The Brain at Work: Cognitive Labor and the Posthuman Brain in Alvin Lucier's Music for Solo Performer

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ABSTRACT (ENGLISH)

This essay examines cognitive labor and the posthuman brain in composer Alvin Lucier's *Music for Solo Performer* (1965). Alongside a discussion of the historical relationships between cybernetics, posthumanism, and political economy, it contextualizes Lucier's neurofeedback experiments in light of the expansion of the military-industrial complex and the large-scale labor transformations of late capitalism. Read as staging the performer's "brain at work," *Music for Solo Performer* appears here as a response to post-Fordist economic models that prioritize cognitive over manual forms of labor.

FULL TEXT

Introduction

When asked about his compositional process, John Cage often explained that he could not hear music in his head (Retallack 86; Duckworth 27, 112). Cage, so the story goes, radicalized this supposed shortcoming by using chance and indeterminacy to remove his musical tastes from the artistic process. In a seemingly converse gesture, Alvin Lucier began in 1965 to use the literal contents of his head, specifically brainwaves, to perform experimental music. Following a conversation with Cage, Lucier premiered *Music for Solo Performer*, a work in which electrodes are attached to the scalp of a performer who sits motionless as electroencephalogram (EEG) signals are routed to percussion instruments distributed throughout the performance space. Upon producing alpha waves, a process referred to as a "skill" (Mumma 81) and even "work" (Lucier qtd. in Kahn, *Earth* 101), individual speakers activate the instruments, which pulsate at frequencies analogous to the performer's brainwaves.

Lucier's work can be viewed as an attempt to relocate the labor of musical performance to the site where Cage's interlocutors had expected to find his composing: the brain. In the score to *Music for Solo Performer*, Lucier asks the soloist to produce alpha waves by manipulating psychological states, typically obtained by closing one's eyes and refraining from visualizing—a task the composer says requires specific training and endurance (Kahn, *Earth* 99). "Working long hours alone in the Brandeis University Electronic Music Studio," Lucier recalls, "I learned to produce alpha fairly consistently," given "the right physical and psychological conditions" (Strange 59). Lucier describes his composition further as an effort to bypass the body altogether and, using only the performer's alpha waves, link the brain to musical instruments directly (". . . to let alpha" 50). The composer construes his soloist, then, less as an embodied actor than as a kind of cognitive performer. Musical performance, including *Music for Solo Performer*, doubtless requires coordination between both mind and body, just as factory labor demands an amount of intellectual engagement. But considered alongside the economic and technological changes of the era, Lucier's gesture resonates—consonantly, yet also critically—with historical shifts in the conception of labor that foreground cognitive over physical activity. These transformations, largely associated with the industrial shifts of post-Fordism, reconceive the worker as a kind of processor of information: a brain worker.

Music for Solo Performer emerges from Lucier's artistic engagement with neuroscience research and biofeedback techniques adopted from cybernetics, an interdisciplinary scientific field premised on technological paradigms of control and communication first articulated during the 1940s and 1950s. In addition to laying important groundwork

for Cold War military technoscience, cybernetics also assisted in many of the economic transformations associated with post-Fordism, including the shift to cognitive labor. More recently, cybernetics has been seen as the locus of a broader cultural movement based on the technological decentering of the human, later to become associated with the figure of the "posthuman." The kinds of biofeedback and neuroscience research Lucier used in *Music for Solo Performer* have been central to this discourse. Considered more broadly, Cagean indeterminacy can also be viewed as a shift from the centrality of human artistic expression to the nonhuman forces of chance, natural processes, or, more recently, artificial intelligence (see, for instance, Yasunao Tone's *AI Deviation* [2016]). Studies of Lucier and Cage have increasingly acknowledged the import of cybernetics; but equally pertinent to this conversation, I think, is the critical continuation of that discourse in posthumanism.

This essay examines experimental music of the 1960s, concentrating on Lucier's *Music for Solo Performer*, in order to respond to historical debates around cognitive labor and posthumanism. Contemporary realizations of *Music for Solo Performer* (e.g., Cyngler) almost invariably use brain-computer interfaces, tools considered central to the development of computational neuroscience and artificial intelligence. *Music for Solo Performer* was a collaboration between Lucier and Edmond M. Dewan, a physicist (and friend of cybernetics pioneer Norbert Wiener) who had also linked brainwave analysis to artificial intelligence. Through a reading of *Music for Solo Performer*, I will speculate on the artistic and economic possibilities of neuroscience research that seeks to create fully functional replications of the human brain. This process, known as "brain emulation," incorporates both artificial intelligence and computational neuroscience. Inaugurating what one could call without exaggeration a "neuromusical turn" beginning in the experimental music of the 1960s,[1] Lucier anticipates the rise of the kinds of neuroscience research central to brain emulation and recent theories of the "posthuman brain" (Stollfuß 82–90).

Lucier's *Music for Solo Performer*, a work indebted to Cagean notions of indeterminacy and experimentalism, emerged alongside the expansion of the military-industrial complex and the large-scale labor transformations of late capitalism. When read as staging the performer's "brain at work," *Music for Solo Performer* appears as a response to post-Fordist notions of "cognitive labor," wherein mental as opposed to manual work had become prioritized. Already in this literature one finds a discussion of automation (Ramtin 60–73), the consequences of which doubtless become exacerbated in scenarios of posthuman AI. I suggest then that indeterminacy might figure not only as a formal feature of experimental music, but also can be imagined here as a political response to capitalism's slope toward the posthuman. That is, through Lucier's reflexive use of cybernetics and his work with indeterminacy, experimental music becomes capable of a kind of inchoate critique of posthumanism and its requisite political economic conditions. Finally, I contrast indeterminacy with Catherine Malabou's notion of *automaticity* in concluding my discussion of cognitive labor, experimental music, and the posthuman brain. Throughout I want to keep in tension some of the important yet under-discussed historiographical and theoretical threads connecting experimental music and posthumanism[2] through their mutual intersections and inheritances from cybernetics along with their shared relevance to contemporary technoculture.

