UNIVERSITY OF CALIFORNIA SAN DIEGO

Modes of Listening: Practice-led Perspectives on Music and Biofeedback

A Dissertation submitted in partial satisfaction of the requirements
for the degree Doctor of Philosophy

in

Music

by

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The Dissertation of Alexandria Smith is approved, and it is acceptable in quality and form for publication on microfilm and electronically.

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ABSTRACT OF THE DISSERTATION

Modes of Listening: Practice-led Perspectives on Music and Biofeedback

by

Alexandria Smith

Doctor of Philosophy in Music

University of California San Diego, 2023

Professor David Borgo, Co-Chair
Professor Amy Cimini, Co-Chair

For the past eight years, I have been cultivating a bioartstic practice that enables me to listen to my biological signals and interact with a fuller array of embodied states in a way that is inviting and instills collaboration and puts my work in discourse with works of the past. This dissertation establishes the theoretical framework, historical inquiry, and practice-led

research that has led me to define three modes/methods of listening to biological signals: Situated Listening, Embracing Irregularity, and Listening Beyond the Ear. These modes of listening to biological signals continue to inform my work characterized by the construction, design, theoretical exploration, and performance involving wearable electronics capable of capturing and translating biological data into immersive sonic and visual environments. I presented a body of work created with these methods as a featured artist on the nienteForte Series in New Orleans, Louisiana, on May 11, 2023.

Chapter 1 INTRODUCTION AND CONTEXT FOR PRACTICE

Introduction

The skin is the body's largest organ. Our interface between our internal and external experience. It is conductive and resistive, electrically charged. A vibration rumbles from the heart, exciting the sensory receptors at the fingertips. Lungs fill with air, stretching against the ribcage. As the internal organs expand, the epidermis speaks as it takes its reading. Electrical impulses amplify infinite potentials. A cyborg-like synthesis and embodied dialog between the future and the past, the external and the internal, has begun. The dialog has been facilitated; a second skin formed.

I invite you to listen to listen to the supplemental file, Smith_hearingVision.mp4. In this performance, you will hear the sound of the trumpet flicker through a gate that is activated by my heartrate. Throughout the piece, you will hear galvanic skin response, heart rate, and respiration act in counterpoint to sound the voices in my skin.

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> "It matters what matters we use to think other matters with; it matters what stories we tell to tell other stories with; it matters what knots knot knots, what thoughts think thoughts, what descriptions describe descriptions, what ties tie ties. It matters what stories make worlds, what worlds make stories."
>
> -Donna Haraway

This dissertation is an autoethnographic account of my practice-led research and feminist technoscience intervention on working with sonifying biological signal. This project emerged from my creative process of building, designing, and performing with wearable electronics that measure and sonify biological data, and researching biofeedback methods. Through an interdisciplinary methodology, this dissertation will draw upon articulations and animations of

methods that address a set of feminist modes of listening that are energized through using wearable electronics and biosignals: Situated Listening, Embracing Irregularity, and Listening Beyond the Ear. This dissertation presents works by Milford Graves, Pauline Oliveros, Kite, Evic Shen, and Miya Masaoka that have inspired these modes of listening. Through this analysis, the dissertation aims to offer insights into how these works and practices offer alternative approaches to the production of knowledge and a critical pressure point to the study of Human-Computer Interaction (HCI), computer music, interactive media, and thinking through experimental music practices. This project aims to illustrate ways that biological data does not need to be seen as a means for control, but instead an extended, intersectional, and situated listening practice.

In Chapter 1, Introduction and Context for Practice, I will discuss my context for practice. I will address challenges that come with listening to biological signals, wearable electronics, and components of feminist interventions that have informed my approach to working with and sonifying biological signals. In Chapter 2, Biofeedback and Interventions, I will discuss Dr. Barbara Brown, the first president of the Biofeedback Research Society and a central influence on my work, the history of biofeedback, biofeedback music, and the work of Milford Graves and Pauline Oliveros. In Chapter 3, Modes of Listening, I will discuss the three modes of listening that I have developed through studying the works of my interlocutors and analyze Listening Beyond the Ear through the works of Kite and Miya Masaoka. Accompanying each mode of listening is a piece that I performed at my the nienteForte Series show in New Orleans, Louisiana, on May 11, 2023, that addressed the corresponding mode of listening. In Chapter 4, Articulations through Practice, I will discuss my wearable electronic: design, data sonification, and methods.

Context for Practice

Designing and performing with wearable electronics that measure biological data come with challenges that include and are not limited to: implications of hearing and sharing biological signals on the performer and listeners, how to approach interface design in a historically and socially informed way, capitalization of health data collection and what to do with that data, a history of violence that medical devices have on marginalized bodies, and the erasure of marginalized historical figures and gendered feminine labor that often happens in the quest for novelty and high impact research in technoscience. In this section of the dissertation, I will discuss feminist approaches to theorizing design, medical devices, wearable electronics, and cyborgian frameworks.

Design and Intra-actions:

Donna Haraway asked us in her work, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective (1988),"[1] to insist on the embodiment of *vision* and to question the declaration of an impartial stance or 'objective truth'. Haraway argued that knowledge is situated within one's social, cultural, and historical context and is shaped by the perspectives and interests of those producing that body of knowledge. Situated Knowledges are not fixed or absolute but is instead dynamic and contingent. They morph and are shaped by ongoing interactions between actors, agents, and contexts. *Vision* was the metaphor that Haraway

[1] Haraway, Donna. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies* 14, no. 3 (1988): 575–99. https://doi.org/10.2307/3178066.

chose to unpack her stance.[2] The persistence of vision is a prothesis for oppositional consciousness and acknowledges perspectives that lie outside of the dominant cultural lens.

An ethics and politics of partiality should be assumed when working with the interaction of data and devices. In the discipline of Human-Computer Interaction (HCI), devices are often planed, made, and studied with assumptions of use. Typically, designing a technological device comes with an assumption of input and output (I/O) and how people have traditionally interacted with machines. As Lucy Suchman stated in "Human-Machine Reconfigurations: Plans and Situated Actions," "[e]very account of communication involves assumptions about action, in particular about the bases for action's coherence and intelligibility."[3] Suchman's 'situated actions', "challenge traditional assumptions regarding purposeful action and shared understanding."[4] If there is going to be an understanding or plan that accounts for a theorized interaction between humans and machines, there needs to be room for improvisation, acknowledgment of distributed cognition, and that people rely on external resources to support their cognitive process.

Tom Faber claims that "Decolonizing Electronic Music Starts With Its Software."[5] I argue that it is also starts with designing hardware that moves beyond the typical keyboard, drum pad, knob, etc. relationship. Translating continuous biological sensing to music affords other potentials of extended cognition, interfacing with Digital Audio Workstations (DAWs), and

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[2] Perhaps it is important to note that her *persistence on vision* was inspired by two short stories by John Varley, one of the same names, *The Persistence on Vision* (1978) and *Blue Champagne* (1986). Haraway stated that these texts made prothesis a fundamental category for understanding the making of meanings, bodies, and understanding our most intimate selves

[3] Suchman, Lucille Alice. *Human-Machine Reconfigurations : Plans and Situated Actions*. 2nd ed. Cambridge ; Cambridge University Press, 2007. 51.

[4] Ibid. 69.

[5] Faber, Tom. "Decolonizing Electronic Music Starts With Its Software." https://pitchfork.com/thepitch/decolonizing-electronic-music-starts-with-its-software/

requires a more flexible approach to mapping data to electronic instruments. I will discuss this approach in Chapter 4. Andrew Parkinson stated in *Embodied Listening, Affordances and Performing with Computers* that "[t]he design and development of these instruments [new musical instruments or systems for live performances of computer music] is often informed by a series of assumptions about musical performance, the role of gesture, and just what it is that makes a performance musically compelling."[6] Parkinson suggested that approaches to the design of computer based musical instruments should perhaps avoid "a reductive focus on 'gestural legibility'."[7] He pointed that mapping should focus on the affordances of the materials at work and don't necessarily have to map to what an would be considered a legible sound, e.g., mapping heart rate to the sound of something that has a 'heart-like timbre.'

What does it mean to give a sensor data autonomy? Thinking about new musical interfaces through a feminist new materialist lens[8] affords a post-humanist standpoint for theorizing material. To connect these feminist new materialist frames of thought alongside the body, Karen Barad's proposed notions of 'intra-actions' as a performative term that describes the nature of phenomena. Karen Barad's term, intra-actions, signifies *the inseparability of "objects" and agencies of observation."*[9] Oftentimes new musical interfaces get discussed alongside how they interact with music. The term, interaction, suggests that there are two independent entities that externally influence each other. For example, in the case of working with biological signals, it could mean that heart rate directly maps to a specified sound that is designed in the computer.

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[6] Parkinson, Adam. "EMBODIED LISTENING, AFFORDANCES AND PERFORMING WITH COMPUTERS." *International Computer Music Conference Proceedings* 2013http://hdl.handle.net/2027/spo.bbp2372.2013.020. 162.
[7] Ibid. 167.
[8] Coole, Diana, and Samantha Frost, eds. New Materialisms: Ontology, Agency, and Politics. Durham, NC: Duke University Press, 2010.
[9] Barad, Karen (1998), "Getting Real: Technoscientific Practices and the Materialization of Reality". In: *Differences: A Journal of Feminist Cultural Studies, V*ol. 10, no. 2, 96.

An interaction would imply that the heartrate signal causes the computer to generate the mapped sound and heart rate operates independently. In a similar vein to performing with a great improviser, performing with biosignal data is a more vibrant experience when I let myself listen to the data streams as if they were a duo partner. Even though data streams are being measured from readings that are taken from my body, due to their involuntary nature, they become matter that in ways sounds and *feels* autonomous.

Medical Devices

Medical devices "powerfully shape and make possible specific ways of visualizing and imagining the world."[10] They serve as a material-semiotic actor.[11] The use of a medical device, e.g., how it is supposed to collect data, what it is used for, how much it costs, etc., not only consists of the hardware that is being used in the treatment or data collecting process but embodies elements such as what is an 'optimal' data set, how was this data set constructed, who and what data is included and excluded. In other words, medical devices are shaped by the social, cultural, and cognitive interactions that the healthcare industry value and continue to shape the interpretation of data and treatment of individuals.

The medical industry in the United States has historically exhibited violence and discrimination toward marginalized people and communities. The healthcare system in the United States has systemically continued explicit and implicit provider biases towards communities of color, the LGBTQIA+ community, women, and more.[12] In June 2022, the

[10] Kazimierczak, Karolina Agata. "Medical Imaging and the 'Borderline Gaze of Touch and Hearing': The Politics of Knowledge beyond 'Sense Atomism' ." *Catalyst: Feminism, Theory, Technoscience*, Special Section on The Processes of Imaging/ The Imaging of Processes, 4, no. 2 (October 16, 2018). https://doi.org/doi.org/10.28968/cftt.v4i2.29907, 21.

[11] Haraway, Donna. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies* 14, no. 3 (1988): 575-99. doi:10.2307/3178066, 595.

[12] Greenwood, Shannon. "1. Half of U.S Latinos Experienced Some Form of Discrimination during the First Year of the Pandemic." *Pew Research Center's Hispanic Trends Project* (blog), November 4, 2021.

United States Supreme Court overturned Roe v. Wade, effectively declaring that there are no constitutional rights to abortion,[13] forced sterilization has been disproportionately performed on Black women,[14] and gender-affirming care is under attack with enacted legislation restricting gender-affirming care.[15]

Scientific racism has continued to cause a lack of diverse data sets for research. Dr. Eliseo J. Pérez-Stable, Director of the National Institute on Minority Health and Health Disparities, noted that "[u]ntil recently, researchers assumed that what they learned about White male participants could be safely applied to anybody, regardless of gender, race, ethnicity or other variables."[16] Some data that has been collected from people of color has been done to perpetuate White Supremacy such as the 1932 "USPHS Syphilis Study at Tuskegee" where 600 Black men were denied medical care for syphilis and were recruited to be participants for study without consent to study whether Syphilis had different effects on Black folks.[17] Some data has been coercing people into being test subjects or tested against their will, e.g., the Pill (birth

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https://www.pewresearch.org/hispanic/2021/11/04/half-of-u-s-latinos-experienced-some-form-of-discrimination-during-the-first-year-of-the-pandemic/, NETWORK Advocates. "The Legacy of Injustices Against Native Americans." Accessed July 29, 2023. https://networkadvocates.org/recommittoracialjustice/legacy/, Beech, Bettina M., Chandra Ford, Roland J. Thorpe, Marino A. Bruce, and Keith C. Norris. "Poverty, Racism, and the Public Health Crisis in America." *Frontiers in Public Health* 9 (September 6, 2021): 699049. https://doi.org/10.3389/fpubh.2021.699049, and more.

[13] National Institutes of Health (NIH). "Communicating the Value of Race and Ethnicity in Research," June 27, 2018. https://www.nih.gov/about-nih/what-we-do/science-health-public-trust/perspectives/science-health-public-trust/communicating-value-race-ethnicity-research.

[14] "Forced Sterilization Policies in the US Targeted Minorities and Those with Disabilities – and Lasted into the 21st Century." Accessed July 29, 2023. https://ihpi.umich.edu/news/forced-sterilization-policies-us-targeted-minorities-and-those-disabilities-and-lasted-21st.

[15] Human Rights Campaign. "Attacks on Gender Affirming Care by State Map." Accessed July 29, 2023. https://www.hrc.org/resources/attacks-on-gender-affirming-care-by-state-map.

[16] National Institutes of Health (NIH). "Communicating the Value of Race and Ethnicity in Research," June 27, 2018. https://www.nih.gov/about-nih/what-we-do/science-health-public-trust/perspectives/science-health-public-trust/communicating-value-race-ethnicity-research.

[17] "Tuskegee Study - Timeline - CDC - OS," December 20, 2022. https://www.cdc.gov/tuskegee/timeline.htm.

control) being tested on a small group of Puerto Rican women before being released to the public in the 1960s.[18]

Continued violence, unaffordable treatments, and distrust in the healthcare industry have caused a lack of fair access to medical care in marginalized communities. This trauma is also embedded into the materiality of medical devices. Karolina Agata Kazimierczak's article, *Medical Imaging and the "Borderline Gaze of Touch and Hearing": The Politics of Knowledge beyond "Sense Atomism,"* drew upon vision, touch, and hearing as metaphors for "responsible and accountable knowledge making."[19] Her article built off of Michel Foucault's "medical gaze" and as "the cornerstone of the sociological imagination of the relationship between vision, knowledge, and embodiment in the space of the clinic,"[20] and traced medical devices and practices such as the ultrasound scan, fine needle aspiration, and breast examination to discuss the materiality of 'visualization apparatuses' their intra-actions between what they are observing. Kazimierczak problematized the notion of the medical devices being separate from their objects of investigation and affirmed that the device is materialized through the intra-action between the device and the person being observed/treated.

The development of wearable devices designed to measure biological data cannot be disentangled from the original intent of why these sensing methods were created and how they have been used to collect data from the human body in a medical context.

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[18] Morris, Bonnie J., and D-M Withers. *The Feminist Revolution: The Struggle for Women's Liberation*. Washington, D.C: Smithsonian Books, 2018. 84.

[19] Kazimierczak, Karolina Agata. "Medical Imaging and the 'Borderline Gaze of Touch and Hearing': The Politics of Knowledge beyond 'Sense Atomism' ." *Catalyst: Feminism, Theory, Technoscience*, Special Section on The Processes of Imaging/ The Imaging of Processes, 4, no. 2 (October 16, 2018). https://doi.org/doi.org/10.28968/cftt.v4i2.29907, 6.

[20] Ibid. 2.

Wearables

My survey of the discourse has shown that wearable electronics and the practice of building wearable electronics are usually defined by the boundaries of their computational function and how they augment the body. Steve Mann, considered the "father of wearable computing," defines wearable computing as "the study or practice of inventing, designing, building, or using miniature body-borne computational and sensory devices."[21] M. Malmivaara broke them into three categories, wearable computers, wearable electronics, and intelligent clothing: wearable computers "a computing device assembled in a way which allows it to be worn or carried on the body while still having the user interface ready for use at all times;" wearable electronics, "simpler than full-scale wearable computers…[they] both [have] input and output and [are] capable of adjusting to multiple tasks…[they are] constructed with set tasks to fulfill one or more needs of a specific target group;" and intelligent clothing, an addition to "something traditionally unclothing-like to the garment, without taking away or compromising any traditional characteristics such as washability or wearability."[22] These definitions, while acknowledging their techno-social and technoscientific potentials (some more than others), still limit wearables to being an object that is static and defined/assigned by their function.

Based on my research, I suggest embracing more fluid definitions that consider the situated lens of the discipline, viewer, materiality of the object, and/or performer. A wearable does not necessarily have to be defined as an electronic device that is operated in physical contact with the human body but is rather defined as the space between the phenomena of the

[21] Mann, Steve. "Wearable Computing." The Encyclopedia of Human-Computer Interaction, 2nd Ed. . https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/wearable-computing, n.d.

[22] Malmirvaara, M. "The Emergence of Wearable Computing." Essay. In *Smart Clothes and Wearable Technology*, edited by J. McCann and D. Bryson, 3–23. Cambridge, UK: Woodhead Publishing Limited, 2009, 4-5.

material between the body and the device. Prescribing definitions for wearable electronics that only address the technical function does not meet all the contexts and/or phenomena for which wearable electronics function.

Karen Barad's theory of performative metaphysics is useful for thinking beyond the power of language and representational descriptions and for viewing them through a post-humanist lens that challenges their position as given by the "mere effect of human agency."[23] Ana Viseu and Lucy Suchman use the term "wearable personal technologies" to describe the relationship, symbiosis, between the technology and its user. In *Wearable Augmentations: Imaginaries of the Informed Body*, they explore 'human-artifact' relations,[24] the potential for collaboration and material agency between humans and wearables. They defined wearable personal technologies as "a primary form of augmentation, intended not only to extend and enhance the body technologically but to treat the body as a kind of intimate host giving rise, at least in theory, to a symbiotic relationship between person and device."[25] Thus, acknowledging human and non-human agency.

Sabine Seymour highlights their aesthetic statement and the intentionality of performance that wearable electronics and their design afford. She refers to these devices as 'fashion technology' and defines them as "'designed' garments, accessories, or jewelry that combine aesthetics and style with functional technology."[26]

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[23] Barad, Karen. "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter." *Signs* 28, no. 3 (2003): 801-31. doi:10.1086/345321, 802 and 827

[24] Viseu, Ana, and Lucy Suchman. "Wearable Augmentations: Imaginaries of the Informed Body." In *Technologized Images, Technologized Bodies*, edited by Edwards Jeanette, Harvey Penny, and Wade Peter, 161.

[25] Ibid. 162.

[26] Seymour, Sabine. Fashionable Technology: the Intersection of Design, Fashion, Science, and Technology. Wien: Springer, 2008, 12.

Thinking through the materiality of a wearable electronic alongside their intra-actions with the body is a central theme in Susan Ryan's text, *Garments of Paradise: Wearable Discourse in the Digital Age.* Ryan presents an expansive way to think through wearable electronics beyond the linguistic boundaries of the objects themselves through the performative term, *dress acts*. *Dress acts*, "works that use technology—the enhanced actions it embeds in dress—as part of their systems of meaning,"[27] which implies that wearable electronics must be explored through phenomena; 'human-artifact' relations and human-artifact mergence. Ryan argues that the act of 'dressing' and what folks wear is a primary interface for navigating changing environments. Clothing transmits a subjective response to and from a social fabric.

Cyborgian Frameworks

As stated in the previous section, Wearable electronics are intra-active artifacts. They fuse into fluid devices that engage with the body they are attached to and/or built for, thus evoking a cyborg. Feminist science and technology theorists such as Donna Haraway, Chela Sandoval, and Jasbir K. Puar discussed the complexities around the formation of the cyborg. These theorizations aid in an understanding of difference and the feminist study of difference and address an alternative epistemic standpoint to the 'cyborg' that is centered outside of the "Euro-American 'white' society" lens.[28] They are critical touchstones for understanding the artists that I will discuss in my "Modes of Listening" chapter and my thinking behind my artistic practice.

[27] Ryan, Susan Elizabeth. Garments of Paradise: Wearable Discourse in the Digital Age. London: The MIT Press, 2014, 10.
[28] Sandoval, Chela. "New Sciences: Cyborg Feminism and the Methodology of the Oppressed." In *Cybersexualities: A Reader in Feminist Theory, Cyborgs and Cyberspace*, edited by Wolmark Jenny, 247-63. Edinburgh: Edinburgh University Press, 1999. http://www.jstor.org/stable/10.3366/j.ctvxcrxdq.20. 253.

Donna Haraway defined the cyborg as, "a cybernetic organism, a hybrid of machine and organism, a creature of social reality as well as a creature of fiction."[29] The cyborg, from Haraway's perspective, is a feminist embodiment that can resist a 'fixed' body by fusing component parts. Becoming a cyborg is an intervention to the dominant power structures. Cyborg embodiment through the lens of Haraway isn't just the cybernetic organism itself, but a "body that can be capable of challenging what she calls the 'networks and informatics' of contemporary social reality.[30] The cyborg is a metaphor for challenging the separation between human and material, human and animal, and human and machine. The cyborg is also a metaphor for seeing difference and still being able to form collective identities to dismantle oppressive power structures. It is a being of the past, present, and future as determined by its component parts.

Chela Sandoval argued that people colonized in the Americas had already developed a set of technologies for survival under the oppressive techno-human conditions experienced over the past three hundred years.[31] It is crucial to acknowledge that discussions surrounding Second Wave Feminism often excluded Black and Third World women, Indigenous individuals, transgender individuals, lesbians, and women from lower socio-economic classes.[32] The organizers of the second wave gathered to promote and advocate for common objectives. However, the objectives were often decided upon and were more advantageous to cis, white

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[29] Haraway, Donna Jeanne. Simians, Cyborgs, and Women: the Reinvention of Nature. New York, NY: Routledge, 2015, 148.
[30] Sandoval, Chela. "New Sciences: Cyborg Feminism and the Methodology of the Oppressed." In *Cybersexualities: A Reader in Feminist Theory, Cyborgs and Cyberspace*, edited by Wolmark Jenny, 247-63. Edinburgh: Edinburgh University Press, 1999. http://www.jstor.org/stable/10.3366/j.ctvxcrxdq.20. 252.
[31] Sandoval, Chela. "New Sciences: Cyborg Feminism and the Methodology of the Oppressed." In *Cybersexualities: A Reader in Feminist Theory, Cyborgs and Cyberspace*, edited by Wolmark Jenny, 247-63. Edinburgh: Edinburgh University Press, 1999. http://www.jstor.org/stable/10.3366/j.ctvxcrxdq. 248.
[32] Lorde, Audre. *Sister Outsider : Essays and Speeches*. Trumansburg, NY : Crossing Press, 1984. 110.

women in the middle class and upper middle class. White feminists often advocated for the rights of women and minorities but did not advance rhetoric that intersected both identities.[33] This was echoed in the media. When the Civil Rights and Women's Movement were covered, it would "only feature black male power and white feminist imagery."[34]

Haraway's essay theorized a 'fabricated hybrid, a 'fictional mapping' that affords one to displace the self. BIPOC folks cannot displace themselves and their bodies, in other words, a cyborgian framework and/or technologies for seeing differences and intervening with power structures are not just a call to action but a means for survival. Sandoval stated that as the oppositional cyborg politics presented by Haraway traveled through the academy, it was "utilized and appropriated in a fashion that ironically repressed the very work that it also fundamentally relies upon, and this continuing repression then serves to constitute the apartheid of theoretical domains once again."[35] The motions that Haraway made toward intersectionality, indigeneity, third-world feminism, ecological thinking, etc. have not always been included in the conversations in the academy beside this important contribution to the literature. Intersectional identities and experiences by BIPOC folks are not prosthetic devices that can be fused to the cyborg as a 'seeing device' but a central lens for which we should discuss feminist literature.

