback investigations pursued by the psychologist Neal E. Miller in the 1960s, mainly based on finding new methods to reduce stress. However, this article explains and shows examples in which biofeedback research is used for artistic purposes only.

## Keywords

Live electronics, Butoh, performance, biofeedback, interactive sound and video.

## 1. INTRODUCTION

The biofeedback method developed in the 1960s by the psychologist Neal E. Miller consists of the process of measuring physiological parameters from a subject (for example, the heartbeat, the brainwaves or the breathing), sending this data to a computer to be analysed and afterwards translating these parameters to sound and video, feeding them back to the subject and increasing body and mind awareness. Diebner explains that "[F]or example, we are consciously and only partially aware of the heart rate under physical strain or under cardiac arrhythmia. If, however, the heart rate is recorded and the signal transformed into sound or visuals, then this physiological process is accessible to our senses". [2] This treatment technique was originally created to improve health, helping tense and anxious people to learn how to alter these functions by relaxing.



**Figure 1. Visual representation of biofeedback**  
(<http://en.wikipedia.org/wiki/Biofeedback>)

There is a wide range of sensors used for the biofeedback methods

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such as the GSR (Galvanic Skin Response), the EMG (Electromyography), the EEG (electroencephalography), the ECG (Electrocardiography) and some others. The two bio-interfaces introduced in this paper are the EMG<sup>1</sup> and the EEG<sup>2</sup>.

## 2. First Examples of the Usage of Bio-data

One of the first art works using bio-data is the famous brain wave piece by Alvin Lucier: *Music for a Solo Performance* (1965). For this piece, he attached some electrodes to the performer's scalp, measuring his brain activity (the alpha rhythm range from 8 to 12 Hz.) and sending these electrical signals to amplifiers and loudspeakers connected to a large set of percussions instruments. At that time, bio-feedback devices were not as sophisticated as nowadays, so he used EEG equipment belonging to the US Air Force and with the technical support of Edmon Dewan. "He generously lent me his apparatus, consisting of a pair of electrodes, a differential amplifier, and a band pass filter, set to a band-width just wide enough to let the ten Hertz alpha waves flow through and at the same time reject unwanted electrical and ambient noise." [4]



"Music for a Solo Performer", performance by Alvin Lucier at Zeitgleich

**Figure 2. Music for a Solo Performer**  
(<http://www.kunstradio.at/ZEITGLEICH/CATALOG/ENGLISH/lucier-e.html>)

Since the mid 1960s, many composers and video artist such as, for example, David Rosenboom, Atau Tanaka, Yoichi Nagashima and Mariko Mori have experimented with bio-data to produce music, installations and interactive performances. From the EEG Air Force's equipment used by Alvin Lucier to the sensor-based musical instruments research by A. Tanaka in the last 20 years, the use of bio-signals to interact with the media (sound or/and video) continues to raise the interest of several artists worldwide, mostly seeing the accessibility, for example, via internet, of

<sup>1</sup> The EMG signal is a biomedical signal that measures electrical currents generated in muscles during its contraction representing neuromuscular activities. [5]

<sup>2</sup> The electroencephalogram (EEG) is defined as electrical activity of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media. [7]

several devices/software which are able to perform the data exchange (such as, for example, the *Arduino* project). The following two artworks introduced in this paper, *Seed/Tree* (an interactive Butoh performance-installation) and *INsideOUT* (an interactive multimedia performance) were produced using new accessible technologies and one of them (the EEG) with an open source hardware/software, was assembled without the need of expensive and difficult-to-access hardware by myself, and then programmed in real time with the software MAX/MSP-Jitter.

### 3. SEED /TREE (2005) Installation/Butoh Performance/Live Electronics

This project was created during an “artist in residence” program at the ZKM (Centre for Media Art in Karlsruhe, Germany).