Experimenting the Human: Experimental Music and Posthumanism

Posthumanism represents a heterogeneous body of thought that responds to the decentering of the human in an era of rapid technological advance, environmental instability, and economic crisis.[3] Although posthumanism appeared initially in literary theory in the 1990s, most trace its origins to the formative discussions of the human–technology relationship found in the work of Wiener, Warren McCulloch, John von Neumann, and other cyberneticists during the 1940s and 1950s. Cybernetics was conceived as an amalgam of scientific disciplines based on mechanisms of regulation and systems of communication, emblematized by Wiener's 1948 publication *Cybernetics: Or Control and Communication in the Animal and the Machine*. Its genealogical relevance to posthumanism is difficult to overstate; cybernetics was, as literary theorist Bruce Clarke puts it, "the technoscientific forethought of the contemporary posthuman" (*Posthuman Metamorphosis* 4). In addition to its inception in cybernetics, posthumanism originates through miscegenation between technological, biopolitical, and philosophical discourses, from French anti-humanism to artificial intelligence to recent debates concerning the Anthropocene. Rather than standing for an unchallenged anthropological category, the posthuman marks a moment when the privileged "human" enters into

discourse—a discourse shaped as much by philosophy and science as by literature and art.

Experimental music is an artistic movement that began largely in postwar North American, British, and East Asian music circles (with roots heard already in the prewar avant-garde) and extends beyond concerns with technology to encompass a heterogeneous network of techniques, attitudes, and practices. Nevertheless, indeterminacy, open forms, and extended uses of music technology have been critical to the development of experimental music. Conversely, experimental music has played an important role in shaping the fields of biofeedback, artificial intelligence, and robotics—paradigms central to cybernetics and, later, to posthumanism. Experimental music, not unlike its postwar serial and postserial counterparts, has proceeded often through direct recourse to the methodologies of science and technology. Note the scientistic valence of John Cage's 1955 definition of experimental music: "not as descriptive of an act to be later judged in terms of success or failure," experimentalism stood for "an act the outcome of which is unknown" (*Silence* 13). Yet beyond the modernist project of subjecting sound parameters to the deterministic human control of serialism, experimentalism used *in*determinacy—beginning with chance and natural processes and later incorporating computer algorithms, biofeedback, and artificial intelligence—in ways that mirror posthumanism's challenge to the centrality of human agency.[4]

A clear tension can be located, then, between cybernetics as a *control* paradigm and experimentalism's programmatic withdrawal of authorial control that characterizes indeterminacy. Examples of the latter can be found in Cage's iconic 1951 silent composition *4′33″* and in the chance procedures Cage used to compose his piano work *Music of Changes* of the same year. If indeterminacy was amplified through engagements with technoscience, it was also complicated by its inheritances from cybernetics. Beginning in the experimental music of the 1950s, as computer algorithms, biofeedback, and robotics began to replace the composer's individual aesthetic decisions, the "human" component in the human–technology relationship endemic to music was challenged and, in some sense, deprivileged. James Tenney suggested, for instance, that while composing *Ergodos I (for John Cage)* (an algorithmic computer music work generated in 1964 at Bell Laboratories), his "last vestiges of external 'shaping' ha[d] disappeared" (38). No longer beholden to the sole will of the human, experimental music cedes compositional agency here to the algorithm. Lucier extends this dynamic to the domain of neurological biofeedback.

In addition to experimental music, cybernetic feedback made possible precisely the kinds of technological and economic shifts associated with post-Fordism, including the full-scale automation of machine control. Once machines could use sensors that adjust for output and auto-correct for errors in performance, the formerly irrevocable role of the human was lessened up to the point of obsolescence (Dyer-Witheford 45). Feedback thus imparted to machines qualities once thought of as unique to living labor, including adaptability, flexibility, and even learning (Dyer-Witheford 45; Ramtin 45). Like cybernetics more broadly, feedback foreshadows the figure of the contemporary posthuman. Such a dynamic, moreover, represents another level at which feedback itself actually feeds back: the reduction in labor time afforded by machine automation (and feedback) figures as the new ground upon which capital's own feedback loop begins another production cycle (Ramtin 68–9). Cyberneticists, furthermore, saw no fundamental difference between machines, organic life, and even the human brain: all could be placed within, or indeed could constitute, a feedback loop. Biofeedback inserts specifically biological life forms, including the human subject, into the cybernetic circuit, thus calling into question the boundaries of both entities—a contention imbricated programmatically throughout posthumanist discourse.

Posthuman Political Economies: From Biofeedback to the Posthuman Brain

Posthumanism thus responds not only to the kinds of cybernetic biofeedback found in *Music for Solo Performer*, but speaks to the crisis of the liberal humanist subject. "From Norbert Wiener on," N. Katherine Hayles writes in *How We Became Posthuman*, "the flow of information through feedback loops has been associated with the deconstruction of the liberal humanist subject" (2), the version of the human that occupies the remainder of her posthuman critique. Hayles's study periodizes cybernetics in three phases, calling the first, foundational stage, which includes Wiener and von Neumann's focus on feedback loops and information, *homeostasis* (1945–1960); the second, which includes Heinz von Foerster and Humberto Maturana's second-order cybernetics and autopoiesis, *reflexivity* (1960–1980); and the third, based on brain emulation and AI, *virtuality* (1980-present). Lucier's *Music for Solo*

Performer relates most directly to the first phase through its use of biofeedback, while it also speaks to the third phase in ways that resonate with contemporary technoculture debates. Hayles opens her study with a reference to this third cybernetic phase, describing the sense of terror and amusement she experienced upon reading MIT robotics expert Hans Moravec's 1988 prediction that it would soon be possible to "upload" human consciousness to a computer (Hayles 1).

There's no mind uploading in Lucier, but a similar fantasy is at play in *Music for Solo Performer*'s basic premise of "offloading" cognition through a novel cybernetic feedback loop. For Hayles, though, such a fantasy of disembodied cognition represents nothing genuinely new, and in fact parallels a key feature of liberal humanism. Namely, the Cartesian subject's identification with a rational mind that *possesses* a body (rather than *being* a body) was, paradoxically, both a product of and a condition for market liberalism in the first place. Liberal political theorists from John Locke to Thomas Hobbes to James Mill have similarly argued that the liberal subject is effectively constructed through a kind of internal split with the body. In the words of Locke: "every man has a property in his own person" (18). The posthuman can be seen, then, as an extension of the kind of possessive individualism (Macpherson) found at the heart of liberalism. Liberal capitalism and the posthuman, in this sense, both turn on a dematerialization of the body.[5]

Such a posthumanist critique of liberalism, when radicalized, requisitely becomes a critique of political economy (as Hayles's nod to Marxist political scientist C. B. Macpherson [3] might suggest).[6] Hayles and other posthumanists argue that the denial of bodily materiality has been key to preserving the liberal subject's supposed universality through an erasure of sexual, racial, and ethnic markers of difference.[7] This, along with the "dematerialized" character of digital media, is one sense in which Hayles argues that through the figure of the posthuman, "information has lost its body." Political economic theorists would corroborate such a contention, as in, for instance, Philip Mirowski's claim that the "economic agent" represented by neoclassical economics is ultimately nothing more than a "processor of information" (18). Already in cybernetics, as Mirowski notes, one finds the ambition to apply the same kinds of control and communications paradigms to financial exchange; Wiener acknowledged such an interest from the very beginnings of his engagements with cybernetics (18). Ardent anti-communist cyberneticist von Neumann, co-author (with Oskar Morgenstern) of *Theory of Games and Economic Behavior* (1944), is hailed in fact in Mirowski's account as the "single most important figure in the development of economics in the twentieth century" (99).