To which Chela Sandoval has summarized five technologies for the methodology of the oppressed. They are as follows:

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[33] Morris, Bonnie J., D-M Withers, and Roxane Gay. *The Feminist Revolution : The Struggle for Women's Liberation*. Washington, D.C: Smithsonian Books, 2018. 63.
[34] Ibid.
[35] Sandoval, Chela. "New Sciences: Cyborg Feminism and the Methodology of the Oppressed." In *Cybersexualities: A Reader in Feminist Theory, Cyborgs and Cyberspace*, edited by Wolmark Jenny, 247-63. Edinburgh: Edinburgh University Press, 1999. http://www.jstor.org/stable/10.3366/j.ctvxcrxdq. 249.

1. Sign-Reading: “What Anzaldua calls 'la facultad,' Barthes calls semiology, the 'science of signs in culture,' or what Henry Louis Gates calls 'signifyin' and Audre Lorde calls 'deep seeing' are all forms of ‘sign-reading’…”
2. De-construction: The second, and well-recognized technology of the subaltern is the process of challenging dominant ideological signs through their 'de-construction': the act of separating a form from its dominant meaning.”
3. Meta-Ideologizing: The third technology is what I call 'meta-ideologizing' in honor of its activity: the operation of appropriating dominant ideological forms and using them whole in order to transform their meanings into a new, imposed, and revolutionary concept.
4. Democratics: “The fourth technology of the oppressed that I call 'democratics' is a process of locating: that is, a 'zeroing in' that gathers, drives, and orients the previous three technologies, semiotics, deconstruction, and meta-ideologizing, with the intent of bringing about not simply survival or justice, as in earlier times, but egalitarian social relations…with the aim of producing 'love' in a de-colonizing, postmodern, post-empire world.”
5. Differential Movement: “the one through which, however, the others harmonically maneuver.”[36]

Sandoval theorizes these methodologies as “comprised of techniques for moving energy — or better, as *oppositional technologies of power*: both ‘inner’ or psychic technologies, and ‘outer’ technologies of social praxis.”[37]

[36] Ibid. 249-50.
[37] Ibid. 249.

Jasbir K. Puar built off this notion to explore the 'friction' between intersectionality and assemblages as "interlocutors in tension."[38] "Paur played off of the famous line in Haraway's "A Manifesto for Cyborgs" that implicitly evoked a binary between intersectionality and assemblages,[39] by stating that the two do not need to be separated. There could be a "cyborgian goddess in our midst."[40]

Central to Puar's argument is that feminists must embrace the friction of modes of feminist inquiry and not only engage with the one that may be more comfortable or more aligned with the discursively. Puar's use of 'friction' brings forward the limits of the postmodern techno-human position by introducing the idea that intersectionality and assemblage theory can live beside each other and inform each other. Puar stated that "decades of feminist theorizing on the question of difference, difference continues to be "difference from" that is, the difference from "white women" …[m]uch like the language of diversity, the language of intersectionality, its very invocation, it seems, largely substitute for intersectional analysis itself." [41] ."[42] Audre Lorde argued in her text Sister Outsider: Essays and Speeches (1984) that "[a]s, women, we have been taught either to ignore our differences or to view them as causes for separation and suspicion rather than as forces of change."[43] The work of addressing difference isn't finished at the mention of intersectionality.

While there are many scholars that have built off and reacted to Haraway's call for a Cyborgian lens, I have found that positioning Haraway, Sandoval, Lorde, and Puar beside each

[38] Puar, Jasbir K. "'I would rather be a cyborg than a goddess': Becoming-Intersectional in Assemblage Theory." *philoSOPHIA* 2, no. 1 (2012), 50.
[39] Ibid. 56.
[40] Ibid. 63.
[41] Ibid. 53.
[42] Ibid.
[43] Lorde, Audre. *Sister Outsider: Essays and Speeches*. Trumansburg, NY: Crossing Press, 1984. 112.

other generative to my approach to studying the artistic practices that I will discuss later in the dissertation and to my approach to designing wearable electronics.

Chapter 2 BIOFEEDBACK AND INTERVENTIONS

Biofeedback and Me

While researching sensor design and the implementation of respiration and heart rate sensing, I came across information related to biofeedback. This got me interested in understanding the history of biofeedback, as well as the various techniques and methods used in biofeedback training. I began to survey the discourse and study biofeedback methods and the history of biofeedback. From this, I found a text by the first president of the Biofeedback Research Society (BRS), Dr. Barbara B. Brown (figure 1)[44], "New Mind New Body Bio-Feedback: New Directions for the Mind" (1974). Her approach to forming arguments and research mirrored the feminist discussions in Science and Technology Studies that began emerging in the 1980s. She acknowledged a partial perspective and centered listening as a method. She argued against behavior control, instead, she advocated for the training of an individual to understand how to control[45] their own mind-brain capacities.[46]

The synergy of interest in using biofeedback technology in experimental music in the 1960s and 70s is one of the earliest instances where a substantial collection of music performance practices emerged through the application of biofeedback methods. Composers such as Alvin Lucier, David Rosenboom, Richard Teitelbaum, Milford Graves, and Pauline Oliveros; and visual artist Nina Sobell extensively used biofeedback in their work between 1965-1975. While there was great diversity and gender representation in the medical practice of biofeedback, the discourse of biofeedback music has erased many of the contributions of women

[44] Brown, Barbara B. *New Mind, New Body: Bio-Feedback: New Directions for the Mind*. [1st ed.]. A Cass Canfield Book. New York: Harper & Row, 1974. Back Cover.
[45] Brown's use of the word control is more related to a general understanding or way of communicating than forcing the body to be at a designated state.

and people of color made in the field at the same time. As Tara Rodgers stated in, *Pink Noises: Women on Electronic Music and Sound,* "The terms *technology* and *music* are often marked as male domains, and the trenchancy of associated gendered stereotypes seems to gain force when these fields converge in electronic music."[47]

Figure 1: Photo of Dr. Barbara B. Brown placing electrodes on someone. Back cover of New Mind, New Body : Bio-Feedback: New Directions for the Mind. [1st ed.]. A Cass Canfield Book. New York: Harper & Row, 1974.

Dr. Barbara B. Brown

Dr. Barbara B. Brown (figure 2)[48] was the Chief of Experiential Physiology at the Veterans Administration Hospital in Sepulveda, California, and a Lecturer in the Department of Psychiatry at the UCLA Medical Center. She defined biofeedback as "the feedback of biological

[47] Rodgers, Tara. *Pink Noises: Women on Electronic Music and Sound*. Durham; London: Duke University Press, 2010. Accessed June 6, 2021. doi:10.2307/j.ctv1134dqn. 2.
[48] *Biofeedback, Listening to Your Head.* New York, NY: Cinema Guild, 1973. (2:20)

information to the person whose biology it is. Feedback is a shorthand term for something being "fed back" to the same something."[49] This definition was by far the simplest definition that I read. I didn't explicitly mention the advanced technology being used or create clinical separation the practitioner from the patient.

Figure 2: Dr. Barbara B. Brown taking and EEG Reading. From Biofeedback, Listening to Your Head. New York, NY: Cinema Guild, 1973. (2:20)

Reading Dr. Barbara B. Brown's approach to biofeedback training (BFT) informed my method for articulating and working with sensor data and recognizing voices that have not traditionally been heard in scientific studies. Brown argued that biofeedback was an intervention to scientific objectivity and impartial truth traditionally celebrated in the hard sciences, 'the god-trick' of "seeing everything from nowhere."[50] She stated that:

[49] Brown, Barbara B. *New Mind, New Body: Bio-Feedback: New Directions for the Mind*. [1st ed.]. A Cass Canfield Book. New York: Harper & Row, 1974. 4.
[50] Haraway, Donna. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies* 14, no. 3 (1988): 575–99. https://doi.org/10.2307/3178066. 581.

> "The experiences and observations of nonscientists on the feelings of health and illness have been, in the last fifty years, regularly in sharp conflict with the authoritarian conclusions and "hard data" of the medical establishment. But the current widespread social revolutionary activity is giving us room to test intuited questioning the decisions of authorities, including those decisions affecting our own behavior."[51]

In other words, Western medicine and inquiry traditionally celebrated(s) an absolute objectivity and scientific distance between the observing and the embodied knowledge of the observed.[52] She compared herself to a midwife attending to the delivery of the "excitement and birth trauma of bio-feedback."[53] She stressed the importance of listening to voices that had traditionally been ignored or inviting folks to partake in their healing process.

Her text, "New Mind New Body Bio-Feedback: New Directions for the Mind" (1974) was written to be understood by the public while presenting scientific evidence supporting biofeedback and why this therapeutic method and process is vital to medical, psychosomatic, psychological, and behavioral therapy and warrants more scientific inquiry. She began the book with a dedication, "[f]or the people whose Government has financed the journeys of so many minds, including mine." Reading out of context, it seemed she had dedicated the text to the funding body of her research or even took a nationalistic stance; however, as the text unfolds, I speculate that she was acknowledging a science with a more distributed power structure.

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[51] Brown, Barbara B. *New Mind, New Body: Bio-Feedback: New Directions for the Mind*. [1st ed.]. A Cass Canfield Book. New York: Harper & Row, 1974. 15.
[52] Haraway, Donna. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies* 14, no. 3 (1988): 575–99. https://doi.org/10.2307/3178066.
[53] Brown. *New Mind, New Body*.19.

Research made in the public sector has traditionally been supported by an institution, defense funding, and other external funding that funnels into the institution. By dedicating the text to lay people, she participated in a more activist science and acknowledged that the folks outside of the institution are the actual stakeholders and shareholders.

Throughout the text, Brown called for recognizing and embracing the partiality and situatedness of knowledge.[54] Brown referred to the founding of the Biofeedback Research Society (BRS) as "a novel, perhaps revolutionary, departure from the traditional *scientific society*.[55] Brown referred to this traditional scientific society as the "Science on the Assembly Line," the academic conference paradigm of traveling at considerable expense to a university that is tied to a society member, reading research papers out loud at strictly scheduled slots that may or may not be attended by the "important people", and presentation as a publication in the publish-or-parish society of scientists. Brown motioned towards the elitist nature of these research paradigms and lack of collaboration.[56]

When she discussed work in the lab, she stated, "I prefer to make observations in the laboratory and let *them* dictate the theory rather than follow the custom of making research fit the theory."[57] Karen Barad's proposed notions of 'intra-actions' as a performative term that describes the nature of phenomena resonate here. The term signifies *the inseparability of "objects" and agencies of observation."*[58] Brown's approach to lab work was not only scientifically

[54] Haraway, Donna. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies* 14, no. 3 (1988): 575–99. https://doi.org/10.2307/3178066.
[55] Brown. *New Mind, New Body.* 35.
[56] Ibid. 33-35.
[57] Brown. *New Mind, New Body.* 20.
[58] Barad, Karen (1998), "Getting Real: Technoscientific Practices and the Materialization of Reality". In: *Differences: A Journal of Feminist Cultural Studies, V*ol. 10, no. 2, 96.

responsible, but it also made room for observations that may lie outside of 'scientific norms' and/or not fit traditionally celebrated data sets or theories.

Brown's approach to lab work and care also made room for a process-based research practice more aligned with feminist healthcare practices of the time. Methods of self-sensing became popular amongst feminists and folks that aligned with the Counterculture Movement. Brown referred to a "large gray area between adequate recovery produced by currently used therapeutic measures."[59] She suggested that biofeedback therapy could provide a way to provide patient confidence that they can soothe themselves by recalling therapeutic techniques at moments of stress. She stated that "[s]uch "self-therapy," which may be assisted by professional attendants, could effectively reduce the number of hours now required for counseling and guidance, reduce the number of visits to a therapist, prevent a certain percentage of patients from returning to the hospital or medical units…"[60]

At the time, West Coast feminists[61] would hold *self-help clinics*[62] to learn about "self-examination techniques associated with gynecology and to "demystify" their own bodies as facilitated by a lay health worker."[63] These clinics were organized by Los Angeles area Feminists Women's Health Centers to explain various protocols of vaginal self-examination and

[59] Brown. "New Mind, New Body." 383.
[60] Ibid.
[61] As a speculative note, they were based very close to Brown's work. I wonder if Dr. Brown was involved or knew about this movement. This is an avenue for future research.
[62] It is important to note that these were not physical places, but events organized in Los Angeles and later throughout the US and Canada. Murphy, Michelle. 2012. "Seizing the Means of Reproduction: Entanglements of Feminism, Health, and Technoscience." Duke University Press. https://doi.org/10.1215/9780822395805, 26.
[63] Ibid.

reproductive health. Some clinic groups would move on from those examinations to investigate "sexuality and female ejaculation, lesbian health, or the practice of menstrual extraction."[64]

Motions by feminists and biofeedback practitioners such as Dr. Barbara B. Brown toward a more capacious understanding of healthcare and collective well-being over profit and control made space for a different type of listening in the healthcare environments that expanded into the protocols and arguments that are still being used to combat medical violence today. The coalition building of the feminist self-help movement and Brown's call for the care-based collaborative methods of biofeedback have inspired me to think through protocols for working with biological signals in music. As an avenue for future research, I plan on writing a set of feminist protocols for sonifying biological data.

Biofeedback

Origins

The Biofeedback Research Society (BRS) was established in October 1969 during the inaugural gathering held at the Surfrider Inn located in Santa Monica, CA. The term biofeedback was agreed upon by an interdisciplinary group of researchers that included Joe Kamiya, Barry Sterman, Thomas Mulholland, Barbara B. Brown, and others. The AAPB (formally known as the BRS) defines biofeedback as:

> "a process that enables an individual to learn how to change physiological activity for the purposes of improving health and performance. Precise instruments measure physiological activity such as brainwaves, heart function, breathing, muscle activity, and skin temperature. These instruments rapidly and accurately "feed back" information to the user. The presentation of this information — often

[64] Ibid.

in conjunction with changes in thinking, emotions, and behavior — supports desired physiological changes. Over time, these changes can endure without continued use of an instrument."[65]

Biofeedback was developed as a non-pharmacological method for treating various medical conditions that include post-traumatic stress disorder (PTSD), migraines, urinary incontinence, addiction, high blood pressure, anxiety, depression, and more.

Explorations into what would later be called biofeedback date as far back as J.R. Tarchanoff's experiments with voluntary control of heart rates without depending on the alteration of the breath in 1865[66], R Caton's recordings of spontaneous electrical potentials from the exposed cortical surface of monkeys and rabbits (i.e. EEG responses to various event-related stimuli) in 1885,[67] and Féré's discovery of the resistance of the skin to a small electric current that changed in response to emotional arousal.[68] The clearest resurgence of this area of study happened after World War II.

Feedback, a term developed during WWII, signaled a self-regulating mechanical system that worked by correcting actions by feeding back effects into the systems to influence actions that would follow.[69] Feedback was brought into popular consciousness by mathematician Norbert Wiener in the 1940s when he published his book *Cybernetics: Or Control and Communication in the Animal and the Machine* in 1948.[70] Cybernetics is "the science of control

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[65] "Assoc. for Applied Psychophysiology Biofeedback - About BioFeedback." Accessed July 1, 2023. https://aapb.org/About_BioFeedback.

[66] Tarchanoff, JR (1885). "[Voluntary acceleration of the heart beat in man]" (PDF). Pflügers Archiv für die gesamte Physiologie. 35: 109–135. doi:10.1007/BF01612726.

[67] Caton R (1875). "The electric currents of the brain". British Medical Journal. 2: 278.
Lucier, A. 2012. Music 109: Notes on Experimental Music. Middletown: Wesleyan University Press.

[68] Brown. "*New Mind, New Body,"* 54.

[69] Belgrad, Daniel. "The Culture of Feedback: Ecological Thinking in Seventies America." In *The Culture of Feedback*. University of Chicago Press, 2019. https://doi.org/10.7208/9780226652672. 1.

[70] Ibid. 13.

and communications in the animal and machine" and the study of information processing.[71] Andrew Pickering stated, "biofeedback touched on other lines of inquiry into the performative brain and crossovers between cybernetics and the psychedelic sixties, with the sixties, too, graspable as ontological theater and ontology in action."[72] The field of cybernetics would go on to influence biofeedback in that biofeedback training involves using cybernetic principles to learn how to achieve 'voluntary' modifications or communication over physiological processes that were thought to be in-voluntary or uncontrollable.[73]

The origin of applied biofeedback, as defined by the AAPB (formally known as the BRS), can be traced back to the popularity of cybernetics and the convergence of multiple disciplines, including the humanities, psychology, neurophysiology, experimental psychology, medicine, military research funding, and more. [74] The 1969 formation of the discipline has been described as an awareness that emerged from a zeitgeist[75] or tapestry woven out of many independent threads[76] of researchers that became interested in these areas simultaneously. Barbara Brown referred to the founding of the BRS as "a novel, perhaps revolutionary, departure from the traditional *scientific society*.[77] [78] Brown suggested the exciting potential for the social

[71] "Cybernetics | Definition & Facts | Britannica," July 13, 2023. https://www.britannica.com/science/cybernetics.
[72] Pickering, Andrew. *The Cybernetic Brain: Sketches of Another Future*. Chicago, IL: University of Chicago Press, 2011, 88.
[73] Sterman, Lorraine Taylor. "Clinical Biofeedback." *The American Journal of Nursing* 75, no. 11 (1975): 2006–9. https://doi.org/10.2307/3423961.
[74] D. Moss (Ed.). 1998. Humanistic and Transpersonal Psychology: A Historical and Biographical Sourcebook. Westport, CT: Greenwood Publishing. Reprinted with permission of Greenwood Publishing Group. https://www.researchgate.net/publication/259558495_Biofeedback_mind-body_medicine_and_the_higher_limits_of_human_nature. 1.
[75] Ibid. 2.
[76] Peper, Erik, and Fred Shaffer. "Biofeedback History: An Alternative View." *Biofeedback* 46, no. 4 (Winter 2018): 80–85. https://doi.org/10.5298/1081-5937.46.4.80. 2.
[77] Brown, Barbara B. *New Mind, New Body : Bio-Feedback: New Directions for the Mind*. [1st ed.]. A Cass Canfield Book. New York: Harper & Row, 1974. 35.
[78] Brown referred to this traditional scientific society as the "Science on the Assembly Line" approach as the academic conference paradigm of traveling at considerable expense to a university that is tied to a society member,

impact of Biofeedback on both the sciences and the public by recognizing that healing is connected to psychological and physiological processes, not a singular event (i.e., one is not more important than the other).

Biofeedback was driven by many years of scientific research that demonstrated that the mind and body are connected and that people can be taught and encouraged to harness the power of this connection.[79] In the same year, 1969, Humberto Maturana revealed his theory of *autopoiesis* and asserted that "cognition is a biological phenomenon" at the University of Illinois.[80] Second-wave cybernetics "grew out of attempts to incorporate reflexivity into the cybernetic paradigm at a fundamental level."[81] In other words, homeostatic systems needed to be refined and incorporate the observer.

Influence of the Counterculture Movement and Women's Movement:

In the late 1960s, the counterculture movement was being marketed to the mainstream in the United States. At that time, people became interested in finding connections with themselves, the environment, humans, and non-humans. In the 1970s, "the idea of the ecosystem as a community of mutual interdependencies offered a significant popular alternative to the two dominant views of nature previously extant in American culture: that of nature as a savage wilderness to be subdued and civilized; and that of nature as a resource given significance only

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reading research papers out loud at strictly scheduled slots that may or may not be attended by the "important people", and presentation as a publication in the publish-or-parish society of scientists. Brown motioned towards the elitist nature of these research paradigms and lack of collaboration. Ibid 33-35.

[79] "Assoc. for Applied Psychophysiology Biofeedback - About Biofeedback." Accessed July 1, 2023. https://aapb.org/About_BioFeedback.

[80] Hayles, N. Katherine. "Making the Cut: The Interplay of Narrative and System, or What Systems Theory Can't See." In *Observing Complexity: Systems Theory and Postmodernity*, edited by Rasch William and Wolfe Gary, 137-62. University of Minnesota Press, 2000. http://www.jstor.org/stable/10.5749/j.ctttv4c8.11, 149.

[81] Hayles, N. Katherine. 1999. *How We Became Posthuman*. 74th ed. Chicago, IL: University of Chicago Press, 10.

through human utilization ."[82] There was a popular openness to the idea that they were part of a larger ecosystem of thinking and being in the world and that there were things that needed to be understood beyond human consciousness.

Biofeedback training (BFT) also considered 'electric yoga,'[83] exploded in the 70s as a techno-mediational medical practice that puts one 'in-touch' with their inner state(s). It gained popularity in the late 60s due to the counterculture movement, developments in cybernetics, and increasing interest in Eastern medicine and martial arts, as well as the rising costs of healthcare and interest in non-pharmacological methods.[84] It was equally mystical, strategic, and technoscientific, a method for "discovering internal waves that may be at the center of our being, more powerful than any music ever heard."[85]

The counterculture movement also brought with it a questioning of the status quo or norms of healthcare practices. The Women's self-help movement started to take off in Los Angeles, CA.[86] Women's health was considered private or taboo. Interventions in women's health were often implemented in response to infant mortality or caring for children, thus tying women's health to the health of bearing children.[87] Due to a lack of research in Women's healthcare, hundreds of women suffered from toxic shock syndrome (TSS) in the 60s and 70s[88]

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[82] Belgrad, Daniel. "The Culture of Feedback: Ecological Thinking in Seventies America." In *The Culture of Feedback*. University of Chicago Press, 2019. https://doi.org/10.7208/9780226652672.21

[83] Pickering, Andrew. *The Cybernetic Brain: Sketches of Another Future*. Chicago, IL: University of Chicago Press, 2011, 84.

[84] Schwartz, Mark S., and Frank Andrasik. *Biofeedback: A Practitioner's Guide*. New York, UNITED STATES: Guilford Publications, 2016. http://ebookcentral.proquest.com/lib/ucsd/detail.action?docID=4000019. 13-14.

[85] *Biofeedback, Listening to Your Head.* New York, NY: Cinema Guild, 1973.

[86]Murphy, Michelle. 2012. "Seizing the Means of Reproduction: Entanglements of Feminism, Health, and Technoscience." Duke University Press. https://doi.org/10.1215/9780822395805, 26.

[87] Achievements in Public Health, 1900-1999: Healthier Mothers and Babies https://www.cdc.gov/mmwr/preview/mmwrhtml/mm4838a2.htm

[88] Centers for Disease Control (CDC). Toxic-shock syndrome, United States, 1970-1982. MMWR Morb Mortal Wkly Rep. 1982 Apr 30;31(16):201-4. PMID: 6804780.

and other illnesses that were easily preventable. These disparities were (and still are) especially felt among trans women and women of color.

To address women's health issues, the West Coast Feminists took matters into their own hands and formed coalitions for more capacious methods for understanding feminine self-care and reproductive care:

> "[c]onventional medical methods were designed for anonymous encounters between doctors and strangers, while feminist self-help was to be practiced by "a cluster of women" who had earned an intimate and affective knowledge of each other's bodies."[89]

They would perform visual examinations of their genitals and share experiences about what was going on in their bodies. The information discussed at these gatherings would be inscribed into pamphlets that would be circulated and taught internationally, making women's healthcare gain more political mobility.[90]

Group health practices were also becoming a part of the culture of biofeedback. Biofeedback is a decentralized medical practice where the practitioner and the patient actively work together to bridge psychological and physiological sensations in real time with the assistance of sensor data. Books were made to explain these methods to the public and advocate for their usage. It was deemed "the folk art of an electronic culture" by practitioner Dorelle Markley Heisel (Figure 3).[91] Alpha-wave states were being experimented with as methods of

[89] Murphy, Michelle. 2012. "Seizing the Means of Reproduction: Entanglements of Feminism, Health, and Technoscience." Duke University Press. https://doi.org/10.1215/9780822395805, 26.
[90] Ibid. 28.
[91] Heisel, Dorelle Markley; photos. by Connie Sullivan. *The Biofeedback Guide : Affiliating with Excellence*. Gordon and Breach, 1977.

