

"Biofeedback and the arts: listening as experimental practice"¹

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The discovery of the human brain as an organ yielding electrical pulsations in 1875 by Richard Caton and the development of the electroencephalograph (EEG) by Hans Berger in the 1920s broke open a vast field for scientific and medical inquiry. Decades later, these discoveries were applied in biofeedback systems developed by physicians and cognitive science researchers in order to explore alternative therapeutic treatments for ailments such as migraines and other stress-related disorders. Such biofeedback systems involve the real-time monitoring of autonomic functions in order to become self-aware of one's own physiology. "Through the use of an electroencephalogram (EEG), one can measure the frequency and amplitude of brain waves, and therefore when connected to such a device, a subject can learn to recognize, and eventually gain control of bursts of alpha waves, and thus have the ability to enter a state of heightened awareness."² During the 1960's and 1970's biofeedback was incorporated in artistic applications, most notably within the context of experimental music such as in the compositions of Alvin Lucier and David Rosenboom.

Most of us are used to thinking about biofeedback in terms outlined in Norman Weiner's *Cybernetics*, where feedback allows an operator greater control of a complex system.³ In terms of medical applications, this feedback is often thought of in terms of its therapeutic potential. A patient using biofeedback, for example, can promote healing resting states and lower her overall stress level. Despite the fact that some composers also saw their work in these terms, we are interested in two other aspects of biofeedback music, or more specifically brainwave music, at this time 1) the intertwining of internal and external relations that lead to novel experiences of a dynamic world through a deepening of the experience of the self and 2) a phenomenology of the temporal and spatial relationships expressed by the music. What emerges from this study is a glimpse of consciousness as a relational process, where experimenting on one's self opens up new ways of exploring and understanding one's environment.

The interest of composers working in the use of biofeedback in music emerged out of process-based models for creative practice established by Fluxus artists and promoted by John Cage. In particular, John Cage's composition 4'33" performed on

¹ This paper was presented at the REFRESH conference, First International Conference on the Media Arts, Sciences and Technologies held at the Banff Center sept 29-oct 4 2005 and co sponsored by the Banff New Media Institute, the Database of Virtual Art and Leonardo/ISAST.

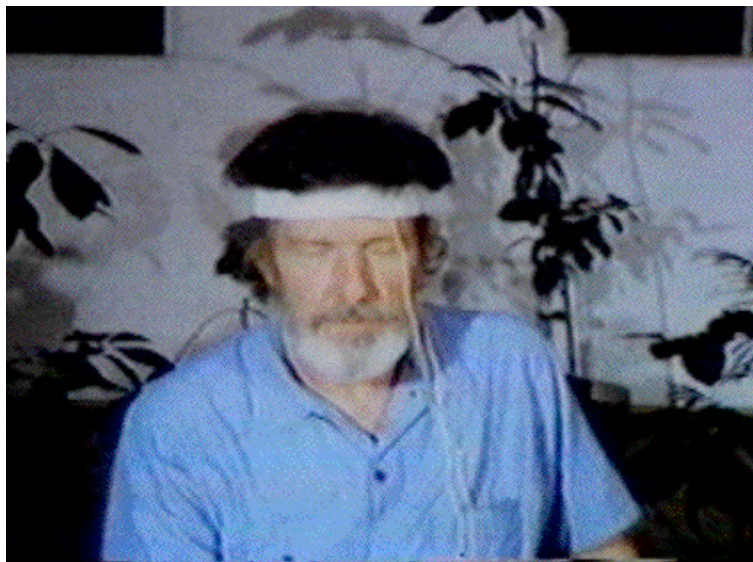
² <http://music.calarts.edu/~kent/biofeedback/>

³ See for instance Norbert Wiener, *Cybernetics or Control and Communication in Animal and Machine* (Cambridge, Mass.: MIT Press, 1948).

piano in 1952 by David Tudor, radically transformed the landscape of music for the composer, performer, and listener.

Cage's piece comprised of four minutes and thirty three seconds of silence by the pianist and his instrument requires engagement of the listener's perceptual capacities in order to recognize the work as a formal musical composition evolving in real time. Experiencing the piece in silence, the listener's attention is focused upon the perception of all ambient sounds. This process of attending to the external environmental sonic landscape occurring within a specific time and space yields within the listener a heightened consciousness of perception per se, and in turn, a consciousness of the self as perceiver.

4'33" makes the listener simultaneously conscious of the internal time of the self co-existing with the world's time and space embodied in sound. Through the process of learning to listen to the world's sounds, the listener moves between awareness of the world around him/her and a consciousness of the self.⁴ [Cage had also engaged in biofeedback, as seen in the screenshot below from Nam June Paik's 1976 video tribute to Cage. Suggestively, Alvin Lucier emphasizes the importance of 4'33" in the development new music in the audio component of this scene. Paik even uses Lucier's pronounced stutter as a means for heightening an awareness of the thickness of the self through the interrelatedness of listening and performing. For instance, the abrupt stops and starts of Lucier's speech directs the viewer's attention to the embodied dimension of speech, tempting us to see speech not as expression but sound.]