It would not be until 1961 that cybernetics would receive what theorists cite as its first Marxist analysis in the work of Italian *operaist* (workerist) Romano Alquati. Here, as in Hayles's account, *information* becomes primary:

> Information is the most important thing about labor-power: it is what the worker, by the means of constant capital, transmits to the means of production upon the basis of evaluations, measurements, elaborations in order to operate on the object of work all those modifications of its form that give it the requested use value.
> (qtd. in Pasquinelli 183)[8]

Information thus forms both the medium of transmission and the object upon which labor works, marking a qualitative alteration in the means of production. What characterizes this shift, and indeed necessitates the term "cognitive labor," is a change in work of a certain quality, not the fundamental, yet historically specific, status of the system in which it operates. That is, both physical and cognitive labor are subject to value generation as a function of time under capitalism. As Moishe Postone explains in his reinterpretation of Marx, *Time, Labor, and Social Domination*, "Value is a social form that expresses, and is based on, the expenditure of direct labor time" (25). Whether coding a computer application or working in a steel factory, labor as a category is united by the commodification of the worker's time. Cognitive labor, in particular, is nevertheless a useful analytical category for apprehending labor's shifting valences brought about through changes in industry and technology, here specifically through automation and cybernetics. It is through the advent of the latter that the worker, in Pasquinelli's analysis, is no longer a "thermodynamic animal steaming in front of a machine but is already a brain worker" (183). Hence the posthuman brain at work.

A critical distinction is to be made, still, between the posthumanist *critique* of market liberalism and its posthuman

amplification. Characteristic of this latter position (which is reflected across popular culture), for instance, is a desire to expand the category of the human to encompass "multiple forms of life and machines" (Nayar 2).[9] Indeed, not all posthumanists (or would-be posthumanists) begin with a radical critique of democratic capitalism (at least not from the left), but a recent sampling of technoculture across the political spectrum reveals a variety of implications about AI and the posthuman brain. Right-wing Deleuzian and self-proclaimed "neoreactionary" philosopher Nick Land, for instance, claims that the one premise guiding his work for the past twenty years has been "the teleological identity of capitalism and artificial intelligence" ("Teleological Identity").[10] Roughly twenty years prior, Land conjectured: "what appears to humanity as the history of capitalism is an invasion from the future by an artificial intelligent space that must assemble itself entirely from its enemy's resources" ("Machinic Desire" 479). This appears to be a strong claim, even from someone who thinks it's a good thing. Yet considering the billions of dollars invested annually in artificial intelligence, institutions like Oxford's Future of Humanity Institute (FHI) and the recently established Cambridge Centre for the Study of Existential Risk (CSER) could be justified in corroborating warnings from popular figures like Stephen Hawking that the development of full artificial general intelligence could be disastrous for humanity (Cellan-Jones).[11]

Many right-leaning thinkers, including Moravec, have actively participated in such endeavors.[12] Take libertarian economist Robin Hanson's recent Moravecian prediction:

[S]ometime in roughly the next century it will be possible to scan a human brain at a fine enough spatial and chemical resolution, and to combine that scan with good enough models of how individual brain cells achieve their signal-processing functions, to create a cell-by-cell dynamically-executable model of the full brain in artificial hardware, a model whose signal input-output behavior is usefully close to that of the original brain. (*Age* 47)[13]

It will be purportedly through such a process that we will create the first operational artificial minds, what Hanson calls ems. "A *good enough* em has roughly the same input-output signal behavior as the original human." Hanson, an investor in such technologies (and cryogenics), explains: "One might talk with it, and convince it to do useful jobs" ("What" 298, emphasis added). Another reason Hanson gives for the looming ascendancy of brain emulation technology is the ability to cheaply copy and run any number of emulations—potentially trillions—limited only by hardware costs. This promises a virtually infinitely reproducible source of labor power ultimately irresistible for investors. Wages for ems, then, become Malthusian (which turns out to be more efficient than enslaving them), reduced to an amount just above subsistence levels (the cost to run their hardware), while (non-investor) humans ultimately die off.

Much of the work is already underway to realize similar visions of the posthuman brain. The European Union's Blue Brain Project and the Human Brain Project, along with the American BRAIN Initiative beginning under Barack Obama, collectively command billions in their efforts to map and emulate the human brain (Underwood; Chu). Research conducted by the Human Brain Project and the BRAIN Initiative promises important benefits to brain disorder treatments, along with a better understanding of neurological diseases and brain injury trauma. But work remains to be done to achieve complete brain emulations: computers must become considerably faster, microscopy scanning techniques must improve, and functional models of the brain must become more robust. The BRAIN Initiative and the Human Brain Project have only begun the modest goal of mapping the brains of mice and rats. Moravec's "mind children" have yet to even crawl.

Such an approach to engineering virtual life forms nevertheless represents a key goal of computational neuroscience, a relatively new field based on the intersection between cybernetics, informatics, and neuroscience. This emergent discipline draws significantly upon the kinds of neurofeedback technologies used in *Music for Solo Performer*, but represents neuroscience's radical shift "from a life science approach (biology and medicine) to a computer science approach in order to perpetuate a techno-rationality that concentrates on engineering [rather than] representing nature" (Stollfuß 81). The object of computational neuroscience is, as already with neurofeedback, the posthuman brain.

The posthuman brain emerges as the result of a process beginning with the biofeedback loops of first-phase

cybernetics, which find artistic expression in experimental music works like Lucier's *Music for Solo Performer*, and culminates seemingly in one of various eschatological scenarios of posthuman AI. More recent experimental music works like Tone's *AI Deviation* (2016) make direct use of artificial intelligence. But Lucier's *Music for Solo Performer* was one of the first compositions based on neurofeedback, and concerns pertinent issues related to cognitive labor. Additionally, through its use of experimentalism and indeterminacy, Lucier's work posits, as I discuss in conclusion, a response to the kind of "automaticity" that undergirds scenarios of posthuman AI. Automaticity, wholly distinct from but not unrelated to the problem of technological determinism,[14] is a term Michel Foucault borrows from psychology to describe an individual's conditioned responses to stimuli (Fedler 78); Malabou extends the concept in her political and philosophical critique of posthuman AI ("Metamorphoses").