"togetherness," i.e., telepathic communications, by the "Serenity Seekers" in the San Fernando Valley of California (Figure 4).[92]

Figure 3: Biofeedback guide by Dorelle Markley Heisel that was meant to be understood by the public. Front cover of by Dorelle Markley Heisel's book Heisel; photo by Connie Sullivan. *The Biofeedback Guide : Affiliating with Excellence*. Gordon and Breach, 1977.

Figure 4: The "Serenity Seekers" experimenting with methods for accessing mindful togetherness. Image from Biofeedback, Listening to Your Head. United States: Cinema Guild, 1972.

There are two primary aspects of biofeedback training (BFT) as practiced in the United States. The first aspect is the interfacing with electronic instruments that provide meaningful

[92] *Biofeedback, Listening to Your Head.* United States: Cinema Guild, 1972.

information about the physiological processes of the subject, e.g., EEG, EKG, EMG, etc. A biofeedback practitioner does not take a single reading, such as the ones that a person would receive at the doctor's office when their blood pressure or heart rate is measured. Instead, the practitioner takes continuous readings of internal states observed by a patient and practitioner in real time and provides meaningful feedback. The second aspect is what happens after the visit with a biofeedback practitioner. During each visit, the aim is for the patient to enter a state related to their condition. Together, the practitioner and patient work towards achieving a balanced and comfortable equilibrium, 'homeostasis,' that they can draw upon and repeat independently. The healing starts to happen when the patient and practitioner formulate a training plan that gets repeated as a result of the acquired data and emotional reactions. In other words, biofeedback makes internal and external bodily processes visible and audible to one's self.

A Militarized History

BFT has also been used for and funded by strategic military operations. As mentioned above, there was a resurgence of interest in funding biofeedback research after WWII. The Department of Defense sought alternative treatments that could enhance a soldier's performance in battle and aid in a smoother transition back to civilian life. Due to this resurgence in funding in the United States, several brain wave studies constructed various conversion circuits for making brain rhythms both audible and visible.[93] The audible and visual representations were intended "to provide the researcher with a form of data presentation that would yield more information than ink writing pens or oscillographs."[94]

[93] Eaton, Manford L. *Bio-Music / Manford L. Eaton*. Barton, Vt: Something Else Press, 1974. 3.
[94] Ibid.

In the 1960s, alpha-waves were being experimented with and studied by Edmond Dewan to serve as a form of telepathic communication (one that works similarly to morse code) and for treating "spatial disorientation experienced by helicopter pilots and crew members produced by the stroboscopic light shining through helicopter rotor blades."[95] [96]Jacques J. Vidal coined the term brain-computer interface (BCI) in 1971. He laid comprehensive plans for an experimental project that would interface the human brain with a computer and also serve as the first node of the Advanced Research Projects Agency Network (ARPANET).[97]

It is impossible to talk about American experimentalism and early computer music in any comprehensive way discounting the knowledge and technologies flowing from the militarized science of World War II and the Cold War, especially with regards to cybernetics and biofeedback potentials. David Rosenboom, when discussing the social transformation of society in the 60s and 70s, posited that "the fantastic technical and social transformations of the recent past are directly or indirectly a byproduct of the Cold War."[98] Tara Rodgers noted that in the United States, there have been links between military and audio technologies established since the 1920s, from broadcast radio development (WWI) to subsequent methods for controlling sound to safeguard effective combat communication.[99] She also noted that "the very act of

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[95] Kahn, Douglas. *Earth Sound Earth Signal: Energies and Earth Magnitude in the Arts*. University of California Press, 2013. http://www.jstor.org/stable/10.1525/j.ctt46n4hg, 94-96.

[96] Dewan, Edmond M. Communication and control by means of brainwave and other processes causing voltage changes that can be measured from the body , issued March 4, 2003.

[97]Miranda, Robbin A., William D. Casebeer, Amy M. Hein, Jack W. Judy, Eric P. Krotkov, Tracy L. Laabs, Justin E. Manzo, Kent G. Pankratz, Gill A. Pratt, Justin C. Sanchez, Douglas J. Weber, Tracey L. Wheeler, and Geoffrey S.F. Ling. "DARPA-Funded Efforts in the Development of Novel Brain–Computer Interface Technologies." *Journal of Neuroscience Methods*, Brain Computer Interfaces; Tribute to Greg A. Gerhardt, 244 (April 15, 2015): 52–67. https://doi.org/10.1016/j.jneumeth.2014.07.019.

[98] Rosenboom, David. *Biofeedback and the Arts, Results of Early Experiments*. 2d ed. Vancouver, B.C: Aesthetic Research Centre of Canada, 1976. 1.

[99] Rodgers, Tara. *Pink Noises: Women on Electronic Music and Sound*. Durham; London: Duke University Press, 2010. Accessed June 6, 2021. doi:10.2307/j.ctv1134dqn. 6.

making electronic music thus unfolds with reference to high-tech combat, shot through with symbols of violent confrontation and domination,"[100] from the terminology used (e.g., triggers, controllers, executes, bang, commands, etc.) to competence and "hard" mastery gatekeeping electronic music.

Biofeedback and Music

In the case of biofeedback music, origin stories have been formed out of music that privileged control and/or activation of biological signals over listening to the signals themselves. Early in the process of researching relevant intellectual and artistic genealogies for my creative practice and research, I decided that I needed to make a collection of intervening figures that I could reference in my creative practice and learn from their methods. I started by researching folks who made music with biofeedback methods at the same time as the canonical figures, David Rosenboom, Alvin Lucier, Manford Eaton, Richard Teitelbaum, etc. To which I identified Milford Graves and Pauline Oliveros.

Graves and Oliveros started to ramp up their research in biofeedback methods and how these methods relate to music in 1973. Historical coordinates such as the counterculture movement, funding from the Department of Defense, widespread interest in non-pharmacological treatments, the rising cost of healthcare, and the establishment of the Biofeedback Research Society (BRS) in 1969 led to biofeedback becoming part of the public conscious. Both figures, living on opposite sides of the United States, Oliveros in California, and Graves in New York, and working in different musical spaces, didn't seem to know about each other's work. Yet, they both engaged with biosignals in similar ways. Unlike the canonical

[100] Ibid.

figures, they used them to inform how they listen and interact with other modes of inquiry, such as martial arts, meditation, gardening, medicine, improvisation, and more, instead of using biological signals to control outcomes.

Many canonical composers of Post-War Experimental Music, e.g., John Cage, Marcel Duchamp, and more, were developing methods, a type of ontological theater, of distancing the subject form authorship of a composition.[101] These composers often used their institutional positions to access computers that could execute algorithms to experiment with this mode of inquiry. Along with the growing interest in biofeedback as a medical treatment and alternative method for communication emerged a growing interest in exploring the use of biofeedback equipment as a musical tool in the 1970s. Composers used it to explore telepathic communication, altered states of consciousness, and more.

Composers David Rosenboom, Alvin Lucier, Richard Teitelbaum, and Manford Eaton extended upon the approach of decentralizing the composer with the use of biofeedback techniques. Brain rhythms were seen as autonomous parameters to be interfaced with, thus, alpha music was seen as a tool to "decentering of the self into a technosocial apparatus."[102] Perhaps the most famous example of biofeedback music in the 1970s is when David Rosenboom collaborated with John Lennon and Yoko Ono on the Mike Douglas Show[103] wearing EEGs and performing "Brain Music for John and Yoko" in 1972 (Figure 5).[104]

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[101] Higgins, Hannah B, and Douglas Kahn, eds. Mainframe Experimentalism: Early Computing and the Foundations of the Digital Arts. Berkeley; Los Angeles; London: University of California Press, 2012. doi:10.2307/j.ctv114c7b3, 9.

[102] Pickering, Andrew. *The Cybernetic Brain: Sketches of Another Future*. Chicago, IL: University of Chicago Press, 2011, 85.

[103] https://www.youtube.com/watch?v=dWfoDjwcttw&t=518s.

[104] Rosenboom, David. *Biofeedback and the Arts: Results of Early Experiments*. Vancouver, B.C.: Aesthetic Research Centre of Canada, 1976. 158.

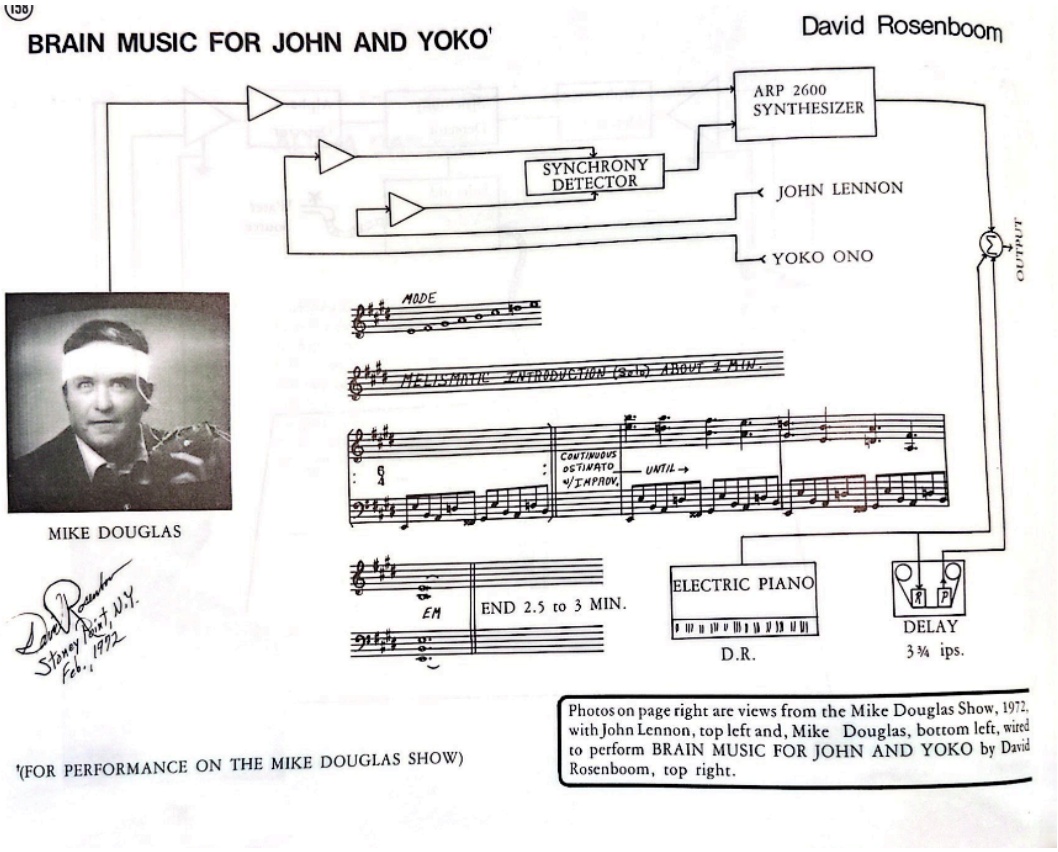

Figure 5: David Rosenboom's Brain Music for John and Yoko. Image from *Biofeedback and the Arts: Results of Early Experiments*.

Composers such as Alvin Lucier, David Rosenboom, John Cage, and Richard Teitelbaum, having composed significant works with biofeedback measurement devices, are placed at the center of the discourse of biofeedback music in American Experimentalism. They are often the only figures mentioned in the discourse of the method of making music with biofeedback techniques. They famously turned to biofeedback as a method to decentralize the composer in the making of music by generating the material from the unconscious mind. These composers used biofeedback as a method for uncovering "questions concerning aspects of subjective experience, states of mind, and their relationship to these signals"[105] and process-based

[105] Rosenboom, David. *Biofeedback and the Arts: Results of Early Experiments*. Vancouver, B.C.: Aesthetic Research Centre of Canada, 1976, iv.

formations of an otherwise western composer/performer and composer and performer relationship.

An Intervention: Pauline Oliveros and Milford Graves, 1973

The interpretation of bio signals from the use of biofeedback technology became a critical touchstone of Milford Graves' and Pauline Oliveros' artistic practice 1973. Both artists started to engage in experiments through biofeedback technology that would shape their musical language for the rest of their careers. Oliveros secured research funding to start her "Meditation Project" at the Center Music Experiments at the University of California San Diego during the Winter Quarter 1973. These experiments would later materialize into one of her most high influential works, the *Sonic Meditations* (1974).[106] In 1973, Milford Graves picked up a record that a Dr. George David Geckeler made of heartbeats a local Barnes and Nobel that would answer his questions about the origins of rhythm and his theory on the ontology of music; "biological music."[107] Graves started recording heart rhythms and cultivating, "biological music," own healing practices at the intersection of martial arts, herbal medicine, biological signals, and music.

Oliveros and Graves used biosignals in a way that differed from the biofeedback musical practices of the canonical figures mentioned above; their goal was not to disembody the intentions of the composer/artist by reaching towards signals that were thought to be involuntary,

[106] Meditation Projects - Outlines and Reports, 1971-1975. Pauline Oliveros Papers. MSS 102. Special Collections & Archives, UC San Diego.

[107] A music and method of inquiry that formed around Graves' study of the body through martial arts, herbs, Eastern and African medicine, and western medicine. Corbett, John, ed. 2015. "Milford Graves: Pulseology." Microgroove: Forays into Other Music. Duke University Press. https://doi.org/10.1215/9780822375531-010.

but instead to reach towards these signals to create a more embodied, intuitive, practice.[108] They trouble the notion of biofeedback sensors being separate from their objects of investigation, through their artistic and research practices, the devices are materialized through the intra-action, circular feedback, that is formed between the device and the person being observed/treated. Pauline Oliveros and Milford Graves practice an intersectional, a haptic, and a feminist science.[109] Pauline Oliveros used EEG (brain wave) and respiration readings while she was conducting the research to complete her Sonic Meditations in 1973. Throughout the course of the research project, the ♀ ensemble, Oliveros and the members of the ensemble explored how one could listen 'inclusively and exclusively'[110] at the same time through various states of awareness, including alpha-wave states. Milford Graves read biological signals of heart variability as a tool to study how folks vibrate together through rhythm.[111]

To illustrate the significance of the Oliveros' and Graves' use of biofeedback techniques as an intervention to the biofeedback music discourse, I will I analyze this critical juncture in their artistic practices and outline how that has come to suggest a more capacious understanding of embodiment and knowledge-making in musical practice.

Milford Graves

In this section, I will discuss how Graves' practice-based research that informed his approach to drumming and auto-didactical exploration of the healing potentials of heart rhythms.

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[108] Both Graves and Oliveros advocated strongly for the intuitive potentials of musical communication. Both believed that 'vibrations' or 'energies' that radiate off the body to communicate music on a telepathic level.
[109] As discussed in Haraway, Donna. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies* 14, no. 3 (1988): 575-99. doi:10.2307/3178066.
[110] Listening in a meditative state where one is equally aware of their own voice and the folks around them.
[111] Rhythm could be understood as an 'invisible connection' to others and/or a vibration that is *felt* in an intuitive sense.

Both elements informed his practice-led research and led to a medical collaboration with Dr. Carlo Ventura, MD, PhD, Cardiologist and Full Professor of Molecular Biology at the School of Medicine of the University of Bologna, Italy. Their collaborative research resulted in a patented method and device for preparing non-embryonic stem cells.[112]

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Milford Graves (1941-2021) often stated that the human heartbeat is his teacher, conductor, and composer. Graves stated that his research:

> "…[O]riginate[d] from a belief that music is a universal language, and a curiosity to define the primary building blocks of that language…Exploring these universals led me to what I believe is the common denominator: *the human heartbeat*. "[113]

Graves came up from drumming up the spirits of the human body and believed that one needed to have a "divine desire" to play.[114] Milford Graves formed a listening ontology around the heart and its rhythms. For Graves, the rhythm of the heart is a form of beingness that understands the body through vibrations, martial arts, listening to ancestors, teaching, research, studying herbs and nutrition, and Eastern, African, and Western medicine (healing). He calls this ontology "biological music."[115]

Figure 6[116] is a mixed-media sculpture by Milford Graves commissioned by the Artist's Institute at Hunter College in Manhattan, New York. One can see wire draping from the heart up and down, connecting through a skeletal assemblage of a video of a pulsating heart. The figure displays the small and large sets of nerves that make up the Anatomic Nervous System (ANS)

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[112] Tremolada, Carlo, Milford Graves, and Carlo Ventura. Method and device for preparing non-embryonic stem cells. US-10689623-B2, filed September 13, 2017, and issued June 23, 2020.
[113] https://www.milfordgraves.com/pageab
[114] Corbett, John, ed. 2015. "Milford Graves: Pulseology." Microgroove: Forays into Other Music. Duke University Press. https://doi.org/10.1215/9780822375531-010, 73.
[115] Ibid. 72.
[116] Mittal, Aakash. "BOMB Magazine | Milford Graves." BOMB Magazine, January 9, 2018. https://bombmagazine.org/articles/milford-graves/.

Electrodes, a fleshy ear on the head, a drum that is protruding from a pelvis that has been fused onto the skeleton with the inscription “DRUM LISTENS TO HEART,” a stethoscope that is weaved around the drum and connected to the skull with headphones that are fused to the ribcage come together. Graves illustrated a feedback loop of listening. Both skulls are listening to the heart feeding back. All come together to tell the story of the many coordinates of research that make up Milford Graves’ practice.

Figure 6: Milford Graves’ Mixed-Media Sculpture, Beyond Polymath. Found on Aakash Mittal’s article, “Milford Graves,” in BOMB Magazine.

To fully comprehend Graves’ biological music, it is important to understand the role that the drums played in his life and how they came into his life. Milford Graves grew up in Jamaica,

Queens, and started playing the drums after "a sublet tenant of his parents, Mr. Page, died and left a bass drum and two field drums in his apartment."[117] As noted, his first instrument was not a standard drum kit, nor would he often play on one during his career. Graves was notorious for refusing to add a snare drum to his kit and turning down gigs that required him to play instruments or styles that he didn't want to play. Unlike many drummers in the jazz tradition, Graves didn't lean into the cymbal to drive time, he foregrounded the drums as if it were a harmonic or melodic instrument.

He started to form his style at a young age while playing with other children who lived in his housing project and performing for the folks that lived there. Graves spent his early years learning Afro-Cuban music, often getting together with his congo-playing distant cousin and Renaldo Tracon, the son of a highly regarded timbale player.[118] He didn't want to copy clone the jazz great's playing by transcribing records; he wanted to capture their energy and use that to inspire his own sound. Playing the drums was not about keeping time or playing patterns. It was about "spirit"[119]. Graves believed that energy came from the drums, not the cymbals. A principle that he learned while playing Latin music. He mostly played in the Afro-Latin tradition and on timbales until 1963 when he started to play more kit[120].

[117] Corbett, John, ed. 2015. "Milford Graves: Pulseology." Microgroove: Forays into Other Music. Duke University Press. https://doi.org/10.1215/9780822375531-010, 73.
[118] Ibid. 73.
[119] Ibid. 74.
[120] He bought a kit after hearing the Coltrane quartet with Elvin Jones.

Figure 7: Drummer, Milford Graves is positioned in front of a start studded ensemble that featured Roswell Rudd (trombone), John Tchicai (alto sax), and Lewis Worrell (bass). The ensemble was assembled by Rudd, yet, Milford Graves is pictured 'fronting' the group. This is an unusual formation in jazz. Photo from the New York Art Quartet Bandcamp Page.

In the mid 1960s, he exploded onto the scene playing with Albert Ayler, Paul Bley, Sonny Sharrock, the New York Art Quartet, and Roswell Rudd. Graves "helped revise the role of percussionist, introducing sounds from non-Western percussion traditions and upending some of the most dearly held conventions of group interaction in jazz."[121] Graves challenged the conventional role of 'the drummer' in a group setting by placing himself at the front of an ensemble (Figure 7)[122] and playing with the melodic intensity and drive of a horn player. His

[121] Corbett, John, ed. 2015. "Milford Graves: Pulseology." Microgroove: Forays into Other Music. Duke University Press. https://doi.org/10.1215/9780822375531-010, 75.
[122] https://newyorkartquartet.bandcamp.com/album/new-york-art-quartet.

insistence liberated the role of the drummer from being a "timekeeper" to an instrumental improviser with the melodic, rhythmic, and expressive potential of any of the front instruments.

While his playing was considered unconventional, novel, and even avant-garde, Graves' positioning of the drummer into a more critical role can be seen as building off the momentum of bebop drummers. As Amiri Baraka stated in his text, *Blues People: Negro Music in White America*, that "[b]ebop also re-established blues as the most important Afro-American form in Negro music by its astonishingly contemporary restatement of the basic blues impulse."[123] He considered his approach to playing with more drums than cymbals and his desire to keep the drums in the foreground more akin to the roots of jazz, African drumming. He further reconfigured the drums to create a multidimensional sound in 1970 by taking the skins off one side of the drum, taking the snare out of his kit indefinitely, adding timbales to his kit, and riding the cymbal much less.[124] In interviews, when asked about his music and approach to playing the drums, Graves always brings the music of the African diaspora into the conversation.[125]

[123] Baraka, Imamu Amiri. *Blues People : Negro Music in White America*. New York, W. Morrow, 1963. 194.
[124] One can hear this in fantastic detail in his record, Meditation Among Us (1977). Also featuring Kaoru Abe (alto saxophone, sopranino saxophone), Toshiyuki Tsuchitori (drums, percussion), Mototeru Takagi (tenor saxophone), and Toshinori Kondo (trumpet, alto horn). *Meditation Among Us*. LP. Japan: Kitty Records - MKF 1021, 1977.
[125] Shteamer, Hank. "Interview: NYC Percussion Legend Milford Graves." Accessed May 1, 2021. https://daily.redbullmusicacademy.com/2015/06/milford-graves-interview, Mittal, Aakash. "BOMB Magazine | Milford Graves." BOMB Magazine, January 9, 2018.

Figure 8: Milford Graves at Central Park Mall with New York Musicians Organization 1973. Photo from the Wire Magazine issue 409.

He considered Afro-Cuban music and free jazz to be alighted in their "refusal to relegate percussion to a merely supportive, time-keeping role."[126] In 1965, Graves kept the drums in the front seat when he recorded his first and only album, *Percussion Ensemble*, for the prominent and later found problematic label, ESP-Disk. [127] He and Sunny Morgan performed exclusively on percussion instruments. Graves played the drums, bells, gongs, and shakers, and Morgan played the drums and bells. There are five tracks, *Nothing, Nothing 13, Nothing 19, Nothing 11-10, and Nothing 5-7*.[128] In interviews, Graves signaled that he was reading about Buddhism at the time

[126] Cox, Christoph. "Christoph Cox on Milford Graves." Accessed June 8, 2023. https://www.artforum.com/print/201803/christoph-cox-on-milford-graves-74302.
[127] The label rose to prominence with the release of Albert Ayler's 1964 album, *Spiritual Unity* amongst others and became a leading label for free jazz.
[128] Milford Graves. "Percussion Ensemble, by Milford Graves." Accessed July 21, 2023. https://milfordgraves.bandcamp.com/album/percussion-ensemble.

and had developed a devoted yoga practice.[129] All the numbers next to each track title were given according to how many beats were in each measure.[130] They mostly sit in odd counts, i.e., not an evenly divisible count like 4/4, similar to those heard in jazz, claves, or other African Diasporic, Persian, Indian, and other types of Eastern and Middle Eastern music. These meters are often called odd, irregular, or asymmetrical meters because they aren't divided into equal (divisible) groupings and consist of combinations of smaller groups of usually 2 or 3 beats. The use of these irregular time signatures directly correlates with his research on the heart and the irregular intervals between beats. These will be discussed later in the section.