Butoh is a modern expressive dance-form created in Japan in the 1960s by Tatsumi Hijikata and Kazuo Ohno. It is traditionally performed in white-body make-up and the movements are very slow and expressive. The movements in this dance form come from the inner world, they must emerge from within and not be imposed from without; Butoh is not a representative dance. During a performance, the Butoh dancer is in a state of ‘hyper-presence’, he is aware of everything around him and within his own body.

This installation-performance consists on a forest environment created by some panels projected by haptic images from tree cortex and human skin. By haptic images I mean: HAPTIC from (the Greek word: HAPTOS - tactile): the sensation “to feel”: the feeling that one can ‘touch’ with the eyes, according to the French philosopher Gilles Deleuze: *‘Where there is close vision, space is not visual, or rather the eye itself has a haptic, non optical function: no line separates earth from sky, which are of the same substance; there is neither horizon nor background nor perspective nor limit nor outline or form nor center; there is no intermediary distance, or all distance is intermediary.’* [1]

There are three Butoh dancers in the space performing the process of a seed growing to become a tree. Each performer moves in his/her own way representing the same subject a-synchronously. In the performance, the inner impulse of every dancer emerges on the stage; the dancers have each their own movements, which are the product of their own imagination.

The installation runs for three hours. The dancers develop the main subject in twenty minutes, then they lie for ten minutes on the floor and afterwards they repeat the process from the beginning. During this time, the performers have the necessary time to experience their own imaginary world combined with the outer space created by the sound and video projection. There is a continuous feedback between the dancers and the media; the translation of emotional physiological parameters to sound and video, however, gives feedback not only to the dancers but also to the spectators.

Feelings, associations, mental images and spontaneous impulses are the starting point for the creation of stories and choreography. In *Seed/Tree* the dancers produce and transform the sound and the audience control the video projections. The results are instantaneous creations, expressions of the moment, with image, movement and music forming living signs in space.

There are two types of interactivity in this performance. The first one is the interaction between dance and sound: the performers have microphones and EMG electrodes attached to their bodies. The breathing and the heartbeat of two of the performers produce sounds that are continuously modified by the muscular tension of a third dancer. The second type of interactivity is that between the

installation space and the visitors. During the performance, visitors can walk freely around the virtual forest. There is a video observing the installation space and human presence influences the video projections; these interactions create subtle differences of the video on the panels. The installation space itself becomes aware of the visitors and reacts according to their movements. In this way the visitor is invited to be part of the environment.

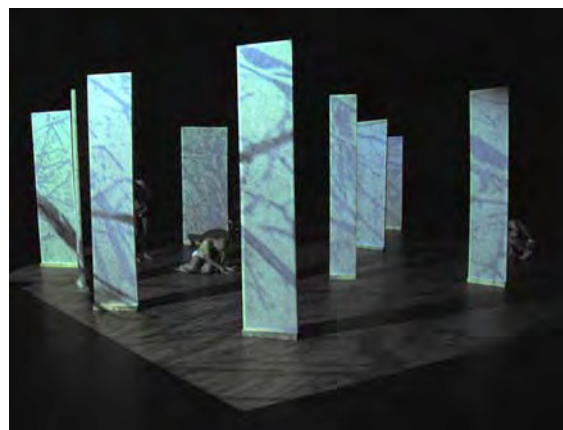


Figure 3. Seed/Tree at the ZKM Centre Karlsruhe (Germany)©, 2004

For *Seed/Tree* I used a wireless EMG (electromyogram) interface developed by Frieder Weiss, as shown in figure 4.

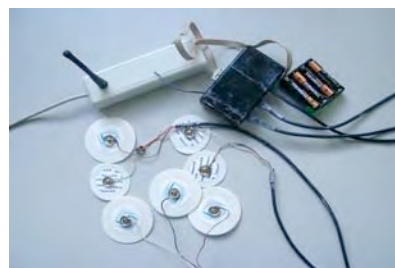


Figure 4. EMG Interface by Frieder Weiss

This interface has three pairs of electrodes, which are attached to three different muscles. This interface measures the muscle tension, while the program sends the values as a continuous OSC packet that is received through an OSC-route object in the MAX program; then, each value is used to trigger different sound effects in MAX/MSP.