Music for Solo Performer, through its reflexive adoption of cybernetics and use of indeterminacy, figures as an incipient, even preemptive, response to the crisis of the posthuman. Thinkers like Hayles have criticized the fantasy at play in both biofeedback and brain emulation, and clearly the topic involves myriad philosophical questions about consciousness, identity, and the self (see Blackford and Broderick). Contemporary technoculture has suggested that runaway posthuman processes might emerge through capitalist economic interests alone, irrespective of questions of embodiment, the uniqueness of the biological human, and so on. Furthermore, Moravecian predictions like Hanson's point to capitalism's properly speculative and "experimental" nature: capitalism simultaneously *forecasts a future*—dynamically yet with a kind of infallible automatism—and *experiments*, relentlessly trying out programs, up to and including various "sci-fi scenarios,"[15] to achieve such results. This structure, I want to suggest, finds an unlikely correlate in experimental music: in the words of Cage, "It doesn't matter if it doesn't work" (qtd. in Straebel and Thoben 17). (Only perhaps that it is good enough.)

Music for Solo Performer *and Cognitive Labor*

Those were Cage's words to Lucier on the eve of the latter's 1965 premiere of *Music for Solo Performer for enormously amplified brain waves and percussion*.[16] The score for *Music for Solo Performer*[17] calls for EEG electrodes to be placed on the performer's scalp to activate a battery of percussion instruments arranged throughout the performance space. Lucier's work attempts to transduce a performer's alpha waves, the relatively faint pulsations of electrical activity of the brain historically associated with states of cognitive idleness, into electrical signals that are subsequently amplified. These pulsations, which oscillate (as Lucier's score notes) between 8 and 12 Hertz, or cycles per second, are well below the range of human hearing. Yet when amplified "enormously" these vibrations can readily be perceived as rhythms.

Exploring this feature of alpha waves, Lucier's score calls for the brainwaves to be routed to an array of speakers which are themselves affixed to various percussion instruments: "large gongs, cymbals, tympani, metal ashcans, cardboard boxes, bass and snare drums (small loudspeakers face down on them)," along with switches that trigger a set of pre-arranged, sped-up brainwave recordings. When the soloist produces alpha waves, which can be achieved by closing one's eyes and refraining from visualizing, the speakers sympathetically resonate the various instruments to which they are attached at a frequency analogous to the amplified brainwaves. The soloist, now embedded in a kind of feedback loop, is exposed to the resulting percussion sounds, which may end up halting alpha wave production. Lucier's performer is thus interpellated into a biofeedback loop constructed through a network of neuroscientific cybernetics.

Music for Solo Performer anticipates the rise of computational neuroscience through Lucier's artistic appropriation of cybernetics and neuroscience technologies. Lucier's work inaugurated what I've suggested calling a neuromusical turn beginning in the experimental music of the 1960s. As noted, John Cage, James Tenney, Manford L. Eaton, David Rosenboom, Petr Kotik, and Nam June Paik had all worked with brainwaves in their respective musical practices. Importantly, such a musical incorporation of neuroscience began in parallel with the expansion of the military-industrial complex and on the cusp of late capitalism's post-Fordist labor transformations. As Douglas Kahn explains, "it becomes impossible to talk about American experimentalism in any comprehensive way distinct from the knowledge and technologies flowing from the militarized science of the Cold War, more specifically, cybernetics" (*Earth* 86). Experimental music not only appropriates the rhetoric of scientific experimentation but here also

reflexively incorporates the tools and working methods of Cold War technoscience.

Yet beyond an analysis of Lucier's work as an instance of "sonification," or an exploration of electromagnetic waves, I want to read *Music for Solo Performer* as an attempt to index cognitive labor through a cybernetic network of neuromusical technics. Although Lucier's work seems to require only a soloist sitting still for an extended duration with electrodes attached to her/his head, the work's score asks the performer to produce alpha waves by manipulating specific mental and psychological states, a job that demands, as noted, special preparation and training. "This is a specially developed skill which the soloist learns with practice," Gordon Mumma contends, "and, no matter how experienced the soloist has become, various conditions of performance intrude upon that skill" ("Alvin" 81).

During the premiere of *Music for Solo Performer* on May 5, 1965 at Brandeis University's Rose Art Museum, Lucier remained virtually motionless for nearly forty minutes while attempting to periodically drift in and out of alpha states by exercising the composer's newly acquired cognitive "skill." Following Cage's opening performance of *0′00″ (4′33″ No. 2)* (1962), which consisted of the composer performing an amplified "disciplined action" (in this instance, he typed out correspondence letters using an onstage typewriter), Lucier sat down as electrodes were affixed to his head. At first nothing happened. But then, as he closed his eyes and settled into place, the various percussion instruments and objects distributed around the room began to rumble. After a while the sounds stopped, and this process continued throughout the performance. Overall, the event seemed to test not only Lucier's but the audience's endurance as well (so much so that one of his Brandeis colleagues reacted by giving another faculty member, who had been pretending to sleep, a "hotfoot," an adolescent practical joke in which a match is inserted into one's shoe and lit [Kahn, *Earth* 90]). In order to produce alpha waves consistently, Lucier worked to avoid such distractions while remaining unperturbed by the recurring percussion sounds. Video documentation of a performance staged roughly a decade later, for instance, shows Lucier on multiple occasions raising his right arm to cover both eyes with his thumb and middle finger to induce concentration (Ashley).