When reflecting on his epistemic standpoint on the drums and how one should learn from their influences, he said, "[t]hey [influences] should inspire you to play like yourself. I'd been brought up with this human feeling, not being someone who went to school to become part of an intellectual club."[131] His desire to play like himself superseded the desire to become famous or play with famous people. He compares this to being a healer, "you've got to know who you're dealing with, man. You can't come in and say, "I like this medicine; this is my favorite medicine." The person comes in and says, "But wait a minute, that has nothing to do with my situation."[132] The right music and situation should fit and resonate like the right medicine.

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[129] Weiss, Jason (2012). *Always in Trouble: An Oral History of ESP-Disk, the Most Outrageous Record Label in America.* Wesleyan University Press. 116

[130] "Percussion Ensemble." Accessed July 21, 2023. http://www.espdisk.com/1015.html.

[131] Corbett, John, ed. 2015. "Milford Graves: Pulseology." Microgroove: Forays into Other Music. Duke University Press. https://doi.org/10.1215/9780822375531-010, 74.

[132] Mittal, Aakash. "BOMB Magazine | Milford Graves." BOMB Magazine, January 9, 2018. https://bombmagazine.org/articles/milford-graves/.

Graves' Turn to Biofeedback

Figure 9: The Institute of Bio-Creative Intuitive Development at Bennington College, 1975. Photo From the Wire Magazine Issue 409.[133]

In 1973, Milford Graves was working in the lab at a veterinarian clinic. He was a laboratory technician that did bacteriological work and would conduct antibiotic sensitivity testing and try to find different reactive elements in the blood. He would frequent the medical section at Barnes and Noble on 18th Street and 5th Avenue during his lunch breaks. One day, something gravitated him toward the cardiology section where he would pick up Dr. George David Geckeler M.D.'s "Stethoscopic Heart Records Revised (Figure 10),"[134] record. Upon

[133] Licht, Alan. "Listen to Your Heart." *Wire Magazine*, no. 409 (January 30, 2018): 32–41.
[134] COLUMBIA RECORDS. CKL 4240/CKL 4976. 1973

listening to this record, he started calling up drummers and sharing his excitement about what he had heard, micro sounds, the beats between the beats of the heart.

The microsounds and grooving irregularity conjured his feelings of the similarities between free jazz and Afro-Cuban musics. He recognized these rhythms from studying Yoruba culture and music, which was brought to Cuba, Haiti, Brazil, and the Southeast United States by enslaved African folks.[135] "[W]e don't have to go around begging no more so-called traditional people…I got a recording that has got everything that we do that's supposedly the so-called secret rhythm or possession rhythms, or ritual rhythms."[136]

Figure 10: Cover of George D. Geckeler M.D.'s Stethoscopic Heart Records, Revised, 1949.

He recognized rhythms from studying Yoruba culture and music, brought to Cuba, Haiti, Brazil, and the Southeast United States by enslaved African people.[137] He saw this as a way to

[135] ICA Philadelphia . (2020, November 11). Cell Melodies: Dr. Carlo Ventura and Dr. Baruch Krauss In Conversation with Milford Graves. YouTube. https://www.youtube.com/watch?v=rdIBQg9w2Ig&t=3639s. (00:35:18-00:36:22)
[136] Milford Graves: Full Mantis. Directed by Jake Meginsky, Neil Young. Cinema Guild, 2018. (00:29:22-00:29:35)
[137] ICA Philadelphia . (2020, November 11). Cell Melodies: Dr. Carlo Ventura and Dr. Baruch Krauss In Conversation with Milford Graves. YouTube. https://www.youtube.com/watch?v=rdIBQg9w2Ig&t=3639s. (00:35:18-00:36:22)

learn traditional rhythms without having to “go around begging” for someone to teach him. He could go straight to the source - the heart. Graves immediately bought an electric stethoscope and started recording heart rhythms in a reel-to-reel tape recorder. No one could come over to play with Graves or hang out with him without getting their heart recorded. He was able to build a massive archive of recordings. He would listen to these collected rhythms critically and play them on the drums (Figure 11).

Figure 11: Milford Graves taking heart readings. Photography by Bruce Davidson.

Graves curation of musical energy and auto-didactical spirt would continue to form his work and epistemological standpoint. To further understand the development of his heart music, and later, cell melodies, it is crucial to recognize the intellectual ecosystem that he was working in at the same time. Going straight to the source, became his method for knowledge-making and

learning things that he couldn't get access to due to racism, geographical location, and/or gate-keeping.[138] Graves stated:

> "I brought it down to a biological configuration. With Afro- American culture, you've got to stop at some point from talking about the negativity that was done to you and see the positive aspect that can come out of your experience. I've been observing what happens to people with all this stress on them: they produce great melodies. It's obvious where black music in this country came from. Gospel, the blues. Such beautiful lines came from stress. When you are denied a kind of existence, you retreat into your place…But there's something from this black experience that can be educational for all people. The true practitioners of Zen were black folks in this country. They didn't have to intellectualize and say I want to forget everything and go into a state of Nirvana. When you were denied existence, you were told to go search your inner soul. When black folks do music, they're serious…I grew up with the feeling. You lose your sense of relating to people, you're finished."[139]

Yara, a practice of martial arts that Graves started to develop in 1971, materialized after studying the praying mantis (the animal) and West African dance and warrior rituals (Figure 12).[140] Graves could not find anyone to teach him 'the pray mantis' a Chinese traditional martial arts practice. According to Graves' account, it was a sacred ritual that was not supposed to be taught to anyone that isn't Chinese. In response, Milford Graves decided to go directly to the source, the

[138] "things that were very protected very protective - culturally or ethnic-wise" https://www.milfordgraves.com/what-is-yara

[139] Corbett, John, ed. 2015. "Milford Graves: Pulseology." Microgroove: Forays into Other Music. Duke University Press. https://doi.org/10.1215/9780822375531-010, 77.

[140] https://www.milfordgraves.com/what-is-yara

insect, and bought a couple of them and let them go in his garden. He watched them and studied their movements. He claimed that they could teach him better than human could teach him, echoing the embrace towards ecological thinking[141] at the time:

> "If you go to another human, he may have a limitation. Maybe he can't move a certain way, right? If he can't move a certain way, then that means I'm not gonna get full mantis. I'm gonna get only a little bit of the mantis. But if I go to see all these different mantises, I'm getting the whole praying mantis, you know. I mean. I'm getting the whole praying mantis, man."[142]

Figure 12: Graves teaching Yara, his method of martial arts, at home. Photo from his website.

Graves' method of 'going to the source' was also influenced by how his grandmother faced racism. His grandmother had a major influence on him and his methods of inquiry, "[s]he

[141] Belgrad, Daniel. "The Culture of Feedback: Ecological Thinking in Seventies America." In *The Culture of Feedback*. University of Chicago Press, 2019. https://doi.org/10.7208/9780226652672.21
[142] https://www.milfordgraves.com/what-is-yara

always told me not to let racism hold me down, to do what I wanted to do…"[143] Graves believed that everyone should have access to knowledge and share it when they can. To him, the healing arts were meant to be shared and mobilized. One of the clearest windows into his ontological standpoint is how he cared for his garden. "I have a global garden. My garden's not like people. You got all these people of different ethnicities, they live in their own communities - this don't work like that. They all hang out together, right? I put them like that man, just to watch (Figure 13)."[144] He would garden herbs and vegetables from all over the world to cook, share, and to study.

One of the things that he studied from plants is how they pick up energies and vibrations from the sun and the wind, "They may not have the machines to detect everything, but to me it's just like humans, man."[145] He always went back to what he considered the nature of human ontologies, 'hanging out with nature.'[146]

Figure 13: Milford Graves in his garden in Queens. Photo from the artist's website.

[143] Corbett, John, ed. 2015. "Milford Graves: Pulseology." Microgroove: Forays into Other Music. Duke University Press. https://doi.org/10.1215/9780822375531-010, 78.
[144] https://www.milfordgraves.com/garden
[145] Ibid.
[146] Milford Graves: Full Mantis. Directed by Jake Meginsky, Neil Young. Cinema Guild, 2018. (00:21:08-00:21:30).

Graves' Heart Rate Experiments

Graves developed the heart rate experiments that he started in 1973 and eventually developed them into cell melodies. In 2000, he won a Guggenheim Fellowship and was able to buy more sophisticated listening equipment and software that could analyze the data. He used the funds to buy a software program that analyzes multiple coordinates of the heart, LABVIEW (Figure 14) and an electrocardiogram machine (for measuring heart rate).

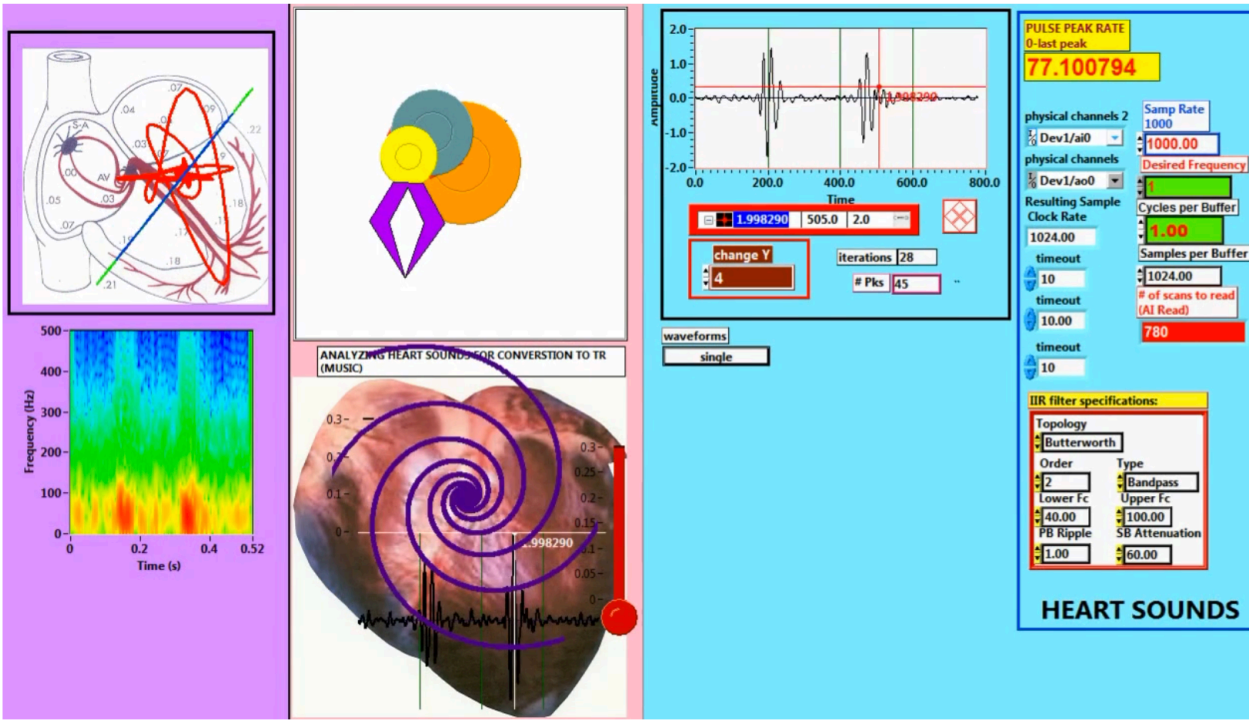

Figure 14: LABVIEW software translating peak frequencies into music. Photo taken from the Artist's website.

While studying the data, Graves found that pitch was as crucial of an element to a heartbeat as rhythm. He wanted to be able to get a more acute reading of the microtonal pitch data of a heartbeat so he could perform the melodies in the correct tuning.

The software enabled the original, acquired heart rate voltages to be sent to a Waveform Amp and resynthesizes into a melody, i.e., music. Pitch became a crucial element for forming his analysis. He found through his research that the pitch that the heart is producing signals whether

the valves of the heart are contracting and relaxing. In other words, that the heart isn't becoming stiff.[147] He started to chop up the wave form and study the heart rhythms down to the milliseconds (to further understand the gestures of the heart) and translated the data into pitch so he could hear the complexities of the rhythmic arcs.

Graves was able to listen to the data and imitate on the drums. He would also experiment with converting the heart melodies to music and then feeding it directly back to the person that he took the readings from.[148] His method was acting as a musical pacemaker:

> "He says he's basically attempting to train the heart to operate healthily in high-stress situations that could cause arrhythmia or cardiac arrest. This principle is similar to the theory behind defibrillation or using a pacemaker, where the heart is shocked into a different rhythm, says Baruch Krauss, MD, a pediatric emergency physician at Harvard Medical School…"It parallels cutting-edge research going on in some leading medical centers." He's defining in a very unique perspective the tonality of normal and abnormal heart rhythms."[149]

He would take this unique method of analysis into further collaborations with Dr. Carlo Ventura.

In 2011 Dr. Carlo Ventura, MD, PhD, Cardiologist and Full Professor of Molecular Biology at the School of Medicine of the University of Bologna, Italy, contacted him to collaborate. Dr. Ventura read about Graves' research on the role of sound and biology and wanted to know more about the Graves' connection the heart and

[147] Licht, Alan. "Listen to Your Heart." *The Wire.* no. 409, March 2018, 38.
[148] Graves, Milford, director. *Vimeo*, 1 Aug. 2023, https://vimeo.com/304505506. Starts at 0:31.
[149] Newhauser, Daniel. Taking Rhythm to Heart. Wavelength Magazine, 2009. https://shamanicdrumming.com/taking_rhythm_to_heart.html.

ritual music.[150] Through their collaborative research, they were able to determine that one could send, heart music, vibrations that sound like heart rhythms/melodies to embryonic stem cells and they would turn into cariogenic cells.

The vibrational patterns of Graves' heart melodies were being read by the cells as cardiac rhythms. Dr. Ventura and Graves determined that one can send these vibrations to non-embryonic cells, e.g., the tissues that repair the heart, and "make them more clever, i.e., effective."[151] Thus, if further developed, this method could potentially replace the need to transplant cells or tissues to regenerate a damaged organ.

To further test Graves' method, Dr. Ventura told him to play random or disordered music, i.e., music that wasn't directly derived from the melodies and rhythms of the heart. Crucial to their findings, the random/disordered music did not cause cells to regenerate or grow. Thus, proving that Graves' research matched the vibrational frequencies of the heart to the point where the body could not tell the difference between the music that he was playing on the drums and an actual heart.

This research was patented in June 2020, and a public concert was held at the VidArts Science Conference in 2018. Graves performed his heart melodies solo and with other instrumentalists while scientists were watching cells regenerate under a microscope.[152]

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[150] Cell Melodies: Dr. Carlo Ventura and Dr. Baruch Krauss In Conversation with Milford Graves. YouTube. ICA Philadelphia , 2020. https://www.youtube.com/watch?v=rdIBQg9w2Ig&t=3639s (00:05:20)
[151] ibid. (00:19:10-00:24:12).
[152] Tremolada, Carlo, Milford Graves, and Carlo Ventura. Method and device for preparing non-embryonic stem cells. US-10689623-B2, filed September 13, 2017, and issued June 23, 2020.

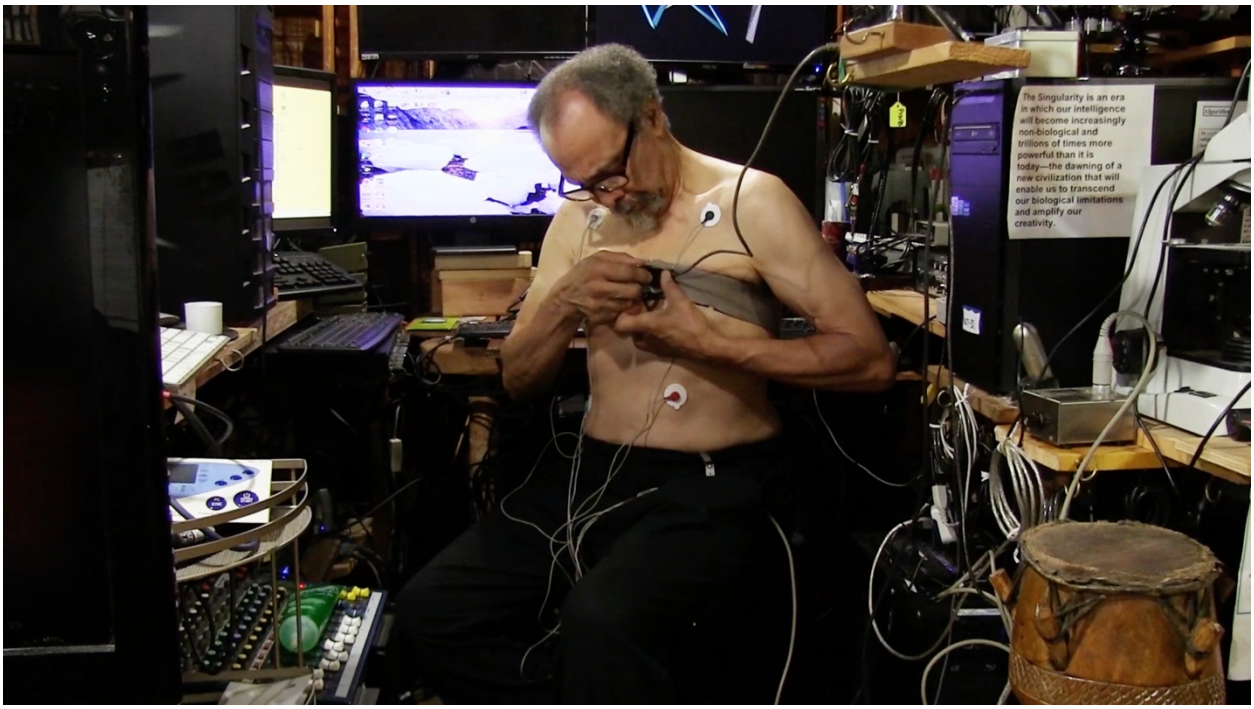


Figure 15: Milford Graves measuring his biorhythms. Photograph from the artist's website.

Pauline Oliveros

Exploring Archives

After starting to read Barbara Brown's text, I noticed some curious references that Pauline Oliveros made to biofeedback in her Sonic Meditation (Figure 16), *Teach Yourself to Fly* (1974).

Teach Yourself to Fly

Dedicated to Amelia Earhart

Any number of persons sit in a circle facing the center. Illuminate the space with dim blue light. Begin by simply observing your own breathing. Always be an observer. Gradually allow your breathing to become audible. Then gradually introduce your voice. Allow your vocal cords to vibrate in any mode which occurs naturally. Allow the intensity of the vibrations to increase very slowly. Continue as long as possible, naturally, and until all others are quiet, always observing your own breath cycle. Variation: Translate voice to an instrument.

Figure 16: Teach Yourself to Fly. Sonic Meditation from Pauline Oliveros' Sonic Mediations (1974). Taken from Pauline Oliveros' *Sonic Meditations* (1974)

To investigate this inclination more, I started to explore the University of California San Diego's Special Collections Archive that housed some of Pauline Oliveros' work. Through this process, I found that she not only explicitly used biofeedback methods to inform her work, but that her Sonic Meditations Workshop led to more performances that engaged with biofeedback methods, notably a piece that would explore biosignals in performance in 1975 called "Bio-Theater." This piece included biosensing that interacted sound and light. Brain waves, respiration, and other biological potentials to control a synthesizer and lighting display.

In this section of the dissertation, I will outline some of the substantial material that I have found in the archives and some of the pieces that I have found to the puzzle of the premiere of Bio-Theater, a collaboration between Bruce Rittenbach, Lin Barron, Mary Lou Blankenburg, and Pauline Oliveros.[153]

The Sonic Meditations Project

In 1973 Pauline Oliveros secured funding from the Rockefeller Foundation and sponsorship by the Department of Music at the University of California at San Diego to conduct an empirical study that would support the Sonic Meditations research she had been developing with the ♀ ensemble and Sonic Meditations Research Group, since the early 1970s.[154] The Sonic Meditation project was concerned with an "exploration of modes of consciousness which result

[153] Rittenbach, Bruce Edwin. "The Musical Application of Bio-Potentials , by Bruce Edwin Rittenbach." University of California, San Diego, 1975. 27.
[154] Oliveros, Pauline. Sonic Meditations." The Painted Bride Quarterly 2, no. 1 | Winter, 1976. http://www.webdelsol.com/pbq/archives/main/index_09.html, 64.

from mental and physical awareness exercise and [her] own Sonic Meditations."[155] Oliveros had two research questions: [156]

1. "How useful and how gratifying are these training methods for musicians, both as performers and composers?" (also listeners)
2. "How important is it for the individual to record, examine, intensify, relate and make sense of one's own experience?"

To address these questions, Oliveros incorporated techniques routed in biofeedback, autogenic exercise, experimental psychology, Zen philosophy, the study of dreams, telepathy, martial arts, and more. She collaborated with Bruce Rittenbach, PME fellow that maintained and guided folks on how to use the biofeedback equipment, Dr. Ronald Lane, Clinical Psychologist of Muir Counseling Service, Al Chung Liang Huang, Tai Chi Master, and Elaine Summers, Kinesiologist.

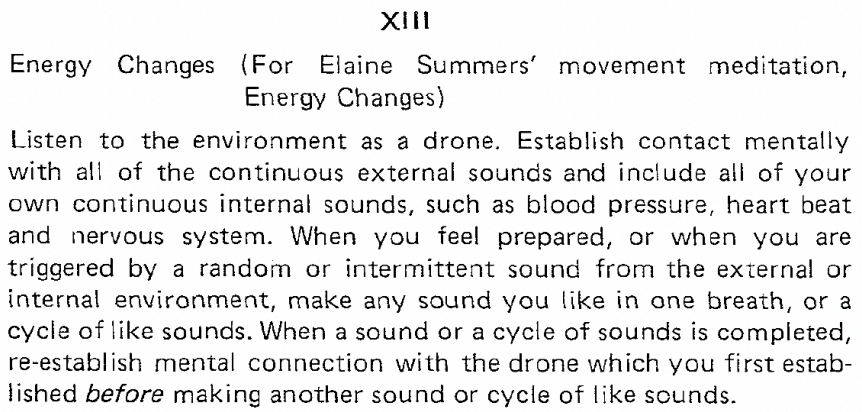
This project was spread over nine weeks in the Winter Quarter at the University of California San Diego. There were four prerequisites for participants, shown in Figure 18.

1. Commitment – participants had to commit to attending daily two-hour group sessions and participate in individual biofeedback training sessions.
2. Silence – Daily sessions were conducted non-verbally except for instructions given by group leaders when needed. There was an explicit agreement made to not talk about the sessions or projects with anyone, including participants.
3. Diary – Participants were expected to keep a diary and document their experience and range of ideas, feelings, and observations (casual or formal).

[155] Oliveros, Pauline. "Meditation Projects - Introduction and Reports," between 1971 and 1975. MSS 102. Special Collections & Archives, UC San Diego. https://library.ucsd.edu/dc/object/bb46138428. 1.
[156] Ibid. 6.

4. No Smoking – participants were not allowed to smoke during sessions.

The Meditation Project was an "intended exploration of mental and physical exercises in concentration, or attention, and awareness for their relationship to the techniques of rehearsal and performance of music."[157] She used the word meditation to describe the process of balancing awareness and attention and listening and hearting. Oliveros defined meditation, in a secular sense, to mean "steady attention and steady awareness, for continuous or cyclic periods of time."[158] [159] *Sonic Meditations* were 'sonic' in that sound and hearing were both "active and receptive...the foci of attention and stimuli of awareness."[160] This attention to awareness of stimuli would oscillate from inside and outside of the body to be brought into space as shown in Sonic Meditation XIII (Figure 17).[161]



XIII

Energy Changes (For Elaine Summers' movement meditation, Energy Changes)

Listen to the environment as a drone. Establish contact mentally with all of the continuous external sounds and include all of your own continuous internal sounds, such as blood pressure, heart beat and nervous system. When you feel prepared, or when you are triggered by a random or intermittent sound from the external or internal environment, make any sound you like in one breath, or a cycle of like sounds. When a sound or a cycle of sounds is completed, re-establish mental connection with the drone which you first established *before* making another sound or cycle of like sounds.