⁴ Many scholars have written on 4'33". Our reading of this piece is especially indebted to Michael Nyman's *Experimental Music: Cage and Beyond* (Cambridge: Cambridge University Press, 1999) 103 and Douglas Kahn, *Noise, Water, Meat: A History of Sound in the Arts* (Cambridge, Mass.: MIT Press, 1999) 158-199. See also James Pritchett, *The Music of John Cage* (Cambridge: Cambridge University Press, 1993).

Figure 1. A screen shot from Nam June Paik's, *Tribute to John Cage*, 1976, showing John Cage experimenting with a biofeedback device. Alvin Lucier explains the importance of John Cage's 4'33" during the sequence.

Building upon Cage's indeterminate process-based model are early experimental compositions by Alvin Lucier investigating sound waveforms and the acoustic properties of sound. While Director of the Chamber Chorus at Brandeis University, Lucier befriended Edmund Dewan, a physicist undertaking brainwave research. A direct outcome of this friendship was his famous "Music for Solo Performer" (1965), the first brainwave music composition and performance.

Lucier sat quietly in a chair while, for several minutes, an assistant swabbed his scalp with conducting paste and attached EEG electrodes – a witty reflection on the traditional instrumentalist's preparations for a performance. Then, sitting still with his eyes closed, Lucier descended into a meditative state. Before long, the electrodes tapped bursts of alpha waves that traveled through amplifiers to a network of remote speakers that rattled snare drums, gongs, metal trash cans, cardboard boxes, bass drums, piano strings and tympani.⁵

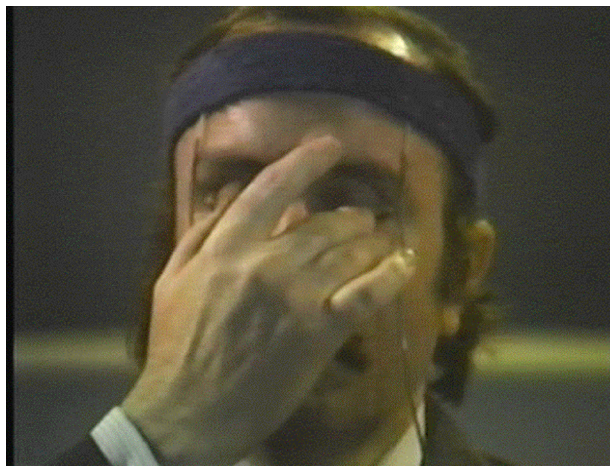


Figure 2. Screenshots from a performance of Alvin Lucier's, *Music for Solo Performer*, 1965. On the left, Lucier places himself into a meditative state to induce alpha waves whose electrical signals he then amplifies. The shot on the right shows in the foreground, a small section of the percussion devices Lucier placed speakers on (kettle drum, snare drum and cardboard box in this picture). When Lucier reached an alpha state, the electrical signals of his amplified alpha waves were distributed via the speakers, which would in turn rattle the resonant instruments. Lucier is in the background.

⁵ Cox, Christop. "Alvin Lucier", *The Wire*, Issue 245 July 2004, 42. See also the description in Michael Nyman, *Experimental Music: Cage and Beyond* (Cambridge: Cambridge University Press, 1999) 106.

While purposefully eliminating any determinate outcome for the sonic architecture of the work, in effect “Music for Solo Performer” becomes a translation, via the analog percussion instruments in the room, of Lucier’s brain and his cognitive processes shifting over time. This translation process intriguingly materializes the perceptual and affective dimension of music making into a defined circuit of relations. Most of us derive meaning from a musical piece through discerning a pattern of relationships between aural events. For instance, musical phrases define a relationship of sounds over time while musical chords provide a relationship based on the frequency of vibrations that produce the sounds.⁶ Although these relationships still exist in “Music for Solo Performer”, the piece also illuminates another set of relationships, the relationships that contribute to the production of an aural event and cognitive event. For instance, in “Music for Solo Performer” we have the relationship between Lucier’s alpha waves and the EEG, the EEG and an amplifier, the amplifier and speakers, speakers and percussion instruments, the percussion instruments and the acoustics of the performance space, and the listeners in the performance space, including Lucier. The sounds produced in this piece exist as a sonic event embodying these complex relationships. Any significant change to one of these relationships will change the sound produced.⁷