Musical performance becomes a cognitive activity that resembles a form of labor. While it can be argued that in Lucier's work the "performer performs by not performing" (Kahn, *Earth* 101), in such a view performance figures as a primarily somatic process.[18] *Music for Solo Performer*, seemingly in response to discourses that mark capitalism's shift to cognitive labor, displaces the site of artistic labor from the body more generally to the brain in particular. As though realizing the fantasy of a technological interface between mind and music, *Music for Solo Performer* attempts to link "the brain to the instruments, bypassing the body entirely" (Lucier, ". . . to let alpha" 50). (Lucier went even further in his 1966 "dream" to link the brain of the performer with audience members in order to exchange thoughts and aural sensations directly.)[19] In Lucier's composition, the soloist becomes what Fernando Vidal has critically identified as the "cerebral subject" of neuroscience, the realization of an equality between the modern "self" and the brain—designated by the phrase "You are your brain"—that began in the mid-twentieth century and strengthened with the introduction of fMRI scanning in the 1990s (Vidal 6, 22).[20]

Cognitive labor discourse was, to be sure, still in its infancy when Lucier premiered *Music for Solo Performer* in 1965. The conceptual groundwork for cognitive labor can be traced to the Italian Marxist feminist movement of the late 1970s and 1980s, which also developed the related concepts of "immaterial labor" and "affective labor" through the work of Leopoldina Fortunati and Silvia Federici. Similar engagements have arisen from those associated with the Italian autonomia movement (Antonio Negri, Mario Tronti, Paolo Virno, Maurizio Lazzarato, and Christian Marazzi); more recently, this discourse has expanded into areas such as digital labor studies and what Jodi Dean has called "communicative capital" (19–48).[21] As early as 1961 Alquati, as noted above, published his unique study of the Italian Olivetti Factory, which Pasquinelli considers both the first Marxist study of cybernetics and a founding inquiry into the notion of cognitive labor. Within this paradigm, Alquati argues, "Productive labor is defined by the quality of information elaborated and transmitted by the worker" (qtd. in Pasquinelli 183, emphasis removed). As such, these theories of cognitive labor mark capitalism's shift from the energy-producing body to the information-producing brain. As Pasquinelli notes, "At the beginning of the industrial age, capitalism was exploiting human bodies for their mechanical energy, but soon it became clear that the most important value was coming from the

series of creative acts, measurements, and decisions that workers constantly have to make" (183). Along these lines, the soloist in *Music for Solo Performer*, when restricted solely to the task of producing alpha waves, is *not* being asked to make these kinds of creative decisions. The focus there is rather on achieving and manipulating specific mental states.

But here it is important to consider the formal differences, especially as related to musical divisions of labor, between Lucier's indeterminate score and the hyper-specificity associated with serial and postserialist modernism. "The score specifies a task to be accomplished, not a composer's idea of a fixed object," Lucier explains ("Notes" 254). Typical of Lucier's compositions of this period, the composer leaves a variety of musical parameters open to the creative discretion of the performer. This includes, as we've seen, the number and types of percussion instruments. The score also invites the soloist "to activate radios, television sets, lights, alarms, and other audio-visual devices," and suggests that the performer "experiment with electrodes on other parts of the head" in order to pick up alternate frequencies that may produce stereo effects. Finally, Lucier's score allows the performance to be of any duration. Such a delegation of the "creative acts, measurements, and decisions" to the performer/worker (as is the case with other experimental music scores of this era),[22] accords with the post-Fordist *redefinition of the worker*, which required workers to be more than "obedient hands" and to actively participate in production (Dyer-Witheford 45; Antunes 39).

Lucier has discussed labor, often in seemingly anthropomorphic terms, in connection with *Music for Solo Performer*. As the composer explains, "Most of the time my sounds do some kind of work" (qtd. in Kahn, *Earth* 101). At times Lucier seems to acknowledge less the artist's labor than the equipment involved, relegating the human component to the work's cybernetic and technological processes. Referring to the ways the speakers physically activate the percussion instruments, for example, Lucier suggests, "The speaker is a performer. . . . It's doing something. It's doing work" (qtd. in Kahn, *Earth* 99). Recall here the cybernetic tendency, though, especially in the context of biofeedback, to flatten operative distinctions between humans and machines. Musical automata have played a critical role in music technology and artificial intelligence dating back to the Enlightenment.[23] Lucier's comment suggests that the speaker forms a kind of prosthesis, ultimately rendering the soloist as a kind of musical cyborg. Such a conception of musical labor, moreover, appears entirely in line with the cybernetic transformations of post-Fordism. "The first step was redefining the worker as part of a feedback loop," Dyer-Witheford contends, "a sensor component in a goal-oriented process which was adjusted until the biological and machine components of the total system were in balance. The machine is not over and against the worker—because the worker is part of the machine" (51). Lucier's soloist is subject to this machinic structure of cognitive capitalism.

Music for Solo Performer contributes to discussions of the movement from industrial to cognitive labor, which occurred alongside art's concomitant shift toward conceptual and "dematerialized" practices (Lippard 5).[24] Along these lines, *Music for Solo Performer* marks a related movement from the sensorial and aesthetic to the cognitive and conceptual, domains more typically seen as relevant to postwar visual art. *Music for Solo Performer* predates foundational works of conceptual art (for instance, Sol LeWitt's 1969 *Sentences on Conceptual Art*) by several years, yet Volker Straebel and Wilm Thoben argue for a consideration of the work as a form of "conceptual music" (27; cf. Kahn, *Earth* 100–1). Although they focus on technological "sonification" practices, Straebel and Thoben consider Lucier's work as music "beyond the audible" that reveals "much more than sound" (27; see Barrett, *After Sound*). Corroborating such a claim, Lucier insists in his discussion of *Music for Solo Performer*: "it isn't a sound idea, it's a control or energy idea" (". . . to let alpha" 48)—a statement that notably recalls the conception of cybernetics as a control paradigm. Along with cognitive labor, Lucier's (post-sonic) neuromusic encapsulates experimentalism's unique encounter between cybernetics and indeterminacy.

Cybernetic Indeterminacy

Music for Solo Performer was Lucier's first work of experimental music and represents his foray into indeterminacy (Straebel and Thoben 19). Experimentalism borrows the iterative testing and verification procedures found in both capitalism and technoscience, while radically deracinating such procedures from their ordinarily correlated systems of value (and knowledge) production. Indeterminacy, practices that depart from the prescriptive form of the musical

score or introduce unpredictable musical variables in composition or performance, was foundational for Cage's conception of experimentalism, viewed as a set of processes whose outcome is unknown (*Silence* 13).[25] Indeterminacy does not refer to a particular musical or artistic style, nor does it necessarily exhibit perceivable qualities apart from, perhaps, a variable sense of unpredictability. Rather, the term describes an artistic process that produces events whose characteristics are not fully knowable in advance. Doubtless this notion of indeterminacy was influenced by work in cybernetics and information theory, such as, for instance, Claude Shannon's 1948 "A Mathematical Theory of Communication," which described the relationship between predictability and unpredictability in interpreting information encoded in signals that may also contain noise (Valiquet).[26] But some of the formative statements on indeterminacy also exhibit a desire to subvert desire itself, or, in Cage's parlance, to remove the "dictates of [the] ego" from the artistic process (35).