Figure 17: Sonic Meditation XIII. Oliveros asks folks to establish contact with "continuous external sounds" and internal sounds that we often aren't aware of while performing, e.g., blood pressure and the nervous system.

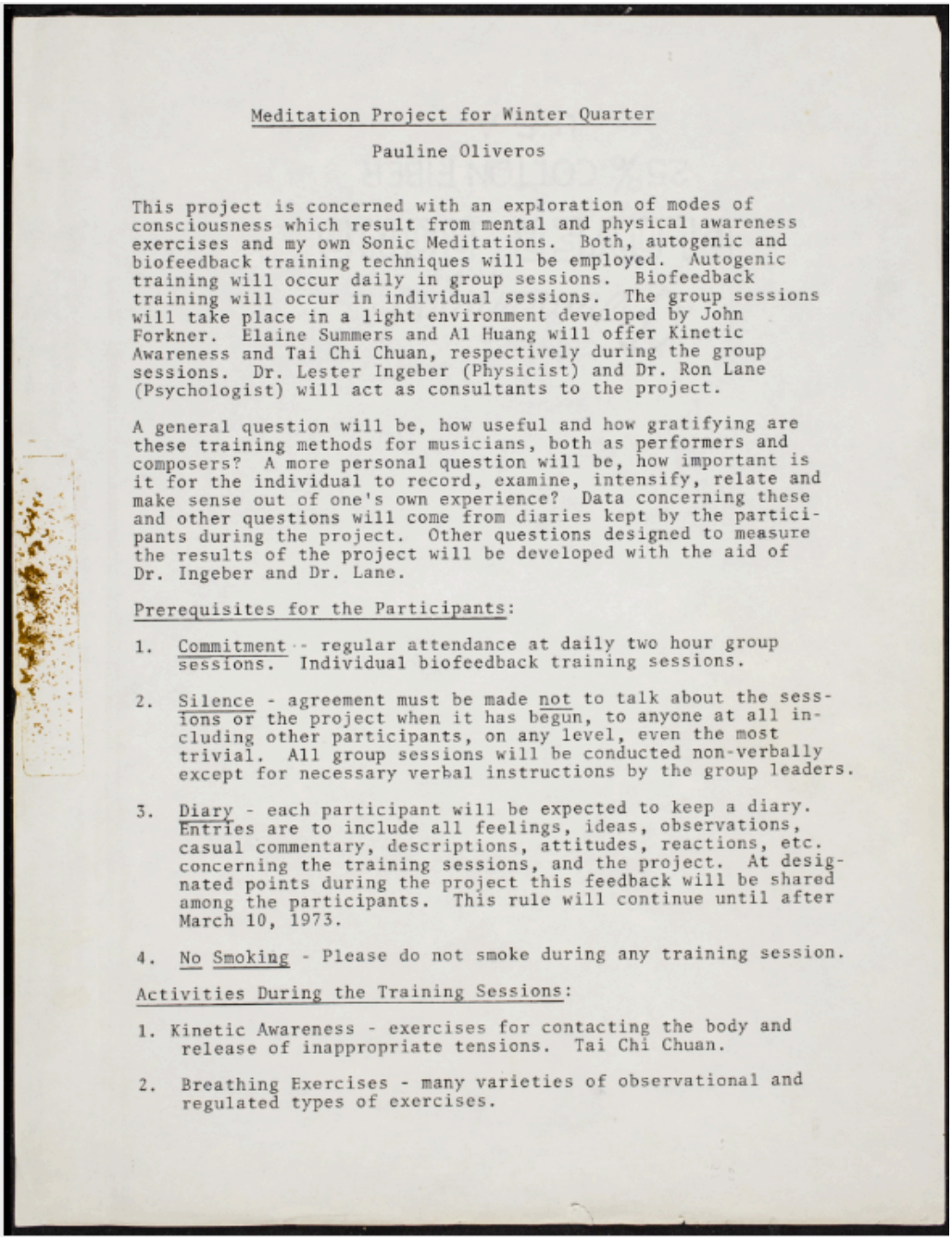
[157] Ibid. 14.

[158] Oliveros, Pauline. Sonic Meditations." The Painted Bride Quarterly 2, no. 1 | Winter, 1976. http://www.webdelsol.com/pbq/archives/main/index_09.html. 54.

[159] It is also important to note that Oliveros recognizes that meditation has many associations and a broad range of practices and techniques that intersect with religious contexts (e.g., Buddhism, Christianity, Sufism, and more), secular modes of awareness, yoga, and martial arts.

[160] Oliveros, Pauline. Sonic Meditations." The Painted Bride Quarterly 2, no. 1 | Winter, 1976. http://www.webdelsol.com/pbq/archives/main/index_09.html. 56.

[161] ibid. 65.



Meditation Project for Winter Quarter

Pauline Oliveros

This project is concerned with an exploration of modes of consciousness which result from mental and physical awareness exercises and my own Sonic Meditations. Both, autogenic and biofeedback training techniques will be employed. Autogenic training will occur daily in group sessions. Biofeedback training will occur in individual sessions. The group sessions will take place in a light environment developed by John Forkner. Elaine Summers and Al Huang will offer Kinetic Awareness and Tai Chi Chuan, respectively during the group sessions. Dr. Lester Ingeber (Physicist) and Dr. Ron Lane (Psychologist) will act as consultants to the project.

A general question will be, how useful and how gratifying are these training methods for musicians, both as performers and composers? A more personal question will be, how important is it for the individual to record, examine, intensify, relate and make sense out of one's own experience? Data concerning these and other questions will come from diaries kept by the participants during the project. Other questions designed to measure the results of the project will be developed with the aid of Dr. Ingeber and Dr. Lane.

Prerequisites for the Participants:

1. Commitment -- regular attendance at daily two hour group sessions. Individual biofeedback training sessions.

2. Silence - agreement must be made not to talk about the sessions or the project when it has begun, to anyone at all including other participants, on any level, even the most trivial. All group sessions will be conducted non-verbally except for necessary verbal instructions by the group leaders.

3. Diary - each participant will be expected to keep a diary. Entries are to include all feelings, ideas, observations, casual commentary, descriptions, attitudes, reactions, etc. concerning the training sessions, and the project. At designated points during the project this feedback will be shared among the participants. This rule will continue until after March 10, 1973.

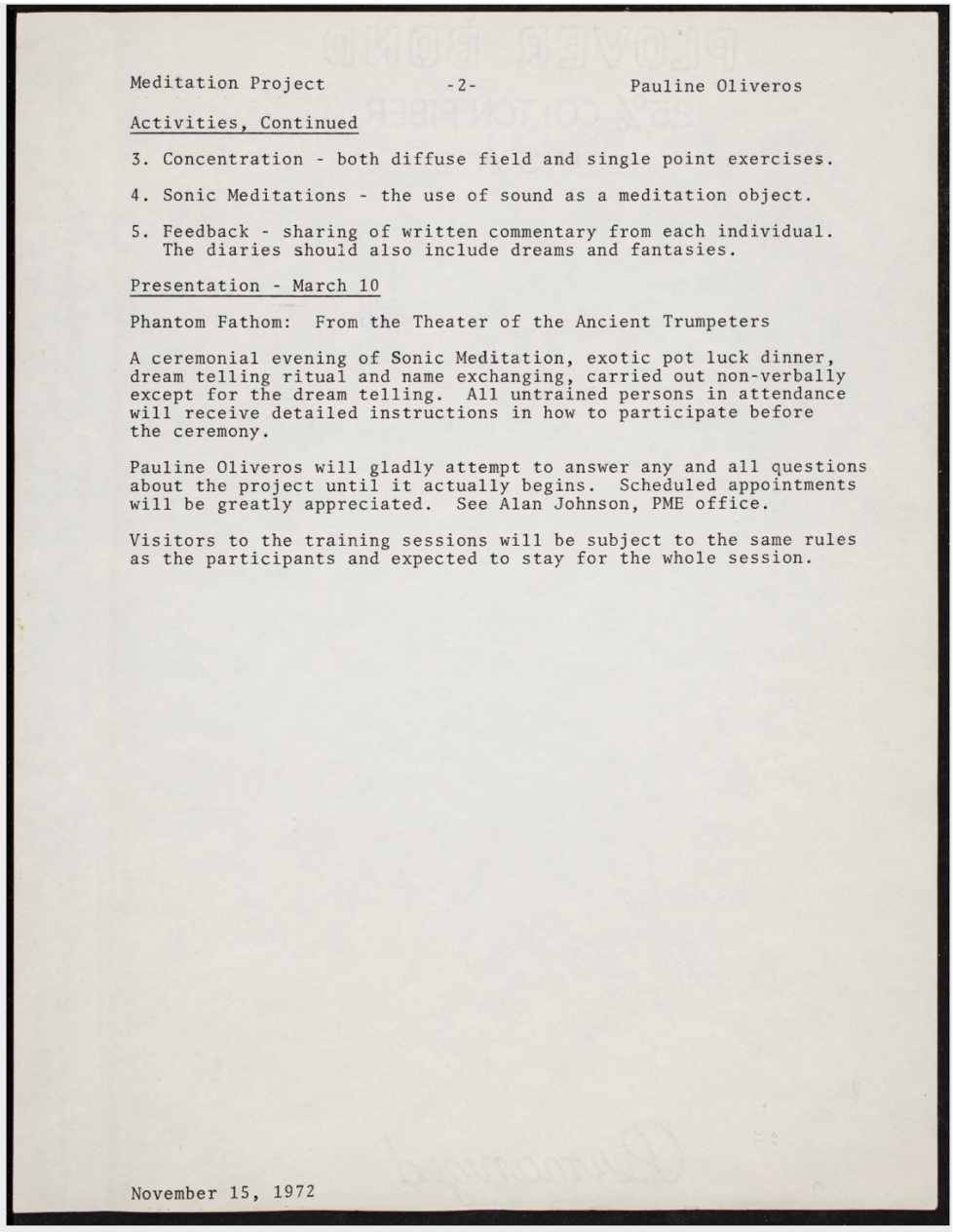
4. No Smoking - Please do not smoke during any training session.

Activities During the Training Sessions:

1. Kinetic Awareness - exercises for contacting the body and release of inappropriate tensions. Tai Chi Chuan.

2. Breathing Exercises - many varieties of observational and regulated types of exercises.

Figure 18: Meditation Project Outline. Expectations and Activities. Document from the UCSD Special Collections. “Meditation Projects - Outlines and Reports,” between 1975 and 1971. Box 11, Folder 4. Pauline Oliveros Papers.



Meditation Project -2- Pauline Oliveros

Activities, Continued

3. Concentration - both diffuse field and single point exercises.

4. Sonic Meditations - the use of sound as a meditation object.

5. Feedback - sharing of written commentary from each individual. The diaries should also include dreams and fantasies.

Presentation - March 10

Phantom Fathom: From the Theater of the Ancient Trumpeters

A ceremonial evening of Sonic Meditation, exotic pot luck dinner, dream telling ritual and name exchanging, carried out non-verbally except for the dream telling. All untrained persons in attendance will receive detailed instructions in how to participate before the ceremony.

Pauline Oliveros will gladly attempt to answer any and all questions about the project until it actually begins. Scheduled appointments will be greatly appreciated. See Alan Johnson, PME office.

Visitors to the training sessions will be subject to the same rules as the participants and expected to stay for the whole session.

November 15, 1972

Figure 19 Document from the UCSD Special Collections. “Meditation Projects - Outlines and Reports,” between 1975 and 1971. Box 11, Folder 4. Pauline Oliveros Papers.

Pauline Oliveros was engaging in a feminist science that centered the subjective experience. Folks involved with the experiment would take notes in their diary, make music together, and engage in biofeedback training every session. While the Sonic Meditations didn’t require the use of technology to perform, e.g., biofeedback sensors, the methods used in her

pieces were instead, used awareness and attentiveness to embrace the "feedback" of results that could be monitored through sensing. The language that Oliveros uses to describe the process of her *Sonic Meditations* echoed Dr. Barbara Brown's exploration into biofeedback at the time. The objective isn't to control how one thinks, perceives the world, or listens; instead, it is to become aware of one's consistently shifting interior and exterior. They are not about control, but instead "the synchronization of voluntary and involuntary mental or physical activity (Figure 17 and 20)."[162]

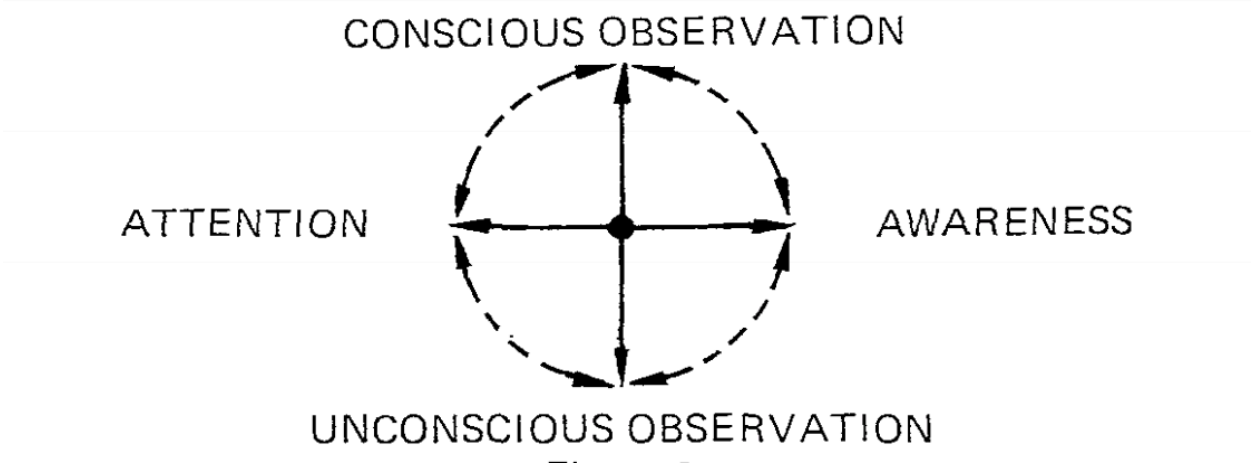
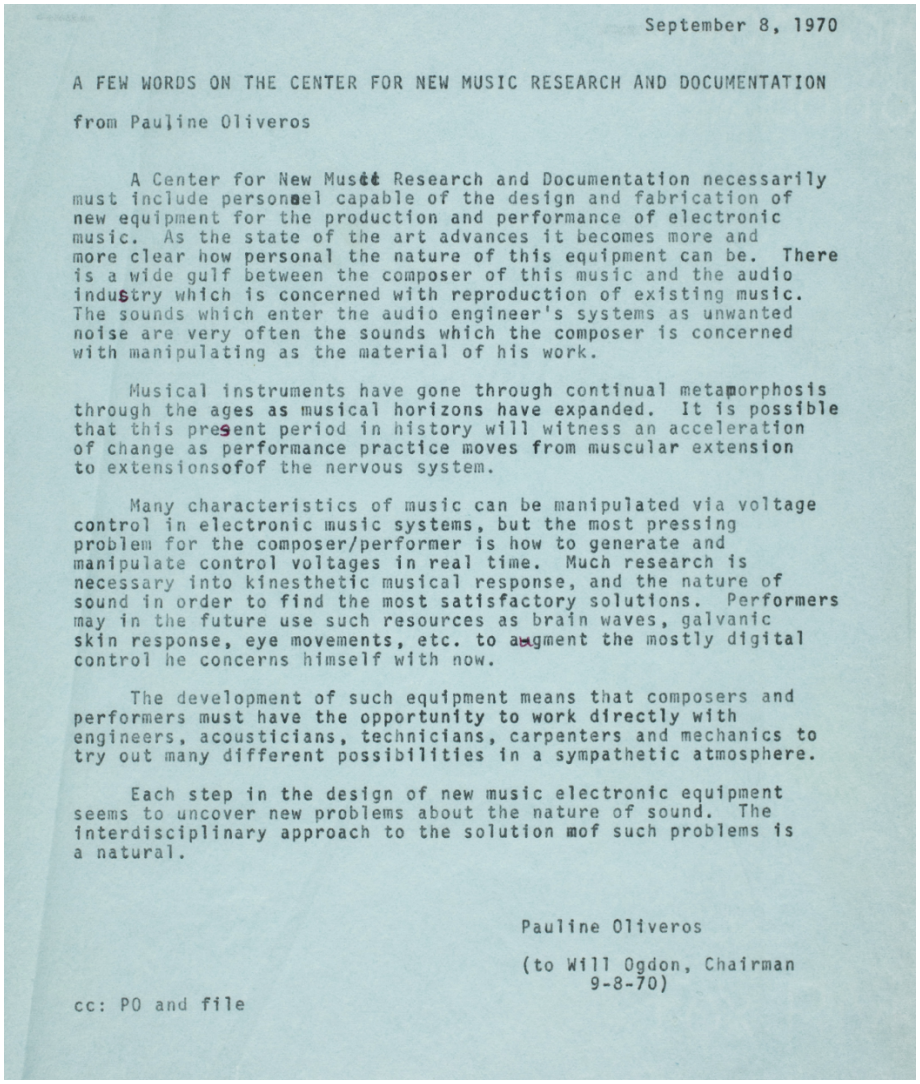


Figure 20: The complimentary relationship between conscious observation, awareness, unconscious observation, and attention. Sonic Mediations, Painted Bride Quarterly.

Pauline Oliveros believed that the future of electronic music involved building electronic instruments that could manipulate control voltages in real time by the means of biofeedback sensing (Figure 21). Oliveros put in a request to hire someone that could build biofeedback sensors. She argued, "[p]erformers may in the future use such resources as brain waves, galvanic skin response, eye movements, etc. to augment the mostly digital control he concerns himself

[162] Ibid. 56.

with now."[163] It would take her three years to secure the funding to receive the biofeedback equipment.



September 8, 1970

A FEW WORDS ON THE CENTER FOR NEW MUSIC RESEARCH AND DOCUMENTATION

from Pauline Oliveros

A Center for New Music Research and Documentation necessarily must include personnel capable of the design and fabrication of new equipment for the production and performance of electronic music. As the state of the art advances it becomes more and more clear how personal the nature of this equipment can be. There is a wide gulf between the composer of this music and the audio industry which is concerned with reproduction of existing music. The sounds which enter the audio engineer's systems as unwanted noise are very often the sounds which the composer is concerned with manipulating as the material of his work.

Musical instruments have gone through continual metamorphosis through the ages as musical horizons have expanded. It is possible that this present period in history will witness an acceleration of change as performance practice moves from muscular extension to extensionsofof the nervous system.

Many characteristics of music can be manipulated via voltage control in electronic music systems, but the most pressing problem for the composer/performer is how to generate and manipulate control voltages in real time. Much research is necessary into kinesthetic musical response, and the nature of sound in order to find the most satisfactory solutions. Performers may in the future use such resources as brain waves, galvanic skin response, eye movements, etc. to augment the mostly digital control he concerns himself with now.

The development of such equipment means that composers and performers must have the opportunity to work directly with engineers, acousticians, technicians, carpenters and mechanics to try out many different possibilities in a sympathetic atmosphere.

Each step in the design of new music electronic equipment seems to uncover new problems about the nature of sound. The interdisciplinary approach to the solution mof such problems is a natural.

Pauline Oliveros

(to Will Ogdon, Chairman
9-8-70)

cc: PO and file

Figure 21: Letter to Will Ogdon explaining the importance of having the necessary equipment for exploring biofeedback methods in music. "Few Words on the Center for New Music Research and Documentation", 1970. Pauline Oliveros Papers. MSS 102. Special Collections

Part of the daily experiments were measuring alpha feedback data with an EEG device and writing about the experience in one's diary. According to Oliveros, alpha brainwaves correlate

[163] Few Words on the Center for New Music Research and Documentation, 1970. Pauline Oliveros Papers. MSS 102. Special Collections & Archives, UC San Diego. https://library.ucsd.edu/dc/object/bb6934681m.

with the meditative states that she was encouraging in her experiments. Participants would sign up for times to privately experiment with the EEG equipment. Pauline Oliveros was trying to see if alpha feedback data would present higher amplitudes by the end of the Meditations Project (Figure 22).[164] She posited that higher rates of alpha would be associated with higher rates of awareness and attention. Participants could monitor their brain waves through headphones and learn to monitor and identify meditative states.[165]

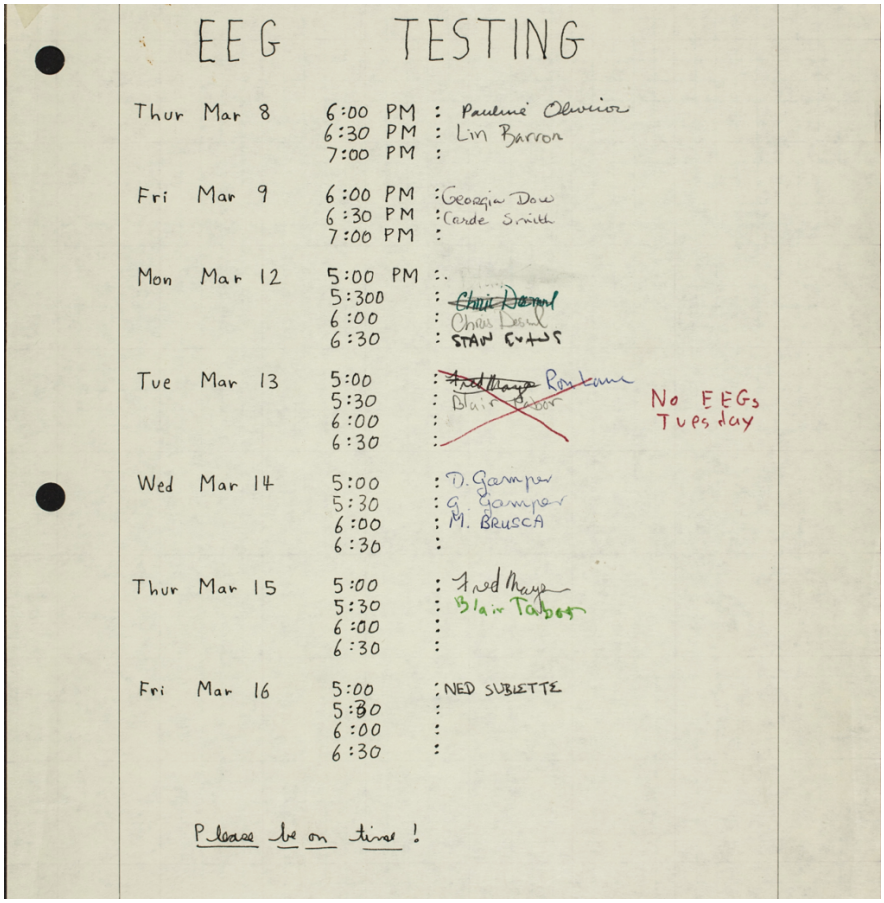
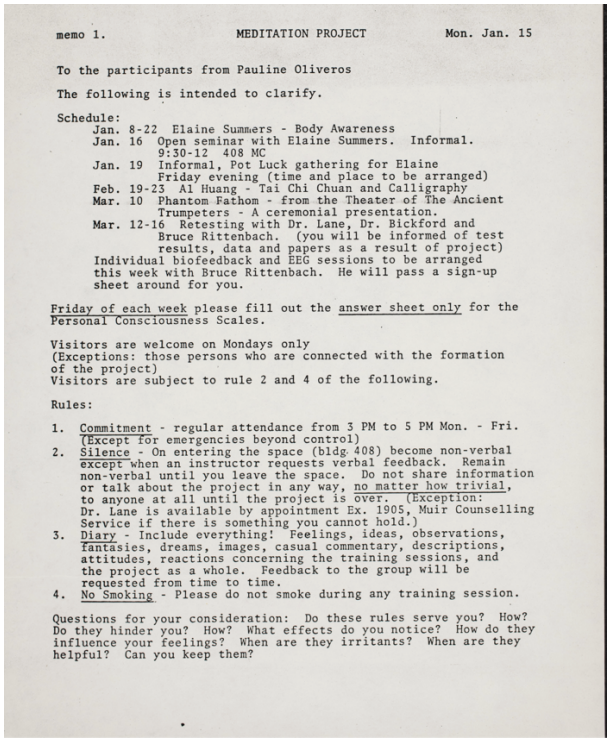


Figure 22: EEG Testing sign-up sheet. Meditations Projects – Questionnaire. 1973. Pauline Oliveros Papers. MSS 102. Special Collections & Archives, UC San Diego.