David Rosenboom has been the most articulate on the role of systemic change in biofeedback music. In “On Being Invisible,” composed in 1976-77, Rosenboom uses his own brainwave analysis software “for creating self-organizing musical forms.”⁸ His computer system is triggered by brain ERP signals [event related potential] and over time it learns the cognitive processes mapped to his listening. The software then passes this evolving algorithm through a series of filters and stimulates correlating sonic elements. What we see is a circuit created by the system that learns and embodies Rosenboom’s subjective perception of sonic events that are in turn produced by his own brainwaves. Steeped in autopoietic systems theory, Rosenboom describes “On Being Invisible” as “a self-organizing, dynamical system, rather than a fixed musical composition”,⁹ since it “involves the real-time evolution of both performer and musical system.”¹⁰ The music produced by this mediated process becomes the sonic

⁶ See Aden Evens interesting work on the phenomenology of music, especially 1-24. Aden Evens, *Sound Ideas: Music, Machines, and Experience* (Minneapolis: Minnesota University Press, 2005)

⁷This model of cognition is deeply indebted to William James, especially “A World of Pure Experience” and “The Thing and Its Relations,” *Essays in Radical Empiricism* (Lincoln: University of Nebraska, 1996).

⁸ Rosenboom, liner notes, to *Invisible Gold*, Pogus Productions, 2000.

⁹ Rosenboom, liner notes, to *Invisible Gold*, Pogus Productions, 2000. See also, “In support of a systems theoretical approach to art media.” In *Proceedings*, 1970. New York: American Society of University Composers/American Music Center, pages 56-68. Although published after Rosenboom’s composition, the most important piece here is Humberto R. Maturana and Francisco G. Varela, *Autopoiesis and Cognition: The Realization of the Living* (Dordrecht, Holland and Boston: D. Reidel Pub. Co., 1980.

¹⁰ Rosenboom, liner notes, to *Invisible Gold*, Pogus Productions, 2000.

topography with which Rosenboom improvises.



Figure 3. David Rosenboom performing *On Becoming Invisible* in 1977. In this section of the piece Rosenboom plays a touch-sensitive keyboard effectively improvising with his brain waves captured in real-time.

Rosenboom's work adds an interesting new dimension beyond the dynamics of translating a cognitive event into a sonic event: the use of improvisation as a form of self-experimentation (a term we borrow from Richard Doyle's work).¹¹ Rosenboom's consciousness is split into two distinct dimensions: a highly mediated but evolving aural topography and an agent who doesn't control so much as initiates new aural events in open-ended experimentation. In doing so, Rosenboom highlights the temporal domain of music making and points to the use of biofeedback to register novel events. Central to this concern is what Rosenboom describes as "becoming invisible," or the submersion of one's affective capacities to the systemic dynamics of the piece:

It is an essential characteristic of all parts of this piece that the performer constantly rides a borderline between being, on the one hand, an initiator of action and, on the other, submerging him/herself in processes larger than him/herself. This requires that the performer become adept at manipulating his/her state of consciousness, application of willful actions, and the energizing or programmed personal response modes. This requires a great deal of practice

¹¹ Richard Doyle, "LSDNA: Consciousness Expansion and the Emergence of Biotechnology" from *Data Made Flesh: Information and Human Body*. Edited by Robert Mitchell and Phillip Thurtle, (London and New York: Routledge, 2003). Rich's work should be read as an interesting twist on Gilles Deleuze's use of the term "experimentation" as a way to engage in the world.

and is the inspiration for the title, "On Being Invisible".¹²

At first glance this may look like a closed system. This is precisely the point. It is anything but. In a self-forming system, perception of the environment is always also a perception of the self (although the opposite is not always true-that the perception of the self is always a perception of the environment).¹³ This is precisely what allows us to take feedback (the technology of control par excellence) and show how even in this state, novel and un-anticipated events occur. In a world that is so open, precipitating out a small closed feedback loop allows one to register for change as a process over time.

Through the process of self-experimentation to generate a biofeedback music, one can reach a state of consciousness that allows for the registering and reaction to novel events. The experience of the self within the feedback loop, however, is always also an experience of the environment. The self is highly embedded, perceptually and affectively linked, to the spatial-temporal context. The boundary between what is definable as the self or environment collapses and in doing so the work renders the affective habitable. Consciousness arrived via these means thus, opens one up to a world that it cannot fully determine while experiments on the self more tightly couples the self to that which lies beyond.

¹² David Rosenboom, "The Qualities of Change: 'On Being Invisible': Steps Towards Transitional Topologies of Musical Forms," from *Collected Articles (1968-1982)* (Santa Clarita, Ca.: David Rosenboom Publishing, 1984. Distributed by Frog Peak Music, Hanover, NH) 8.

¹³ This model of the radical crossing of subject and object Draws heavily from Maurice Merleau-Ponty, "The Chiasm" in *The Visible and the Invisible* (Evanston: Northwestern University Press).

¹⁴ Rosenboom, pg.4.

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