Figure 5. Seed/Tree: EMG electrode attached to the Butoh dancer.

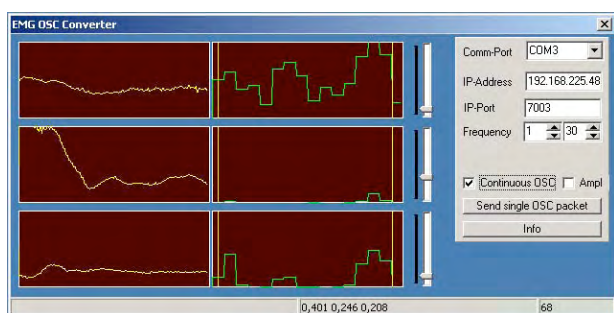


Figure 6. The Frieder Weiss program sending the values as a continuous OSC packet

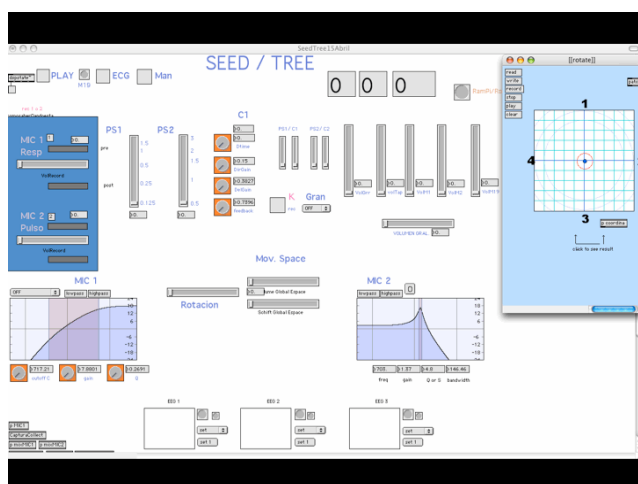


Figure 7. Seed/Tree: the MAX/MSP patch by Claudia Robles.

#### 4. *INSideOUT* (2009) Performance/Live Electronics

This project was created during an “artist in residence” program at the KHM (Academy of Media Arts in Cologne, Germany). It is about the materialization of the performer’s thoughts and feelings on the stage. *‘The stage is a place for the appearance of the invisible. Yasu Ohashi says: the actors aim at our senses, our body and our unconscious and not at our intellect. Their gestures try to envision THE INVISIBLE WORLD’* [3].

The performer interacts with the sound and images using an EEG (electroencephalogram) interface, which measures the performer’s brain activity. Those sounds and images – some already stored in the computer and some produced live- are continuously modified by the values from two electrode combinations via MAX/MSP-Jitter. Hence, the performer determines how those combinations will be revealed to the audience. Images are projected to a screen and also onto the performer, while sounds are projected in surround.

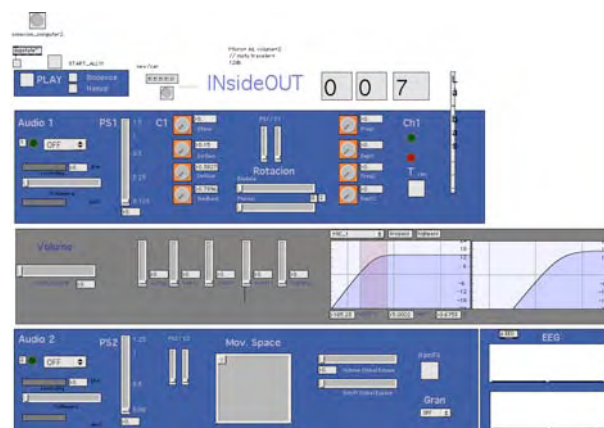


Figure 8. *INSideOUT*: MAX/MSP-Jitter patches by Claudia Robles

The German psychiatric doctor Hans Berger was the first to produce electroencephalograms of human subjects and also the first to observe the characteristic alpha-rhythm. The EEG project was meant at the beginning as the expression of the self, about turning the subject’s imagination from the inside to the outside. For this performance, I used an open source EEG interface from Olimex, which measures the brain activity and consists of two assembled boards: one analogue and the other digital.