[164] Meditations Projects – Questionnaire. 1973. Pauline Oliveros Papers. MSS 102. Special Collections & Archives, UC San Diego. 77.
[165] Oliveros, Pauline. "Meditation Projects - Outlines and Reports," between 1971-1975. Box 11, Folder 4. Pauline Oliveros Papers. https://library.ucsd.edu/dc/object/bb7856191d. 19-20.

PME fellow, Bruce Rittenbach oversaw teaching the participants how to use the equipment and maintaining it. The equipment arrived late as can be speculated looking at Rittenbach's instructions (Figure 24);[166] "Dear People: The biofeedback boxes have finally arrived."[167] In Pauline Oliveros' report, she indicated that "bureaucratic delays interfered with" the ability to incorporate biofeedback throughout the entire workshop. [168] The original schedule of the Sonic Meditations workshop, note the January 15th date, included time set aside to engage with biofeedback readings (Figure 23)[169]. She was not able to start working with it until the 5th week of the project.



memo 1. MEDITATION PROJECT Mon. Jan. 15

To the participants from Pauline Oliveros

The following is intended to clarify.

Schedule:
Jan. 8-22 Elaine Summers - Body Awareness
Jan. 16 Open seminar with Elaine Summers. Informal. 9:30-12 408 MC
Jan. 19 Informal, Pot Luck gathering for Elaine Friday evening (time and place to be arranged)
Feb. 19-23 Al Huang - Tai Chi Chuan and Calligraphy
Mar. 10 Phantom Fathom - from the Theater of The Ancient Trumpeters - A ceremonial presentation.
Mar. 12-16 Retesting with Dr. Lane, Dr. Bickford and Bruce Rittenbach. (you will be informed of test results, data and papers as a result of project)
Individual biofeedback and EEG sessions to be arranged this week with Bruce Rittenbach. He will pass a sign-up sheet around for you.

Friday of each week please fill out the answer sheet only for the Personal Consciousness Scales.

Visitors are welcome on Mondays only
(Exceptions: those persons who are connected with the formation of the project)
Visitors are subject to rule 2 and 4 of the following.

Rules:

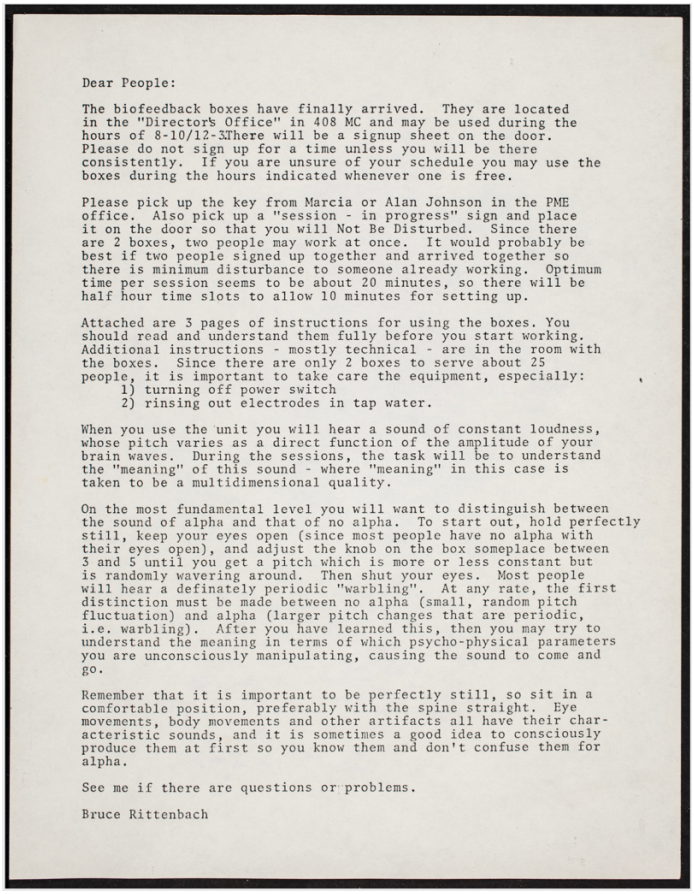
1. Commitment - regular attendance from 3 PM to 5 PM Mon. - Fri. (Except for emergencies beyond control)
2. Silence - On entering the space (bldg 408) become non-verbal except when an instructor requests verbal feedback. Remain non-verbal until you leave the space. Do not share information or talk about the project in any way, no matter how trivial, to anyone at all until the project is over. (Exception: Dr. Lane is available by appointment Ex. 1905, Muir Counselling Service if there is something you cannot hold.)
3. Diary - Include everything! Feelings, ideas, observations, fantasies, dreams, images, casual commentary, descriptions, attitudes, reactions concerning the training sessions, and the project as a whole. Feedback to the group will be requested from time to time.
4. No Smoking - Please do not smoke during any training session.

Questions for your consideration: Do these rules serve you? How? Do they hinder you? How? What effects do you notice? How do they influence your feelings? When are they irritants? When are they helpful? Can you keep them?

Figure 23: Memo 1 of the Sonic Meditations Workshop schedule. In this version of the schedule, biofeedback retesting sessions were included in the schedule. "Meditation Projects - Memos," 1973.

[166] Oliveros, Pauline. "Meditation Projects - Introduction and Reports," 1971-1975. MSS 102. Special Collections & Archives, UC San Diego. https://library.ucsd.edu/dc/object/bb46138428. 14.
[167] Sonic Meditations – Biofeedback instructions by Bruce Rittenbach, 1972. Pauline Oliveros Papers. MSS 102. Special Collections & Archives, UC San Diego. 4.
[168] Oliveros, Pauline. "Meditation Projects - Outlines and Reports," between 1971-1975. Box 11, Folder 4. Pauline Oliveros Papers. https://library.ucsd.edu/dc/object/bb7856191d. 19-20.
[169] Oliveros, Pauline. "Meditation Projects - Memos," 1973. 6.

I speculate that this was perhaps the reason why it took longer for these experiments with biofeedback equipment to be recorded. Bruce Rittenbach would later take the findings from the Sonic Meditations Workshop and his own to build the circuit that would be used in Bio-Theater.[170]



Dear People:

The biofeedback boxes have finally arrived. They are located in the "Director's Office" in 408 MC and may be used during the hours of 8-10/12-3.There will be a signup sheet on the door. Please do not sign up for a time unless you will be there consistently. If you are unsure of your schedule you may use the boxes during the hours indicated whenever one is free.

Please pick up the key from Marcia or Alan Johnson in the PME office. Also pick up a "session - in progress" sign and place it on the door so that you will Not Be Disturbed. Since there are 2 boxes, two people may work at once. It would probably be best if two people signed up together and arrived together so there is minimum disturbance to someone already working. Optimum time per session seems to be about 20 minutes, so there will be half hour time slots to allow 10 minutes for setting up.

Attached are 3 pages of instructions for using the boxes. You should read and understand them fully before you start working. Additional instructions - mostly technical - are in the room with the boxes. Since there are only 2 boxes to serve about 25 people, it is important to take care the equipment, especially:

1) turning off power switch
2) rinsing out electrodes in tap water.

When you use the unit you will hear a sound of constant loudness, whose pitch varies as a direct function of the amplitude of your brain waves. During the sessions, the task will be to understand the "meaning" of this sound - where "meaning" in this case is taken to be a multidimensional quality.

On the most fundamental level you will want to distinguish between the sound of alpha and that of no alpha. To start out, hold perfectly still, keep your eyes open (since most people have no alpha with their eyes open), and adjust the knob on the box someplace between 3 and 5 until you get a pitch which is more or less constant but is randomly wavering around. Then shut your eyes. Most people will hear a definately periodic "warbling". At any rate, the first distinction must be made between no alpha (small, random pitch fluctuation) and alpha (larger pitch changes that are periodic, i.e. warbling). After you have learned this, then you may try to understand the meaning in terms of which psycho-physical parameters you are unconsciously manipulating, causing the sound to come and go.

Remember that it is important to be perfectly still, so sit in a comfortable position, preferably with the spine straight. Eye movements, body movements and other artifacts all have their characteristic sounds, and it is sometimes a good idea to consciously produce them at first so you know them and don't confuse them for alpha.

See me if there are questions or problems.

Bruce Rittenbach

Figure 24: Biofeedback equipment instructions by Bruce Rittenbach. From MSS 102. Special Collections & Archives, UC San Diego.

[170] Rittenbach, Bruce Edwin. "The Musical Application of Bio-Potentials , by Bruce Edwin Rittenbach." University of California, San Diego, 1975.

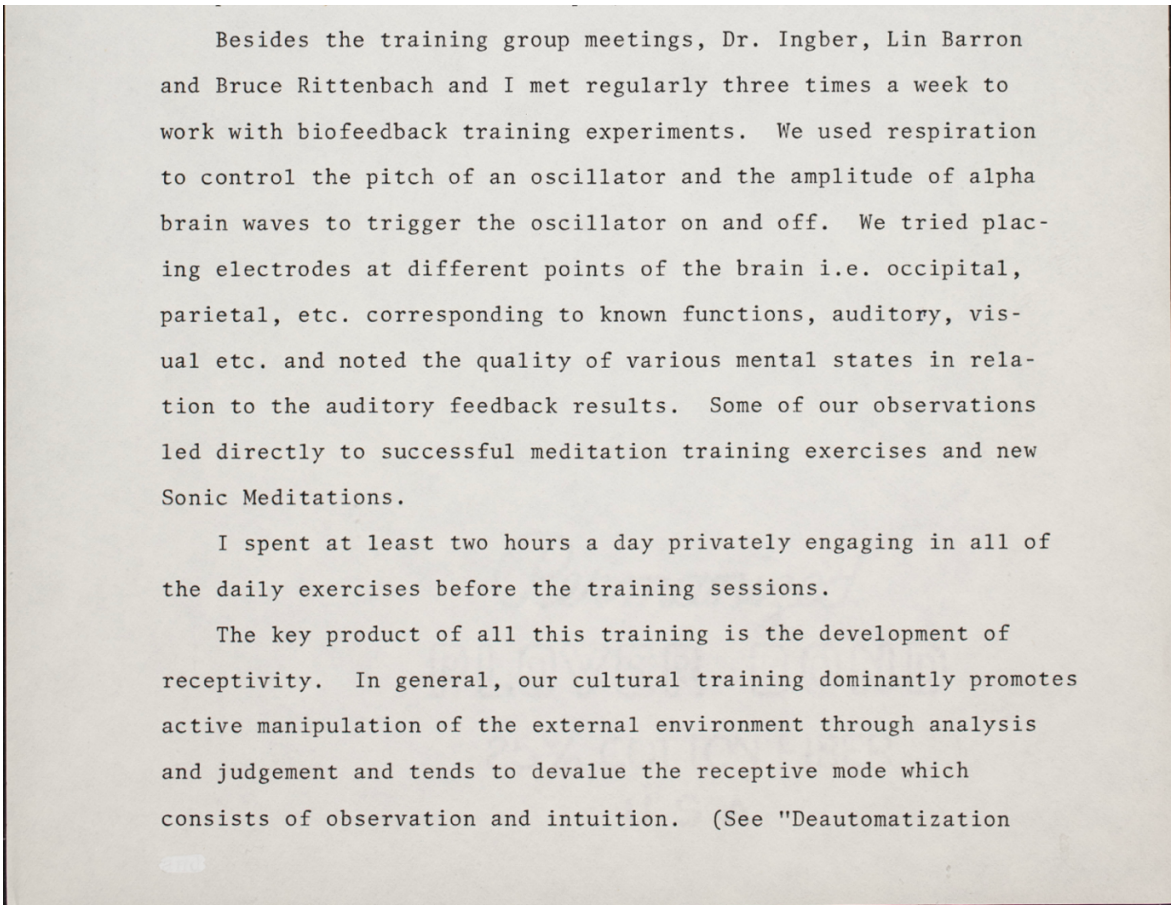
When Oliveros was able to start collecting data, Dr. R. Bickford, the Principal Investigator of the EEG laboratory in the medical center at UCSD, performed tests on the participants. He noticed that most of the participants were already producing high alpha.[171] "Alpha tended to be present in higher a higher amplitude in the right as opposed to the left hemisphere of the brain or vice versa during the first tests. At the end of the project, the tendency was towards more equal amplitude alpha in both hemispheres simultaneous, indicating that some balancing or synchronization might be occurring."[172]

Upon reflection of the work that the ensemble was doing:

> "After a long period of working together, a profound change occurred: rather than manipulating one's voice or instrument in a goal oriented way in order to produce certain effects, we began to *allow* changes to occur involuntarily, or without conscious effort, while sustaining a sound voluntarily…opinions and speculations have no place in this activity."[173]

In her final findings, Oliveros noted that the regular practice of biofeedback aided in encouraging a more receptive approach to performance and awareness (Figure 24). In documenting her findings, Pauline Oliveros noted how important biofeedback was for the *Sonic Meditations* (1974) and for working with musicians on developing receptivity, i.e., awareness (Figure 26).

[171] Oliveros, Pauline. "Meditation Projects - Outlines and Reports," between 1971-1975. Box 11, Folder 4. Pauline Oliveros Papers. https://library.ucsd.edu/dc/object/bb7856191d. 16-17.
[172] Ibid.
[173] Oliveros, Pauline. Sonic Meditations." The Painted Bride Quarterly 2, no. 1 | Winter, 1976. http://www.webdelsol.com/pbq/archives/main/index_09.html, 57.



Besides the training group meetings, Dr. Ingber, Lin Barron and Bruce Rittenbach and I met regularly three times a week to work with biofeedback training experiments. We used respiration to control the pitch of an oscillator and the amplitude of alpha brain waves to trigger the oscillator on and off. We tried placing electrodes at different points of the brain i.e. occipital, parietal, etc. corresponding to known functions, auditory, visual etc. and noted the quality of various mental states in relation to the auditory feedback results. Some of our observations led directly to successful meditation training exercises and new Sonic Meditations.

I spent at least two hours a day privately engaging in all of the daily exercises before the training sessions.

The key product of all this training is the development of receptivity. In general, our cultural training dominantly promotes active manipulation of the external environment through analysis and judgement and tends to devalue the receptive mode which consists of observation and intuition. (See "Deautomatization

Figure 25: Oliveros noting the importance of biofeedback training on the development of receptivity. Document. Oliveros, Pauline. “Meditation Projects - Outlines and Reports,” between 1971-1975. Box 11, Folder 4. Pauline Oliveros Papers.

and the Mystic Experience", Deikman, The Nature of Human Consciousness, Ed. Ornstein, Freeman Press). My project was designed to reverse the above, not to replace the active mode but to complement it. It seems to me that musicians might benefit by the ability to switch modes easily and consciously. Promoting receptivity has high potential value in teaching as well as rehearsal and performance as indicated by the observations of the group leaders, Lane, Huang and Ingber.

Immediate and Future Research Needs:

1. A computer programmer to work with Dr. Lane in order to correlate the data from psychological tests during the project.

2. Computer time for the above work.

3. Technical assistance for the maintenance and development of equipment for further biofeedback experiments.

4. Space for a biofeedback laboratory (currently provided by the Department).

5. A large, open, uncluttered space, free from office and other environmental noises with lighting control for rehearsals.

6. A group of musicians interested in pursuing meditation techniques.

7. Clerical assistance and typing.

Figure 26: Oliveros noting that biofeedback training is useful for musicians to develop a more receptive approach to performance. Document. Oliveros, Pauline. “Meditation Projects - Outlines and Reports,” between 1971-1975. Box 11, Folder 4. Pauline Oliveros Papers.

Bio-Theater

As noted in Figure 25, Oliveros would practice biofeedback training three times a week. She would use respiration sensing to control the pitch of an oscillator, and alpha brain waves to trigger the oscillator on and off (Figure 25). Dr. Inger, Lin Barron, Bruce Rittenbach, and Pauline

Oliveros, central figures in the biofeedback experiments, tried placing electrodes at different points of the brain to note the quality of various mental states in relation to what they were hearing, i.e., auditory feedback. They were experimenting with their own methods of biofeedback training and listening to biological signals. Bruce Rittenbach wrote his masters thesis on the findings of "Musical Application of Bio-potentials."[174] I speculate that these meetings led to the findings that enabled the performance of Bio-Theater March 8-9 in the Recital Hall (Figure 27).[175] [176] As a future avenue of research, I would like to keep on uncovering the puzzle that happened in-between the Sonic Meditations Experiments, Bio-Theater, and what happened after.

[174] Rittenbach, Bruce. "Musical Application of Bio-Potentials." University of California, San Diego, 1975. https://library.ucsd.edu/dc/object/bb99361615.
[175] Bio-Theater, 1975. Pauline Oliveros Papers. MSS 102. Special Collections & Archives, UC San Diego.
[176] https://library.ucsd.edu/dc/object/bb5359530p

Museums: March 8 - 9 Recital Hall

Schedule TBA

Bio-Theater

The Bio-Theater is a sound/light presentation using brain-waves, respiration, and other bio-potentials to control an electronic music synthesizer and lighting display. The 'bio-performer' controls the environment by altering his or her mental modes. The experimental presentation is the result of research at UCSD under the auspices of CME by the Sonic Meditations Research Group, whose concerns are modes of consciousness as related to composition and performance. The group was founded in 1972 by Pauline Oliveros and include Elinor Barron, Lester Ingber, and Bruce Rittenbach with John Forkner, Luminist, joining in this presentation. Consultants to the group include Dr. Ronald Lane - Clinical Psychologist, Al Chung Liang Huang - Tai Chi Master, and Elaine Summers - Kinesiologist.

Figure 27: Documentation of a performance of Bio-Theater. Bio-Theater, 1975. Pauline Oliveros Papers. MSS 102. Special Collections & Archives, UC San Diego.

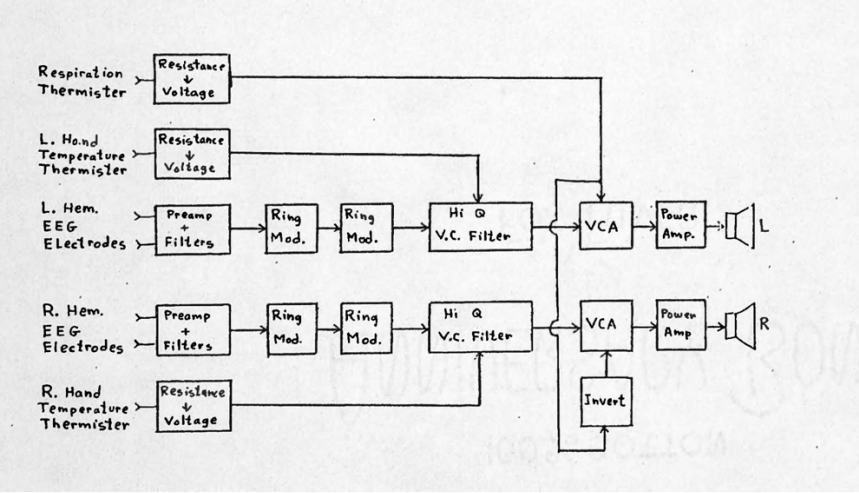


Figure 28: Rittenbach's circuit diagram for Bio-Theater.[177]

[177] Rittenbach, Bruce Edwin. "The Musical Application of Bio-Potentials , by Bruce Edwin Rittenbach." University of California, San Diego, 1975.

Chapter 3 MODES OF LISTENING

Feminist Science and Technology theorists have proposed alternative epistemological frameworks and methods for challenging the 'all seeing vision' historically celebrated in techno-mediated practices. They call for a partial perspective as ethics and politics that not only opens a way to think about embodiment but asks that we think about embodiment in and as situated knowledge. However, while many of these theorists advocate multisensorial methods for suggesting a more capacious understanding of embodiment and knowledge, they often prioritize an ocular-centric approach.

As mentioned in the previous chapter, accounts of electronic music tend to normalize the hegemonic cultural practices and historical accounts of the genre. After finding these similarities between Milford Graves' and Pauline Oliveros' work, I started to make a timeline and map out who made music with biofeedback methods and biological signals and when. I started to find trends in how folks traditionally underrepresented in the field, such as BIPOC, women, non-binary, and trans artists, sonified and engaged with sensor data in their creative and research practices. I also found that there were waves of output, i.e., there were clusters of years where quite a few people were engaging with biological signals as a primary part of their creative practice and clusters of years where folks moved on to other things at the time and/or there were not many people engaging in this method of inquiry. These findings are beyond the scope of this dissertation and will be an avenue for future writing moving forward; however, through mapping out these figures, I started to find trends in how they worked with biological data.

Tara Rodgers stated in her text "Pink Noises: Women on Electronic Music and Sound" that "sounds are points of departure to realms of personal history, cultural memory, and political

struggle."[178] Through studying how these artists approached their work with sounding data and finding connections with the Feminist Science and Technology literature, I have situated these artists' work within three modes of listening: situated listening, embracing irregularity, and listening beyond the ear. These modes of listening have developed into ways of working with biological signals that allow me to approach interface design in a historically and socially informed way and think through the implications of hearing and sharing biological signals.

At the start of each mode of listening is a program note and motion towards video documentation of the corresponding piece. I will present a body of work created with these methods.

Situated Listening

Exhale 2 for Alexandria Smith and Byron Asher (2023)

breathe; get intune with the rhythm of your body.
once you find body tempo, make eye contact.
explore cells and improvise in between.
try to observe the rhythm of your breath without controlling it.
leave space where desired.

Play to the length of your breath.

Exhale 2 is an exploration of sound, listening, and breath. Inspired by Pauline Oliveros' *Sonic Meditations* and performing with Byron Asher in the New Orleans free jazz scene, this piece features cells of instructions and melodies that the performers can visit between improvised material. Each player should be aware of their breath and how they breath

[178] Rodgers, Tara. *Pink Noises: Women on Electronic Music and Sound*. Durham; London: Duke University Press, 2010. Accessed June 6, 2021. doi:10.2307/j.ctv1134dqn. 5.

with each other. Play each cell to the end of your exhale. Start and stop when you need to. To listen to this performance, select Smith_Asher_Exhale 2.mp4 in the supplemental files.

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The first mode of listening that I explored was *situated listening*. This mode of listening is related to my initial reaction to reading the discourse of biofeedback music that I discussed in the previous chapter. Situated Listening, as it relates to my research, is listening in a way that acknowledges that listening to biological signals cannot be detached from the circumstances and lived experiences of everyone involved. To listen inward and outward simultaneously. I was inspired by the work of Pauline Oliveros and her feminist approach to working with biofeedback equipment to inform her Sonic Meditations (1974). Pauline Oliveros describes this as awareness and attention:

> "While one's attention is focused to a point on something specific, it is possible to remain aware of one's surroundings, one's body, movement of all kinds, and one's mental activity; in other words to remain aware of inner and outer reality simultaneously. Attention is narrow, pointed, and selective. Awareness is broad, diffuse, and inclusive. Both have a tunable range of attention that can be honed to a finer and finer point. Awareness can be expanded until it seems all inclusive. Attention can intensify awareness. Awareness can support attention. There is attention to awareness; there is awareness of attention."[179]

[179] Oliveros, Pauline. Sonic Meditations." The Painted Bride Quarterly 2, no. 1 | Winter, 1976. http://www.webdelsol.com/pbq/archives/main/index_09.html, 54.