On this account, indeterminacy contains an intimate link to the libidinal, which is further bound in Lucier's work to the problem of cognitive labor. Indeterminacy can be seen as an attempt to undermine the goal-directed gratification associated with the creative process, emerging here from the context of music composition. Lucier's *Music for Solo Performer*, with its open-ended text score instructions, posits a musical unknowable in the form of the indeterminate outcome of the composer's neurofeedback network, imagined, in Cage's terms, as falling outside the rubric of "success or failure." It doesn't matter if it doesn't work. Indeterminacy might be further reimagined as a kind of inhibitor of one's conditioned responses to capitalist subjectivity as captured by the notion of automaticity. Cage, in fact, first turned to indeterminacy, in part, as an alternative to psychoanalysis and the ego fulfillment otherwise associated with composing music.[27] Indeterminacy appears, then, as a subtle kind of libidinal intervention, extended in Lucier's case to labor and the economic.

A fundamental tension inheres between experimentalism's program of indeterminacy and cybernetics as a *control* paradigm, and *Music for Solo Performer* critically straddles these two domains. The work is the result of a collaboration between Lucier and physicist and brainwave researcher Edmond M. Dewan, a close friend and colleague of cybernetics pioneer Wiener. Dewan worked for the US Air Force and was an adjunct professor at Brandeis University, where he had initially met Lucier, who taught in the music department. Interestingly, in the score to *Music for Solo Performer*, Lucier lists Dewan as "Technical Consultant," even though he introduced Dewan as the composer of the work following its 1965 premiere. Dewan was important enough to Lucier's development that Kahn devoted an entire chapter of his recent book to their relationship (*Earth* 93–105). Complementing Dewan and Lucier, Cage and Wiener rounded out this network of relations. *Music for Solo Performer* was, according to Kahn, "a manifestation of cybernetics within music, a meeting of Wiener and Cage, one step removed" (*Earth* 86).

Here I'd like to extend Lucier's neurofeedback, especially considering this relationship with Dewan, to a discussion of the contemporary impasses of the posthuman brain. Brainwaves are central to Dewan's understanding of consciousness, and consciousness is integral to his conclusions about artificial intelligence. "Let us start by loosely defining consciousness as 'awareness,'" he proposed in a 1957 paper. "Recent investigations with the electroencephalogram [EEG] reveal interesting correlations between certain forms of electrical activity in the cerebral cortex and certain states of awareness." Neurofeedback provides a marker of such an "awareness," which in turn Dewan thinks lies at the root of consciousness. Dewan then discusses the possibility of artificial intelligence. As though presaging the transformations that would later become associated with computational neuroscience, he concludes that, "in order to decide whether or not a machine thinks, one would have to know all the physical correlates of consciousness; for only then could we know whether or not there is a structural isomorphism between the machine and that property of the brain which is associated with consciousness" ("'Other Minds'" 74–6).[28] Once the brain is fully knowable, one possesses the tools to ascertain, and even create, its machinic equivalent.

What Should We Do with Our Brain Music?

Catherine Malabou, upon learning of the Blue Brain Project's competitive goal of simulating the neocortical column of a rat—alongside the release of IBM's "neurosynaptic" CPU chip, which promises the equivalent of neuroplasticity in silicon—suggested a revision of the title of her widely influential 2008 essay, *What Should We Do with Our Brain?* as "Rat Race; or What Can We Do with Our Blue Brain?" ("Metamorphoses"). This is because neuroplasticity, which

the philosopher defines as the brain's radical ability to both give and receive form, had fortified the human brain, for Malabou, against its potential capture via machinic duplication or emulation. According to Malabou, "The 'plasticity' of the brain refers to the capacity of synapses to modify their transmission effectiveness. Synapses are not in fact frozen; to this degree, they are not mere transmitters of nerve information but, in a certain sense, they have the power to *form* or *reform* information" (*Plasticity* 59). If IBM's new chip could, in fact, simulate such plasticity in silicon, as it had claimed, this would challenge the conception of plasticity as a privileged feature of biological human brains. For Malabou, plasticity creates the conditions for a genuine *historicity*—and hence, politics—of the brain. Drawing on Marx's notorious statement about history, she proclaims, "Humans make their own brain, but they do not know they are doing so" (*What* 8). This had led her to posit a "critique of neuronal ideology" which insists upon plasticity against the kind of neoliberal "flexibility" that coincides with what Žižek paraphrases (in his 2006 discussion of *What Should We Do with Our Brain?*) as the resonance "between cognitivism and 'postmodern' capitalism" (209). Importantly, such a formulation of "neuronal politics" also gives way to her critique of the cybernetic conception of the brain as a computation machine. In a section of *What Should We Do with Our Brain?* entitled "End of the 'Machine Brain,'" she criticizes "technological metaphors" of the brain such as Henri Bergson's "central telephone exchange" and, of course, the computer brain. She argues, "Opposed to the rigidity, the fixity, the anonymity of the control center is the model of a suppleness that implies a certain margin of improvisation, of creation, of the aleatory" (*What* 35). Note her use not only of musical, but also of specifically experimentalist metaphors.

Yet, as we've seen, such an attempt to differentiate the biological from the machinic may simply not matter. Recently Malabou has acknowledged a conceptual impasse preventing assertions of the biologically essential, concluding that a "strategy of opposition" has become untenable. She continues,

> Critiques of technoscience and biopower, deconstructions of sovereignty, denunciations of instrumentalization of life in particular produced by biopolitical and cybernetic modes of control lack actuality as long as they rely on the strict separation between the symbolic and the biological and think of critique as a possible outside, whatever its form, of the system. I now realize that the strategy developed in my book, *What Should We Do with Our Brain?*, was itself participating, in its own way, in this confidence in the outside. Because, again, I believed that neural plasticity, which I discovered and studied with such curiosity, such excitement—passion even—was the undeniable proof of the irreducibility of the brain to a machine and, consequently, also of intelligence to a flexible software program. ("Metamorphoses")

Such overconfidence in an outside had inhibited Malabou from apprehending the overlapping non-identity between the human and the machinic, their mutual forms of co-constitution. The problem then becomes not that of ascertaining the uniqueness of the biological human over the machine's supposed determinism, but rather that of disrupting "conditioned responses" to capitalist subjectivity: our own *automaticity*. So how can we break with the teleological relation between AI and capitalism when the latter appears simultaneously so erratic, dynamic, and, indeed, experimental? The kind of experimental indeterminacy shared by Lucier and Cage, along these lines, may already be seen as an artistic model for diverting capital's libidinal pull toward the posthuman. Recall, again, that Cage's turn to chance and indeterminacy was, in part, an alternative to psychoanalysis and the ego fulfillment derived from composing music, With this in mind, indeterminacy might be reimagined as a subtly construed obstruction to the conditioned responses of capitalist subjectivity.