Figure 9. The analogue and digital boards from Olimex.<sup>3</sup>

Each board has two electrode combinations (or two EEG channels). It is possible to connect up to three boards (i.e. six EEG channels). I use only two for this piece: the frontal and the occipital channels. The rubber cap and the contact electrodes of the interface are those typically used in medical applications.



Figure 10. *INSideOUT* at the University of Miami’s CAS Art Gallery (USA). The image shows how the electrodes are connected to the scalp. © 2009<sup>4</sup>

<sup>3</sup> Figure from: <http://www.olimex.com/gadgets/index.html>

<sup>4</sup> Photo by Javier A. Garavaglia

To adapt this interface I received technical support by Lasse Scherffig and Martin Nawrath at Lab3-KHM. They modified the open EEG device by replacing the Atmel microcontroller with one running the Arduino firmware and changing the quartz clock accordingly to 16 MHz.

Lasse Scherffig wrote a program with the software *Processing*, which reads the values of both channels from the open EEG via a serial communication. The modified open EEG sends ASCII-formatted data representing the voltages of both channels (at a frequency of 100 Hz). In *Processing*, a Fast Fourier Transform (FFT) is applied to that data and extracts the bins for the frequencies 0-50 Hz. From these, the median of the frequencies for the alpha channel (8-13 Hz) is extracted, smoothed using a low-pass filter and transmitted via OSC, which is received once again by the OSC-route object in the MAX program. This frequency band between 8-13 Hz correspond to the Alpha frequency range that is accentuated during relaxation.



**Figure 11. *InsideOUT* at the SIGGRAPHAsia2009 Yokohama (Japan) © 2009<sup>5</sup>**

For the performance of *InsideOUT* I have tried to train my brain in order to control the media combinations on the stage, putting in evidence different emotional and mental states, which cannot be achieved without the input of data coming from my own brain waves via the EEG interface. However, this conscious control is not completely attained due to the enormous and uncontrollable stream of feelings that generally appear surprisingly under such circumstances.

Thanks to new accessible technologies, the possibility to built complex interfaces, wireless and lighter as those used in medicine or research context, new forms of performances on the stage or new forms of relations between machine, human body and space have emerged. Lucier's performances in the 1960s and 1970s or David Rosenboom's brain analysis software (1976-77) used "for creating self-organizing musical forms" [6] are probably the first attempts to use bio-data for purposes other than scientific, in which they created new relationships between performers, the performers' brain activity, instruments and performing space, giving a new usage of EEG, creating as Rosenboom said: "a self-organizing, dynamical system, rather than a fixed musical composition". [6] In the case of Mariko Mori's *Wave UFO*,

(1999–2002) there is a search for the representation of the Buddhist concept of *oneness*, by the interconnection between all three participants with each other, bringing them into a deeper state of consciousness, interconnecting the self and the universe. As it can be observed, there has been rather different approaches in the last fifty years in how this technology can be manipulated for artistic purposes.

This research and its artistic results aim to raise awareness of the human body and its functions (e.g. muscle tension, breathing, etc.) as a means to manipulating the media by controlling those functions consciously on the stage via the usage of bio-interfaces. This creates an environment that invites the visitor to perceive the body in a different way and to reflect on the relationship between the human and the machine. Following Ohashi's concept of the *invisible world* already mentioned before, this research and, most specifically, its artistic results should allow for an empty space that could be populated by the invisible or the imperceptible.

## 5. ACKNOWLEDGMENTS

I would like to thank Lasse Scherffig and Martin Nawrat at KHM (<http://interface.khm.de>) for their help in specific technical requirements for *InsideOUT*.

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<sup>5</sup> Photo by M. Goldowski