While the concept of situated listening shares similarities with the listening and performance systems described in Christopher Small's musicking,[180] it is expanded to pull from Donna Haraway's challenge of the normalized and dominant narratives in science and technology studies and call to reject objectivity and acknowledge partiality and embodied knowledge.[181] Acknowledging partiality and embodied knowledge makes me wary of connecting biological data to an objective data set that signifies a particular feeling, attentiveness, or awareness, i.e., not to control the outcome of the biological signals by trying to achieve an objective, prescribed outcome.

Embracing Irregularity

Heart Music, for Milford Graves: Alexandria Smith and Daniel Meinecke (2023)

Graves stated that his research:

> "…[O]riginate[d] from a belief that music is a universal language, and a curiosity to define the primary building blocks of that language…Exploring these universals led me to what believe is the common denominator: the human heartbeat. " (https://www.milfordgraves.com/pageab)

Inspired by the musical and medical research of Milford Graves, Daniel Meinecke and I will perform improvisations that explore the healthy unevenness of heart rhythms.

I invite you to listen to Daniel Meinecke and I perform using a heart-based listening method located in the supplementary files, Smith_Meinecke_Heart Music for Milford Graves.mp4.

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[180] Small, Christopher. *Musicking: The Meanings of Performing and Listening*. Hanover: University Press of New England, 1998.

[181] Haraway, Donna. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies* 14, no. 3 (1988): 575–99. https://doi.org/10.2307/3178066.

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Embracing irregularity as a mode of listening means meeting biological signals where they are and accepting their 'unevenness' and unpredictability. Uneven and unpredictable biological signals are healthy and present.

The first time that I experienced biofeedback art was on November 25th, 2014. Milford Graves came to the New School to present his heart-centered approach to music-making. One of the first things he told us, an audience mostly filled with jazz and classical students currently studying at New School Jazz and Mannes, was to throw away our metronomes. Training to play metronomically is dangerous for our bodies; if your heart is beating in perfect time, your body is not responding (i.e., you are dead or dying). For most people in the room, including myself, this was unfathomable. The metronome was a device for regularity and accuracy. One had to train with a metronome to not only play in time, but to develop an accurate and consistent interpretation that one could draw upon without thinking or feeling during a traditional orchestral audition process.

He spoke about the variability of the heart and how the heart and the rest of the body system are in dialog and feeding back to each other, how our bodies function on latency and expect tempi to change variably. He then proceeded to support his theory by playing samples of heart rhythms that he recorded and citing an extensive amount of medical research that had roots in Western, Haitian, African, Chinese, and other cultural medical practices. When he played the heart rhythms that he recorded over the loudspeakers. The reaction from the audience was mixed. The sound of the heart disturbed many folks in the audience; a few folks even left the room. Graves' demonstration made me reflect on why these sounds heard up close could be considered gross, scary, or revealing. How could sonifying this signal data, the irregularity of the heart, to

music affect someone? What sounds should I map these heart rhythms to? What would it be like to amplify multiple people's heart signals and play them for others?

Graves connected his listening approach to playing and would play back the rhythms he described. His drum sounded like a heart; he could match pitch and rhythm. Graves spoke of music as a healing practice; music should never be destructive. He noted the importance of not only thinking of sound in the literal sense, e.g., the vibration results from a disturbance of molecules, but thinking of it as rhythms, *vibrations*, of the earth, ancestors of the earth, and within our bodies. In other words, if something isn't resonating with us and/or doesn't move the soul, we aren't supposed to be playing it. He didn't mean this in an exclusionary, gatekeeping sense; he wanted everyone to improvise and experience music! It was more of experiencing the 'how' of music instead of the 'what.' A treatment of music that centers vibration, resonance, subjectivity, and process over genre, western understandings of virtuosity, and objectivity. Hearing Milford Graves speak gave me comfort in irregularity and irreproducibility.

When making computer music, accurate reproducibility from session to session is often viewed as an advantage. In *The Deadly Embrace Between Music Software and Its Users* (2014), Miller Puckette compared the advantages and disadvantages of analog gear and using the computer as a musical tool. Analog gear, he used the example of an oscillator, behaves with limited accuracy that can change from one working session to the next due to environmental factors such as temperature, unstable instrument components, user error (e.g., user patching something differently by accident), etc. One of the advantages of using the computer to make music is that one can design a deterministic set of instructions that can produce the same result between days, environments, etc.[182]

[182]Puckette, Miller. "The Deadly Embrace Between Music Software and Its Users." In *Proceedings of the Electroacoustic Music Studies Network Conference Electroacoustic*. Berlin, 2014. www.ems-network.org. 2.

Sonifying biological signals lives in this space between the analog and digital worlds of electronic music. There is often a software environment that stores the readings and enables them to be translated into other forms of data (e.g., sonic, visual, etc.). As stated previously, Milford Graves' work on performing with and theorizing heart music has taught me that signal irregularity is a sign of being healthy and that static, metronomic signals are not healthy. Thus, controlling the outcomes of biological data to achieve a specific outcome could actually be damaging to one's health. I also realize that part of embracing irregularity is giving the signals an interface that lets them speak. Instead of trying to map out a flow or outcomes for a concert, I have designed an environment for shifting the sensor data to other types of instruments and/or timbres. Instead of trying to control my signals, e.g., slow down my heart rate or speed up my respiration, I can shift their timbral output, key center, octave, etc. In other words, to embrace irregularity and still perform with other folks, i.e., not dominate the space with singular outputs and not being able to shift with the music, I have made a flexible interface for moving data into other timbral spaces.

Listening Beyond the Ear

Voices in the Skin 3 for Alexandria Smith and Erin Demastes (2023)

Dr. Barbara B. Brown, a research psychologist that popularized the use of biofeedback and first president of the Association for Applied Psychophysiology and Biofeedback stated in her text *New Mind, New Body* (1974):

> "Emotional judgements expressed by the skin and those expressed by words are often at great odds. And more often than not the voicing of the skin cut through convoluted

> language and the pressures of consciousness with a remarkable accuracy about the nature of reality. Has man been so inordinately proud of his conscious mind that he has abnegated the beauties and extraordinary abilities of the subconscious? Is it possible that the genuine evolution of mind has taken place below the level of a consciousness busy with applying socially created brakes to the natural development of the psyche?"[183]

Throughout this piece, Erin and I will explore alternative methods of ensemble communication and communicate through the voices inside our skin. This piece is my 3rd exploration improvisation exploring these ideas, and the first time I will be performing them with a duo partner. I invite you to listen to this performance in the supplementary files, Smith_Demastes_Voices in the Skin 3.mp4

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Miya Masaoka formed a vaginal listening session that invited folks to hear the vagina and speculate what it is thinking, hearing, and intuitively experiencing in her piece *Vaginated Chairs* (2018). Kite, also known as Dr. Suzanne Kite, built a machine-learning hairbraid interface that listens through sonic landscapes that "include live police scanners, synthesizers played by the hair, and algorithmically rearranging poetry with a voice speaking of a future landscape, prophecies, dreams, rumors, and the possibilities in listening."[184]

Miya Masaoka and Kite have developed extended listening practices that listen beyond the ear and through objects and organs that have not traditionally been considered sites for

[183] Brown, Barbara B. *New Mind, New Body : Bio-Feedback: New Directions for the Mind*. [1st ed.]. A Cass Canfield Book. New York: Harper & Row, 1974. 88.
[184] CCS Bard. "'Listener' by Kite." Accessed July 12, 2023. https://ccs.bard.edu/events/548-listener-by-kite.

listening. *Listening Beyond the Ear* explores how both of these artists have engaged with biological signals that listen beyond the ear and extend to the hair and vagina.

As an improviser, I have always felt that music is not just heard with our ears but also felt and conveyed to others through our bodies. Andrew Parkinson suggested that the embodiment and extension of "listening involves more than just the ears, but the whole body, and in particular the musical instruments we might work with."[185] Sound is embodied and heard in many different ways and isn't always as obvious as an improviser making faster gestures as the music gets faster, a computer musician sitting still as their acousmatic piece sounds through a space, or turning one's ear towards a sound that they are focusing on.

This mode of listening further developed as I read Dr. Barbara B. Brown's *New Mind, New Body: Bio-feedback: New Directions for the Mind* (1974). The first method of sensing she discussed in depth was Galvanic Skin Response in Chapter 2, *Skin Talk: A Strange Mirror of the Mind*. Brown referred to the skin as our emotional "voice box" [186] and "emotional mirror"[187] and illustrated that our skin expresses many coordinates of thought and emotions that are experienced unconsciously. She called this concept of skin talk. To which she wrote:

> "Emotional judgments expressed by the skin and those expressed by words are often at great odds. And more often than not the voicing of the skin cut through convoluted language and the pressures of consciousness with a remarkable accuracy about the nature of reality. Has man been so inordinately proud of his conscious mind that he has abnegated the beauties and extraordinary abilities of the subconscious? Is it possible that the genuine evolution of mind has taken place below the level of a consciousness busy with applying socially created brakes to the natural development of the psyche? Are we now ready to be Alice in Wonderland and look at the world of conscious constraints through the eyes and ears and skin of a wise and prudent subconscious?"[188]

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[185] Parkinson, Adam. "EMBODIED LISTENING, AFFORDANCES AND PERFORMING WITH COMPUTERS." *International Computer Music Conference Proceedings* 2013. http://hdl.handle.net/2027/spo.bbp2372.2013.020. 163.
[186] Brown, Barbara B. *New Mind, New Body : Bio-Feedback: New Directions for the Mind*. [1st ed.]. A Cass Canfield Book. New York: Harper & Row, 1974. 55.
[187] Ibid. 79.
[188] Ibid. 79.

Brown's provocative statement noted that the voices of the skin could be considered the window into the unconscious mind. That the skin hears and processes things that we may not consciously be aware of.

Listening Through the Hair

Dr. Suzanne Kite, also known as Kite, is a Oglála Lakȟóta multidisciplinary performance artist, computational artist, visual artist, and composer that was raised in Southern California. She is a multidisciplinary artist who centers Lakȟóta systems of knowledge making that stem from multiple generations. Kite argues that "ethics is an ontological question, where harm to humans and harm to nonhumans are the results of the denial of beinghood; that an epistemology is only ethically viable if built around an ethical ontology; and that ethical methodologies for the creation of anything are only possible if new knowledge can be produced without harming humans and nonhumans."[189] Kite's performances, compositions, sculptures and sound installations showcase the use of experimentation in new media and digital technologies that touch on issues such as nonhuman and human intelligence, the ethics of extractive technologies, and software design.[190] Her standpoint is centered around ethics, an important Lakȟóta principle, and formed through extensive conversations with her family. Particularly her cousin and frequent collaborator, Cory Stover.

Ethics that are grounded in Indigenous ontologies are a central theme and motivation in her work. The guiding principle to all of Kite's work is the Lakȟóta decision making process that

[189] Kite, Susan. "Hél Čhaŋkú Kiŋ Ȟpáye (There Lies the Road): How to Make Art in a Good Way." Dissertation, Concordia University, 2023. http://kitekitekitekite.com/dissertation. 10.
[190] Ibid.

is based on building thing in a "Good Way."[191] [192] [193] Kite has defined Indigenous protocols, a Lakȟóta methodology, for building technology with a holistic understanding that "affords respect to materials or objects or nonhumans outside of oneself." As stated in her collaboratively written chapter, "How to Build Anything Ethically:"

> "Indigenous protocols set up our relationships with the world in ethical ways, reducing harm to ourselves, our communities, and our environments. These protocols are rooted in contexts of place, ontologies developed in that place, and the communities living in that place, from stones to animals to people."[194]

Every new piece of technology that she builds, whether it is an AI protocol or a wearable electronics, is embedded within the Indigenous decision-making process of looking seven generations ahead. In other words, it is more important to her to consider the impact of a piece of technology seven generations from now than it is just to keep building things for the sake of technological advancement. This method of thought affords respect to humans, objects, and nonhumans outside of oneself. One must have an understanding about how the device that you create and/or bring into the world forms an exchange within the environment. It is essential to Indigenous ontologies and Kite's work that her work resists exploitation of people or resources. Looking seven generations ahead is a method of grounded ethics and experienced in the past and present in Lakȟóta time structures. Two other ways that futurity is expressed and experienced in Lakȟóta tradition is through myth and extrasensory perception. Myth was not separate from

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[191] Kite, Suzanne, Corey Stover, Melita Stover Janis, and Scott Benesiinaabandan. "How to Build Anything Ethically." Edited by Jason Edward Lewis. *Indigenous Protocol and Artificial Intelligence*, January 30, 2020, 75–84. https://doi.org/10.11573/spectrum.library.concordia.ca.00986506, 75.
[192] Suzanne Kite outlines how to make physical computing devices in a "Good Way" in "How to Build Anything Ethically. Kite graphs these protocols beside 11 steps that are required to follow if you want to build sweat lodge in a "Good Way."ibid. 76-82.
[193] Kite, Susan. "Hél Čhaŋkú Kiŋ Ȟpáye (There Lies the Road): How to Make Art in a Good Way." Dissertation, Concordia University, 2023. http://kitekitekitekite.com/dissertation.
[194] Ibid.

everyday life, but a separate dimension.[195] It was a technology for something things down, for seeing the past, communicating with power, nonhuman entities, and connecting with spirits.[196] Extrasensory perception is a method of predicting the future and for being able to sense information that isn't captured by touch, smell, taste, sight, or hearing.

Figure 29: Kite performing Listener. Photo from her personal website.

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Kite's piece *Listener (2018)*, focuses on developing a relationship of listening between the computer as a nonhuman entity and extrasensory (Figure 25). Kite's Hairbraid Interface (Figure 30).[197] Her Hairbraid Interface, or listening device, can extend in and outside her body

[195] POSTHUMUS, DAVID C. *All My Relatives: Exploring Lakota Ontology, Belief, and Ritual*. Lincoln: University of Nebraska Press, 2018. doi:10.2307/j.ctvvndzk, 124.
[196] ibid. 124-25.
[197] https://www.kitekitekitekite.com/portfolio/listener.

while performing and exercise its transformative power.[198] An Oglála Lakȟóta woman is equipped with a sacred hair listening device that is passed down from generations of women and listens beyond time and place[199]. It serves as a listening device, one that can help her listen to the spirits and her ancestors, that protects from the potential dangers of the future; it is her responsibility to listen. The composition is in the form of a sonic and physical (projected) spiral. Lakȟóta womens' quillwork patterns act as a compass.

Figure 30: Kite's Hairbraid Interface. Photo is from her personal website.

Kite must move through the in the circular pattern.[200] he watches a projected video, listens to some radio frequencies and police scanners, and makes a decision to move while watching the projections (She interprets the circle in both directions). Her Hairbraid Interface is connected to a virtual synth, the synth is connected to a resonator that interfaces with the projections.[201] Kite uses Wekinator[202] as a machine learning program to build a system of

[198] *KaleidoLA: Suzanne Kite and Selwa Sweidan Artist Lecture*. *YouTube*. YouTube, 2021. https://www.youtube.com/watch?v=Y__xNtUdE6E.
[199] Ibid.
[200] Many Indigenous cultures, including the Lakȟóta, observe circular time, i.e., not western time structures.
[201] https://www.youtube.com/watch?v=kAEuYoE8ruk (00:01:40-00:03:00)
[202] http://www.wekinator.org/

listening. The computer listens to her, she listens to the computer making a circular process of decision making.[203]

When Kite asked herself, "If she had a listening device, what would it be? What is a logical listening device for someone seven generations ahead?"[204] The hair was an obvious choice. The hair braid interface is a sacred communication device-like artifact that has been passed down from woman to woman to communicate beyond time and place. A device that centered a 'listening touch and vision' through the hair, the hair is sacred to the Lakȟóta, was the obvious choice for transmitting care seven generations ahead. The hair carries power and has transformative powers, it can listen, see, and communicate.[205] When performing while wearing her Hairbraid Interface, Kite centers her body and movement in communication with her hair and the computer. Her hair creates knew new knowledge through the listening body.[206]

Listening Through the Vagina

"Vaginistas! Come Join Our Vagina Listening Sessions!" exclaimed Miya Masaoka in her article The Vagina Is the Third Ear."[207] Masaoka formed a vaginal listening session that invited folks to hear the vagina and speculate what it is thinking, hearing, and intuitively experiencing. "The vagina looks like an ear"[208] stated Masaoka, "[t]he concentrated nerve endings in the vagina indicate it is an organ that has functionality beyond human reproduction

[203] Kite, Susan. "Hél Čhaŋkú Kiŋ Ȟpáye (There Lies the Road): How to Make Art in a Good Way." Dissertation, Concordia University, 2023. http://kitekitekitekite.com/dissertation. 6.
[204] *KaleidoLA: Suzanne Kite and Selwa Sweidan Artist Lecture*. *YouTube*. YouTube, 2021. https://www.youtube.com/watch?v=Y__xNtUdE6E.
[205] Ibid.
[206] https://www.youtube.com/watch?v=yaSTHSLAkag
[207] Masaoka, Miya. "The Vagina Is the Third Ear." *TDR: The Drama Review (MIT Press)* 64, no. 1 (Spring 2020): 2–7. https://doi.org/10.1162/dram_a_00909. 2.
[208] Ibid. 2.

and sexual activity."[209] Technology, has a history of resisting objecthood and being understood as a product that is typically built for functionality, efficiency, or advancement. She signaled the multiplicity of the vagina in her statement, that it isn't only a means for reproduction and/or sextual pleasure, but an extended and intuitive listening technology.

What does it mean to respond through hapicity? María Puig De La Bellacasa proposed a 'touching vision' that for decentering the "abstract and disengaged distances more easily focused with knowledge-as-vision."[210] She posits a 'turn to touch' and/or 'touching vision' as a method to keep a haptic coordinates within speculative commitment, engagement, and thought.[211] As described by de la Bellacasa, "haptic engagement conveys an encouragement for knowledge and action to be crafted *in touch* with everyday living and practice, in the proximity of involvement with ordinary material transformation."[212]

In Masaoka's work, she used a 'hearing vision' that affords a haptic engagement with the vagina as a listening device. For *seeing* or *listening* through the vagina as a hearing device. The readings from the vaginal listening devices are "only as part and parcel of their own apparatus."[213] Lines, beeps, and data are thought and explored through sound, an embodied scientific method that centers haptic engagements with hearing, vision, and touch.

Vaginated Chairs (2016),[214] is comprised of three components. To which Masaoka listed:

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[209] Ibid.
[210] De la Bellacasa, María Puig."Touching Visions." In *Matters of Care: Speculative Ethics in More than Human Worlds*, 95-122. Minneapolis; London: University of Minnesota Press, 2017. http://www.jstor.org/stable/10.5749/j.ctt1mmfspt.6. 112.
[211] Ibid.
[212] ibid. 98.
[213] Kazimierczak, Karolina Agata. "Medical Imaging and the 'Borderline Gaze of Touch and Hearing': The Politics of Knowledge beyond 'Sense Atomism' ." *Catalyst: Feminism, Theory, Technoscience*, Special Section on The Processes of Imaging/ The Imaging of Processes , 4, no. 2 (October 16, 2018). https://doi.org/doi.org/10.28968/cftt.v4i2.29907, 21.
[214] https://www.youtube.com/watch?v=XM1VOy2CBC8

1. “Vaginal inserts (Figure 31) with piezoelectric pickup mics that recorded the sounds of the vagina and sent the audio out over loudspeakers to the audience.”

2. “Sonically treated metal chairs: each was outfitted with two transducers and an individual amplifier for tuning. This turned each chair into a kind of loudspeaker. A computer program of my composition was sent to the chairs, and each had a different mathematically related sound frequency.”

3. “My theory that the “Vagina Is the Third Ear,” which I discussed with the performers and the audience — sometimes informally and sometimes in a preperformance talk.”[215]

To invite the audience to join, Masaoka treated 18 chairs, many more than there were performers. Everyone sat in a group looking at each other and experiencing the moment together. The chair, vagina, sensor intra-action produced a complex and timbre thick sonic field that rung through space.

Figure 31: Vaginal inserts with piezo pickup mics. Masaoka’s ‘vaginal inserts’ look like the Perineometer, a device invented by Arnold Kegel to assist his patience in controlling urinary leakage.[216] Vaginated Chairs, Miya Masaoka. (Photo by Miya Masaoka). Photo found in “The Vagina Is the Third Ear.” *TDR: The Drama Review (MIT Press)* 64, no. 1 (Spring 2020).

[215] Masaoka, Miya. “The Vagina Is the Third Ear.” *TDR: The Drama Review (MIT Press)* 64, no. 1 (Spring 2020): 2–7. https://doi.org/10.1162/dram_a_00909. 2.
[216] https://www.aapb.org/i4a/pages/index.cfm?pageID=3383

Her centering of the vagina as a listening device is a feminist intervention. As mentioned in Chapter 2, the vagina has often been seen as cite for male pleasure or reproduction. Masaoka's *Vaginated Chairs* has given me avenues for future research. I will continue to explore other ways in which we listen. I am also interested on building off of her project to work on a piece for vaginal listening.

Chapter 4 ARTICULATIONS THROUGH PRACTICE

For the past eight years, I have been cultivating a bioartstic[217] practice at the intersection of my foundation as a performer and technologist. My bioartistic practice is an intersection between construction, design, theoretical exploration, and performance involving wearable electronics capable of capturing and translating biological data into immersive sonic and visual environments. This biofeedback system affords me a way to listen to a broader spectrum of embodied states in real-time and feel a connection with my body as the sounding output for electronic music. This is a system for autonomous, empowered, embodied collaboration and the extension of one's instrument, not a means for achievement, domination, or control.

To explore this interdisciplinary terrain, I have built a wearable apparatus that integrates my diverse experience and research in audio engineering, building and designing software and hardware for performers, performing and improvising, and feminist musicological research. With fabrics, elastics, clasps, LEDs, sensors, and my inner electricity, I constructed a wearable electronic that measures the discrete electric and resistive properties of three of my organs: heart, lungs, and skin. This wearable electronic translates readings of my organs into data streams that can be fed into audio and visual software.

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Before you go on, I invite you to listen to "Subaqeous" Smith_subaqueous_ biosensing and projections.mp4 in the suplemental section. Subaqueous (2019. Revised 2023) is defined as existing, formed, or taking place underwater. This piece is a multimedia exploration of the literal definition of the word - water is abstracted into patterns, textures, and unnatural time and the

[217] Zorn, John, and Alexandria Smith. "Voices in the Skin." Essay. In *Arcana X: Musicians on Music*, 271–81. Hips Road, 2021.

deeply personal, musical expression of embodying music and being present in a space. This piece was one of my first experiments making musical environments that could help me channel affect and explore ideas that often felt too vulnerable for me to express in front of an audience. Originally written for processed flugelhorn, projections, and 4 channel audio, this revision was performed with my wearable electronics (no trumpet).

Figure 32: Photo of a performance with my wearable electronic at MoxSonic in 2019. Photo taken by Jeff Kaiser.