Malabou notes that Foucault had similarly asked how we might be capable of interrupting our own automaticity. She answers, in fact, with a call for an experimentalism carried out through the "neurohumanities"—a category in which we can also include neuro*music*. "The historical-critical attitude must be an experimental one," Malabou insists. "Neurohumanities should then be the site for experimental theory, opening the path for diverse thoughts and techniques of self-transformation, inventions of the transcendental, and, again, interruptions of automaticity" ("Metamorphoses"). If Cage's indeterminacy stages a potential challenge to technoscientific automaticity, then Lucier is seen to extend such a gesture through an experimental neuromusic.

A politics of the posthuman brain might take precisely the kind of speculative, experimental attitude found in Lucier's neuromusic as a point of departure. Through its experimental use of cybernetic indeterminacy, *Music for Solo*

Performer imagines an impediment to the kinds of conditioned responses to capitalist subjectivity that ultimately give way to the posthuman. One could, conversely, seek a more directed approach to technological crisis, attempting to calculate and anticipate catastrophes. Hanson admits that his Moravecian scenario can occur only in the absence of a large-scale "global effort" of resistance (*Age* 362). As suggested in this essay's introduction, *Music for Solo Performer* can be said to playfully invert the common trope of hearing music "in one's head" (instead, the contents of the brain are rendered *as* music). In the end, the rise of posthuman AI may similarly turn out to be "all in our heads." As David Golumbia has argued, we may simply never become capable of achieving genuine artificial intelligence, through brain emulations or any other method.[29] Nonetheless, the fervor around such fantasies remains acutely real, as the billions of dollars presently invested in AI and brain emulation make clear. It doesn't need to work in order to impact the present or indeed to shape the future.

Returning to the past—and in summation—Lucier's experimental neuromusic, exemplified in his 1965 *Music for Solo Performer*, responds to the political economic crisis of post-Fordist capitalism through the reflexive use of cybernetic technologies and in its symptomal display of musicalized cognitive labor. When read through the contemporary impasses of the posthuman brain, *Music for Solo Performer*'s use of indeterminacy, as adopted from Cage's notion of experimentalism, may ultimately figure as an ambivalent challenge to the cybernetic control paradigm as well as to the problem of automaticity articulated by Malabou. We've seen the intimate interconnections between experimental music and cybernetics expressed through Lucier's biofeedback and his important relationship with Dewan. But considering experimental music and posthumanism's mutual inheritances from cybernetics, along with a continued relevance to contemporary technoculture—whether by responding to political challenges posed by cognitive labor or in pondering futurist scenarios of posthuman AI—there remains perhaps more to learn by putting these two fields further in dialogue with one another.

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Footnotes

1. For instance, John Cage's *Variations VII* (1966) used brainwaves, as did James Tenney's *Metabolic Music* (1965), various works by David Rosenboom, and Petr Kotik's *There is Singularly Nothing* (1971–73), which incorporated brainwave data from fruit flies. Additionally, the instrumental parts of Kotik's six-hour operatic setting of Gertrude Stein's *Many Many Women* (1976–8) were derived from EEG graphs made by scientist Jan Kučera in order to study the effects of alcohol on the nervous system. Nam June Paik's 1966 proposal for a "DIRECT-CONTACT-ART" (Kahn, *Earth* 278n4) shares many features with both Lucier's piece and Manford L. Eaton's work. For a detailed study of the latter, see Joseph, "Biomusic."

2. Currently there are no major studies of experimental music and posthumanism. Music, more broadly, has appeared in certain isolated cases such as Cary Wolfe's respective chapters on Lars von Trier's *Dancer in the Dark* and on Brian Eno ("When You Can't Believe Your Eyes [or Voice]: *Dancer in the Dark*" and "The Digital, the Analog, and the Spectral Echographies from My Life in the Bush of Ghosts," in *What Is Posthumanism?*). Worthy of mention is Eshun's *More Brilliant than the Sun*, although Eshun's influential call for an Afrofuturist posthuman music is typically identified as a manifesto rather than a scholarly study. Finally, the related but distinct field of sound studies has seen Cecchetto's pathbreaking *Humanesis* and Pettman's pathbreaking *Sonic Intimacy*.

3. A sampling of this rapidly expanding literature includes Halberstam and Livingston; Hayles; Badmington; Clarke, *Posthuman Metamorphosis* and *Neocybernetics*; Wolfe; Braidotti; Nayar; Cecchetto; Roden; and Braidotti and Hlavajova.

4. For Born, the disparity between serialism's "hypercontrol of sound parameters" and the indeterminacy of experimental music represents a key difference between musical modernism and postmodernism (56). Piekut has argued, however, that Cage's thinking, for one, never moved beyond a modernist ontology based on the strict separation between the human and nonhuman (135–148).

5. Roberto Esposito provides a recent contribution, and to an extent an alternative, to this discourse. He draws upon a confluence of Greek philosophy, Roman law, and Christianity to trace a genealogy of the thing/person

distinction—which, he suggests, “biotechnologies,” for instance, threaten to reverse—in order to argue for a renewed primacy of bodily materiality (4, 104). I thank Patrick Valiquet for his thoughts pertaining to this reference.

6. Franklin takes Hayles as a point of departure in locating cybernetics as “a moment in the history of political economy [and] as the epistemic grounding for a worldview that posits all material objects and their interactions as digital and thus predisposed to exchange and valorization” (33).

7. For an incisive critique of posthumanism from the perspective of black studies and feminism, see Weheliye. Drawing on the work of black feminist literary critics Sylvia Wynter and Hortense Spillers, he argues that “posthumanism and animal studies isomorphically yoke humanity to the limited possessive individualism of Man, because these discourses also presume that we have now entered a stage in human development where all subjects have been granted equal access to western humanity and that this is, indeed, what we all want to overcome” (10).

8. For a recent history of the Soviet response to and development of cybernetics, see Gerovitch.

9. For Nayar, “Critical posthumanism . . . is the radical decentring of the traditional sovereign, coherent and autonomous human in order to demonstrate how the human is always already evolving with, constituted by and constitutive of multiple forms of life and machines” (2, emphasis removed).