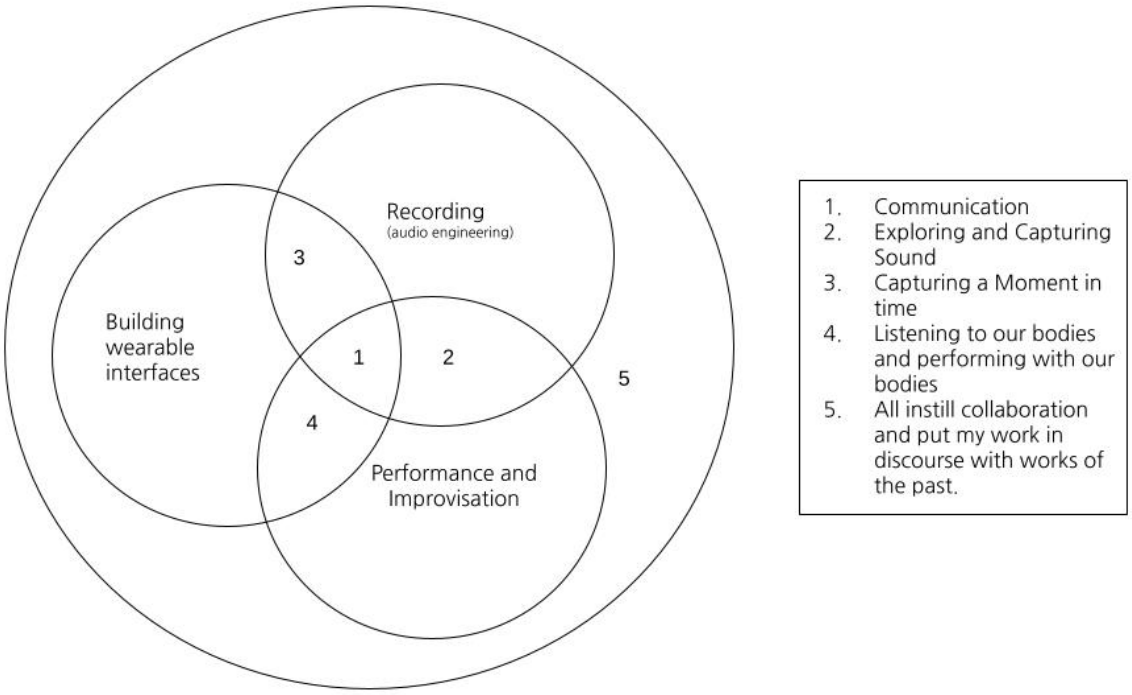

Figure 33: A diagram of how my interdisciplinary work speaks to each other.

As shown in figure 33, I see all the disciplines I work in relating to each other with the central node as communication. Recording and improvising are modes of communication and ways to explore capturing sounds. Building wearable interfaces and improvising communicates data. Whether it be things one has practiced or picked up on during performance, systems that informs one's work, sensor data, the story behind the design or performance, stakeholders involved in both the design process and performance process, etc. Recording and building wearable interfaces both capture a moment in time and afford the ability for something to go from a physical translation to an electronic translation.

Expression, Exploration, and Translation

Listening through techno-mediated practices is a complex system that sits between body expression, exploration, translation, and textures. Texxture as defined by Sedgwick is "the kind of texture that is dense with offered information about how, substantively, historically,

materially, it came into being." Texxture evokes the potential for a cross-modal mapping of embodied states, musical nuances, and methods of listening that afford a temporal and haptic method of listening and experiencing sound:

> "Texxtures are artifacts that are crucial to the creation of the textural object, i.e., the music. However, these are often left unheard by the audience or the performer unless they make a conscious decision to have those sounds be a part of their sonic vocabulary. Texxture evokes the layers between the biological process of making and conceptualizing sound into analog and digital information. It becomes verbal as it brings the present, past, and future all to the same place at the same time."[218]

As a female-identifying trumpet player and technologist, inviting an audience to listen to my body as its sounding mechanism and not connect the sonic output to a visual representation of movement is a radical act. Listening becomes an act of empathy that extends beyond the potential of the visual spectacle of a woman on stage performing electronic music and the expectation of the virtuosic music I have been trained to play (i.e., control my body in ways that amplify a desired goal). While this 'outer physical dialog' has been important for developing a consistent approach to playing an instrument and unlocking ways to express myself musically, this method of 'biofeedback' has also led me to emotional dissociation with music and a focus on product over process.

Design Process

My second skin is a fluid interface built to be changed; added or subtracted over time. It will change as I continue to perform with the wearable in different performance situations. These

[218] Sedgwick, Eve Kosofsky, and Adam Frank. 2003. Touching feeling: affect, pedagogy, performativity. Durham: Duke University Press. 14

modifications are avenues for the future of this research and beyond the scope of this dissertation; however, I will continue to ask myself the following questions:

1. Which methods of sensing enable a user to listen beyond states that they are consciously aware of during performance? Is it needed?
2. What considerations enable me to use them for liberation, listening interconnectedly, and self-observation, not a means for control?
3. What are the implications of building this interface: how does it impact the environment, the folks that wear it, the audience members, and other non-human stakeholders?
4. What and who's work am I in conversation with? What makes up my epistemological and ontological web?
5. How can I keep the device affordable enough to build different variations for other artists who want to experiment with adding different sensing methods to their work, and document my work that is easy for performers and DIY electronics builders to understand?
6. What ways can I depart from the 'usual' control/DAW relationship, i.e., let the sensors have their own way of connecting with sound instead of treating them like buttons, potentiometers, faders, etc.?

These questions form a series of protocols that I will use that address my ethical and epistemological concerns when introducing new technology or building upon older technologies. Articulating these protocols is an avenue for future research.

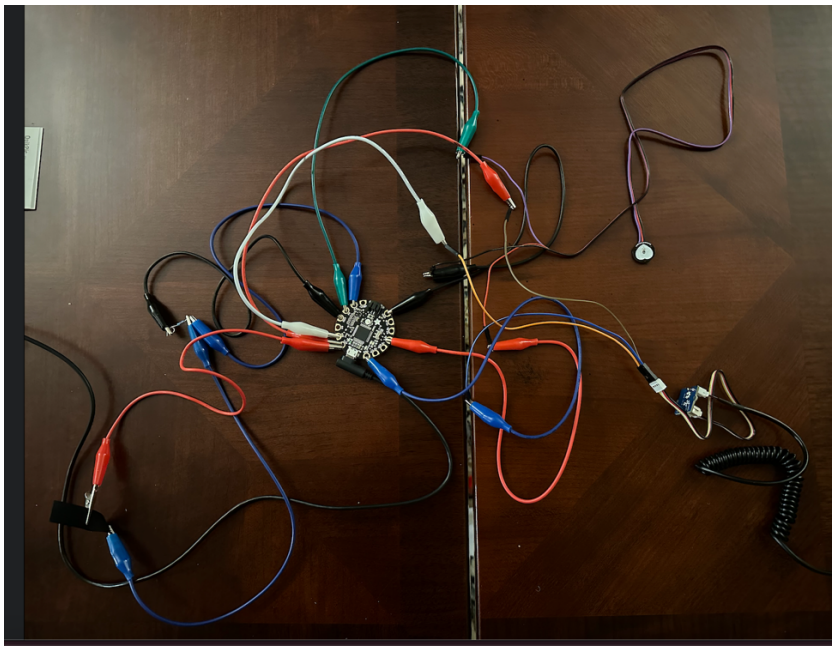

Figure 34: Photo of the circuit prototype.

Sensors

There are currently three sensors located on the wearable which measure the following: respiration, pulse, and galvanic skin response. It is possible to add other methods of sensing; however, I am finding these three to be the most immediate interlocutors between my biological data and the sonic activities beneath the threshold of what I can consciously process in real-time during a performance. Figure 35 is the wearable that I wore while performing all the artistic examples that have been presented in the dissertation.[219] Figure 36 shows the embed electronics in the wearable.

[219] There are other iterations of the wearable that I have made and are continuing to make. These variations are beyond the scope of this dissertation; however, I will be writing about them in future research.

Figure 35: My wearable second skin. It features a reptilian-like scale structure made of CDs, galvanic skin response sensing, respiration sensing, and heart rate sensing. Front view.

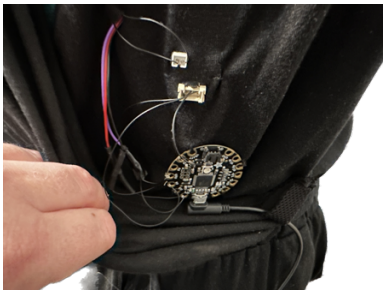

Figure 36: The microcontroller, Adafruit Flora, is embedded. The circuit is built using wire wrapping wire.

Figure 37: Prototype Design; back view. Respiration, galvanic skin response, and heart rate.

Figure 38: Prototype Design; front view.

I have two designs for respiration sensing, one using a conductive rubber sheet[220] that is cut to ~1/4inx1.5-2 inch and reinforced by an elastic band (Figure 39) that is cut to ~1/4 inch x 1 inches[221] (sewn on using a zigzag stitch)[222], and another using a conductive rubber cord stretch sensor. For both designs, I cut a low stretch, nylon strap material that is ¼ inch length-wise that I

[220] https://www.adafruit.com/product/5464
[221] Measurements are approximate. At times, there will be a centimeter or two more or less length depending on whether it feels more secure to use slightly more material.
[222] Zigzag stitches are optimal for stretch fabrics or sensors that are meant to stretch because the stich is less rigid.

took from old messenger bags and backpacks that were long enough to have substantial give for placing the respiration band on areas that measure intercoastal muscle movement, stomach movement, or wherever the performer feels like they are going to get the most useful measurement without being disturbed by the placement of the band. I also considered the need to adjust for body fluctuations that happen during menstrual cycles, times of stress (weight loss/weight gain), or dietary changes. Both designs also have a 5/8th inch parachute (side release) buckle that have slots for adjusting the tightness of the band. The design that utilizes the conductive rubber sheet/elastic strip is reinforced to the nylon strap with a zigzag stitch, the design that utilizes the rubber cord stretch sensor is tied into two holes that I place into the nylon strap with a leather working tool. [223] [224]

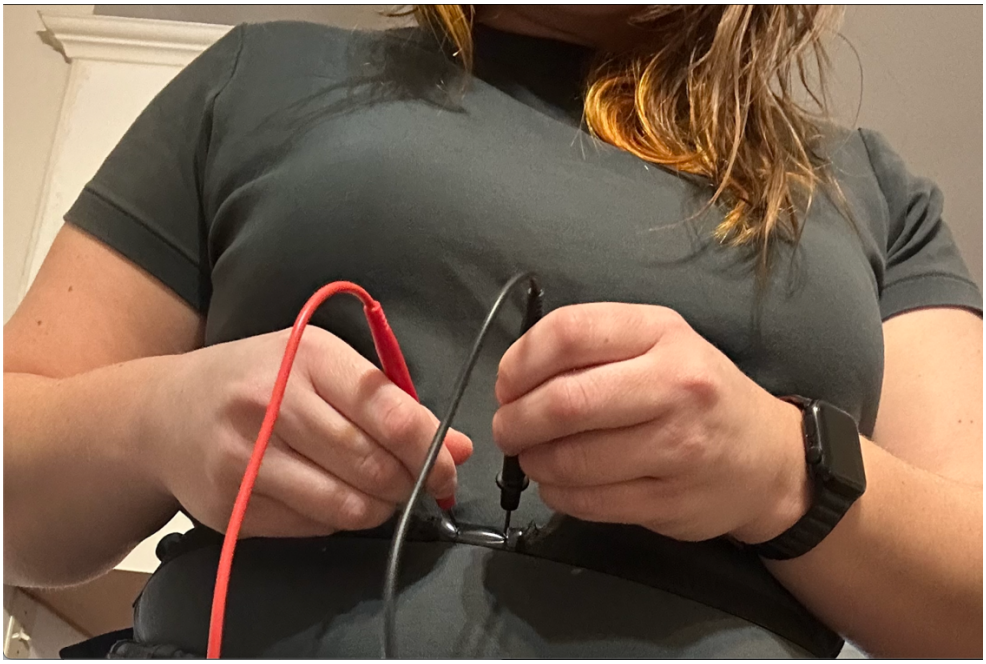

Figure 39: Testing conductive rubber sheet respiration sensor.

[223] Makes a hole with cleaner edges than scissors.
[224] I the future, I will implement a harness design that will use recycled leather instead of recycled nylon straps. I try to use as much recycled materials as possible in my designs.

Heart rate is measured with a pulse sensor.[225] The pulse sensor is weaved under the wearable. I typically attach it to my chest or my ear.[226]It measures inter-beat intervals (IBI), which often result in jagged, rhythmic translations of these voltages. Galvanic skin response is measured with a Grove GSR (Galvanic Skin response) Sensor.[227] An avenue for my future research is building my own heart rate and GSR sensors that fit the tactility of my wearables better

Sensor data is captured by a FLORA[228] microcontroller and connected to the computer with a USB cable.[229] I connect wire wrapping wire. As stated in Figure 36, I used wire wrapping wire instead of conductive thread for three reasons. The first being that it is an acknowledgement of the militarized history of biofeedback. Wire wrapping wire has been used to make connections in rockets, computers, war vehicles, weapons, and more. Second, wire wrapping wire is extremely flexible and easy to troubleshoot. I do not have to sew anything or solder anything. I can use a wire wrapping tool to cut and attach wire wrapping wire to components or wrap the connection by hand. Third because conductive thread is easily tarnished and has no insulator. When placing a wearable electronic close to the skin, insulation is important for preventing short circuits. Insulated wire enables me to have more flexibility with sensor placement by leaving room for wires/sensors to move during performance without risking a short. Wire wrapping wire also connects to resistors and sensors with ease when using a wire wrapping tool, thus reducing the need for soldering, and making a more secure connection than conductive thread (Figure 36).

[225] https://pulsesensor.com/products/pulse-sensor-amped
[226] The heart rate sensor was attached to my ear on all the videos from the nF concert.
[227] https://wiki.seeedstudio.com/Grove-GSR_Sensor/
[228] https://www.adafruit.com/product/659. Sewable, Arduino-compatible microcontroller designed by Adafruit for wearable projects.
[229] It is not wireless because I want to feel the connection with the computer and I am concerned about latency if I use Bluetooth. If I go wireless, it will have to connect via a network. This is an avenue for future research.

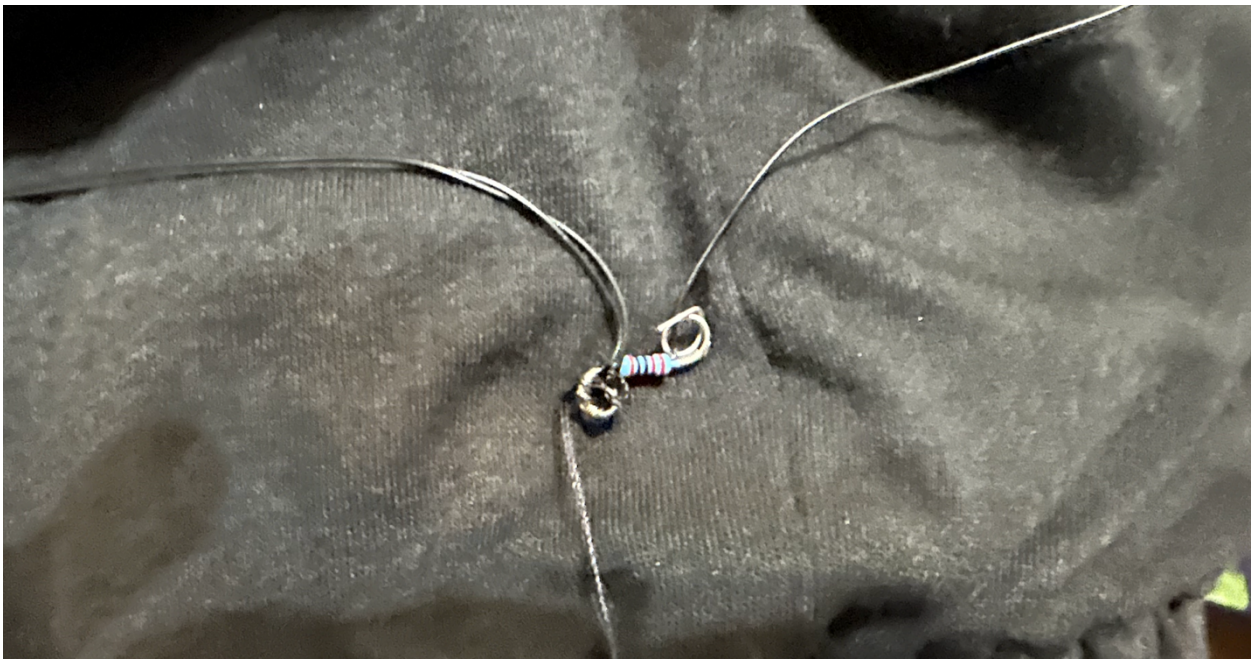

Figure 40: Wire Wrapping Wire weaved around the resistor that I connect to the respiration sensor.

Sound Design Considerations

Performing with biological signals affords a departure from the more common control methods that Digital Audio Workstations have been designed for, e.g., addressable pads, keyboards, faders, potentiometers, etc. Unlike the on/off, 1/0, effect of buttons, biosignals deliver a constant signal. Each method of sensing has its own character. It is crucial to embrace the irregularity of them. I use a silent brass mute on my trumpet to feel and hear my biological readings interact with my trumpet signal. The silent brass mute is a practice mute that drops the amplitude of my trumpet playing substantially, thus hearing very little ‘open’ or ‘live’ trumpet sound.

1. Heart Rate.[230]

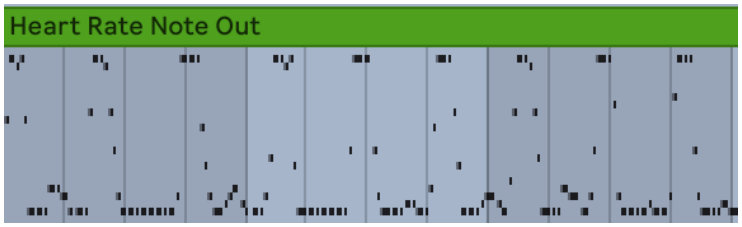

Figure 41: My Heart Rate Data Represented in MIDI.

2. Galvanic Skin Response[231]

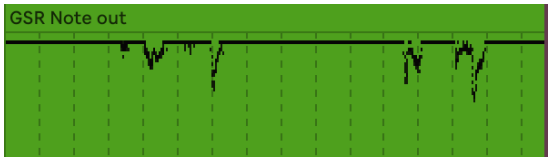

Figure 42: My Galvanic Skin Response Reading Data Represented in MIDI.

3. Respiration[232]

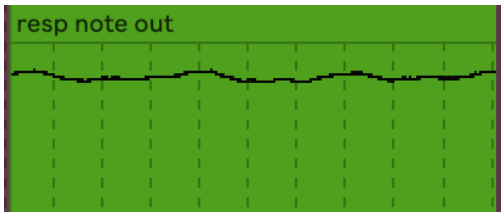

Figure 43: My Respiration Reading Data Represented in MIDI

I send data from the FLORA through the serial into the into the Max 8[233] programming environment (Max MSP). Each sensor has a discrete data stream that gets read in Max MSP; analog signals are mapped to MIDI. Respiration and Heart Rate both have smoothing algorithms

[230] Listen to heart rate here: https://drive.google.com/file/d/1npn4PMDZpfrLgYpelfeVzZwPGRA5juUt/view?usp=drive_link
[231] Listen to Galvanic Skin Response here: https://drive.google.com/file/d/1bgLEfTH80TJDBMr-oMVq34gv6EN5APkf/view?usp=sharing
[232] Listen to my piece, Exhale for Trumpet, Interactive Video, and Biofeedback Sensing. It only uses respiration sensing. https://www.youtube.com/watch?v=qTaGL6Hk8JM
[233] https://cycling74.com/products/max.

that can be applied if the data stream has jitter. In collaboration with Jeffrey Albert, we designed a sub patcher would re-scale sensor data if it went over or under the original threshold (Figure 44). If sensor data exceeds the threshold, the threshold will adjust to contain the adjusted parameters. When I presented my work at MoxSonic in 2023, Gregory Taylor from Cycling 74, suggested that I implement a leaky integrator. I plan on doing in my next iteration of the project. Once each data stream is scaled, it is sent to its own `ctlout` and `noteout` and map it to instrument or effects banks in Ableton Live 11 through Max's internal MIDI routing. Sensor data can be translated into both MIDI control messages and MIDI note messages.

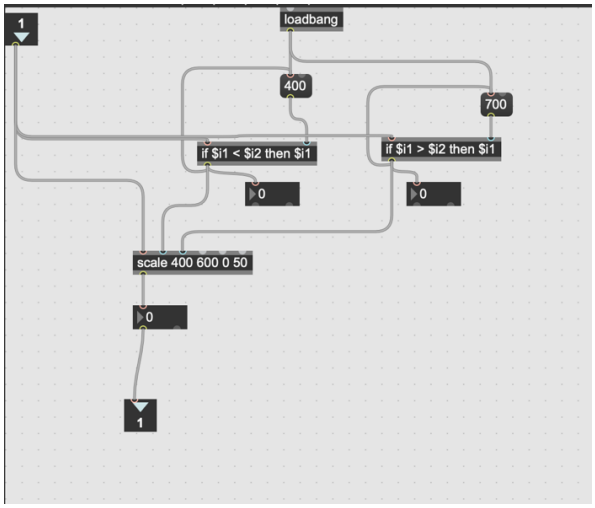

Figure 44: Sensor Re-Scale

I route the data into Ableton Live 11 because as an improviser, I need to be flexible and be able to adjust quickly and with ease.[234] It is also the most simple way for me to interact while performing live. Miller Puckette stated, "a mantra of software design is to hide complexity... Arguably, though, an even more powerful strategy for managing complexity is simply to avoid it altogether, that is, try to think of simple things a program could do instead of doing complicated

[234] As of now, coding live takes me out of the process of listening to my biosignals. Each sensor has its own instrument rack, audio effects, etc.

ones."[235] Simplicity is also crucial for enabling sensor data to speak as it needs to. In other words, the instrument needs to support the shape of the data and how quickly it changes. For example, galvanic skin response fluctuates quickly. If the "attack" setting on a midi instrument (or instrument that gets mapped to a sampler) is too slow, the data will not speak. Instrument racks (Figure 45) in Live give me the capability to map the data to custom samplers, MIDI instruments, drum racks, etc. I have also experimented with having a biological reading be a "carrier" for a vocoder and activate gates.[236]

Figure 45: Heart Rate Pad Instrument. I can shift keys, pitch, and sounds quickly with this setup.

[235] Puckette, Miller. "The Deadly Embrace Between Music Software and Its Users." In *Proceedings of the Electroacoustic Music Studies Network Conference Electroacoustic*. Berlin, 2014. www.ems-network.org. 5.

[236] This can be heard on my performance at in the Black Bayou at New Music on the Bayou 2023. https://youtu.be/8tqryJovles?t=1990

Conclusion

My bioartistic practice emerged from my creative process of building, designing, and performing with wearable electronics that measure and sonify biological data, and researching biofeedback methods. While researching biofeedback methods, I was inspired by Dr. Barbara B. Brown's method of working with biological signals and her feminist approach to biofeedback. This led me to question why the canonical figures mostly worked with masculinist celebrations of novelty and control.

Feminist Science and Technology theorists have proposed alternative epistemological frameworks and methods for challenging the 'all seeing vision' historically celebrated in techno-mediated practices; however, they centered the sense of vision over the sense of hearing. While researching intellectual genealogies relevant to my creative work with biofeedback, I identified Pauline Oliveros, Milford Graves, Kite, and Miya Masaoka. Through studying their creative work and methods, I was able to cultivate three modes of listening that have guided my work with biological signals: situated listening, embracing irregularity, and listening beyond the ear. These modes of listening have informed how I perform with biological signals and approach interface design.

Avenues for future research include but are not limited to: making sensors that feel more like clothing and that read biological signals accurately, collaborations with music therapists to find more holistic treatments, continuing to theorize and experiment with data sonification, and finding more figures that have been erased the discourse and sounding their work.

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