10. For recent critiques of Land, see MacDougald and Haider.

11. See also Bostrom’s “paperclip maximizer” scenario (123).

12. These tendencies are particularly pronounced in the transhumanist movement, of which Bostrom and Moravec have been leading proponents. Moravec is also a frequent spokesperson for the transhumanist Extropy Institute, which promotes a form of libertarian techno-determinism (see Raulerson 51).

13. Hanson uses the terms “simulation” and “emulation” interchangeably to refer to the digital replication of a distinct human mind. Dutch neuroscientist and neuroengineer Randal A. Koene, however, distinguishes between the two terms: “We call the stochastically generated models simulations and the faithful copies [i.e., Hanson’s topic] emulations” (148); see Stollfuß 93. For a technical report on the 2008 state of the art of brain emulation technologies, see Sandberg and Bostrom.

14. For a recent historiography and metacritique of the concept of technological determinism, see Peters. Peters argues that, since its introduction in the work of Marx and the American economic sociologist Thorstein Veblen, technological determinism has played the role of a kind of intellectual slur that effectively stops “difficult but essential inquiry” (10), since, ultimately, “the drive to discover determination lies at the heart of inquiry” (23). Automaticity can be viewed as an alternative to this discourse in that it is concerned not with historical relationships between the social and the technical but with the effects stimuli have on individual psychology.

15. Capital “operationaliz[es] science fiction scenarios as integral components of production systems” (Land, “Teleoplexy” 515).

16. Prior to the score’s 1980 publication in *Chambers*, Lucier referred to the work as *Music for Solo Performer 1965* (year included) in various letters (“Correspondence 1963–1976”).

17. There are multiple versions of Lucier’s score in addition to the commonly referenced version published in *Chambers*. Distinct from the latter, one of the unpublished score manuscripts contains a nine-point list describing in technical detail the 1965 premiere performance at Brandeis University’s Rose Art Museum. A similar score manuscript by Lucier includes a dedication to John Cage in place of the extended title (“for enormously amplified brain waves and percussion”). Finally, yet another version of the score closely resembles the *Chambers* version but contains both a 1965 and a 1977 copyright (“Scores”). My quotations are taken exclusively from the *Chambers* version.

Before he used written scores, Lucier apparently relied on firsthand verbal instruction: “There is not much in the way of a score [for *Music for Solo Performer*], so I rely on an oral tradition, i.e., I tell-teach it to those who want to do it” (Unpublished Letter to Howard Hersh).

18. Kahn’s comparison of *Music for Solo Performer* to Cage’s *4′33″* as an instance of “withheld performance” (*Earth* 101) can be considered in light of Pickering’s thesis that the cybernetic brain is itself already performative. Pickering

draws on the work of British cyberneticist Ross Ashby to conceive of "the brain as an immediately embodied organ, intrinsically tied into bodily performances" (6). Kahn does, however, locate a sense of "concentrated interiority" inherent to *Music for Solo Performer* (*Earth* 100), and discusses Pickering's conception of cybernetics as a "nonmodern ontology" (*Earth* 86; see Pickering 17–36).

19. In an undated letter (ca. 1966) to composer and electronic musician Joel Chadabe, Lucier writes: "I also would love to be able to hook my brain up with the audience's brains so that I can tell them how I hear and think without having to go through the air."

20. From "*you* are your brain," Malabou shifts to the first person plural and draws upon neuroscientist Antonio Damasio's notion of the "proto-self" (and Marx) to contend, "'We end up coinciding completely with 'our brain'—because our brain is us, the intimate form of a 'proto-self,' a sort of organic personality—and we do not know it" (*What* 8). See also Makari.

21. See also the highly influential Hardt and Negri, *Empire*. Additionally, see Crary.

22. For an art historical account of the turn to language beginning with Cage's *4′33″* and the text score compositions of the 1960s, see Kotz.

23. See the study of piano-playing musical automata in Voskuhl. These androids or "Enlightenment automata," Voskuhl notes, "are often taken to be forerunners and figureheads of the modern, industrial machine age, an age in which the economic, social, cultural, and aesthetic constitution of humans changed fundamentally and supposedly became 'mechanized'" (2).

24. This literature is extensive; for an introduction, see Osborne.

25. Compare Cage's quintessential 1955 statement on experimental music to the 1957 words of German scientist Wernher von Braun: "[B]asic research is when I am doing what I don't know what I am doing" (qtd. in Arendt 231). It becomes clear why Arendt contended that the natural sciences had become fundamentally processual and, moreover, capable of triggering "processes of no return" (231). For a compelling critique of cognitive science that, among other things, compares this tendency of cybernetics to the sorcerer's apprentice myth, see Dupuy xii–xiii (cf. Wiener's own invocation of the same myth [176]).

26. Compare Shannon's thesis to Lucier's description of his experiments in preparation for *Music for Solo Performer* : "At first I couldn't distinguish what was noise and what was alpha. . . . Alpha waves pulse from 8 to 12 cycles per second fairly regularly but in uneven bursts. They slow down and speed up a little, get louder and softer. Electrical noise is more complex and constant" ("Music." *Music* 52).

27. "I got involved in [chance operations] in the middle and late '40s, and it took the place of psychoanalysis because I was not only in a troubled state personally, but I was concerned about why one would write music at this time in this society" (Cage qtd. in Miller). See also Cage and Charles, *For the Birds*, 116; and Cage, "Composition as Process III: Communication" (1958), in *Silence* (41–56): "Don't you agree with Kafka when he wrote, 'Psychology—never again?'" (47); cited in Joseph, *Experimentations*, 33n89; Joseph notes that by "psychology" Cage meant orthodox psychoanalysis (26). On the role of Cage's sexuality in his rejection of psychoanalysis, see Katz (233–4).

28. Dewan's 1957 statement, which privileges "consciousness" as a prerequisite for the creation of a thinking machine, warrants a comparison to the work of Ashby. Nearly a decade before Dewan, Ashby's similar statement emphasizes not consciousness but the brain's performative dimension: "To some, the critical test of whether a machine is or is not a 'brain' would be whether it can or cannot 'think.' But to the biologist the brain is not a thinking machine, it is an *acting* machine; it gets information and then it does something about it" (379).

29. More accurately, Golumbia provides a critical historiography of functionalism—the philosophical view that the mind itself must be a computer—along with a related genealogy of cybernetics, cognitive science, computational linguistics, and artificial intelligence, to support his broader challenge to the cultural hegemony of "computationalism," a program he defines as a "commitment to the view that a great deal, perhaps all, of human and social experience can be explained via computational processes" (8).

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