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Listening to Cybernetics

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Scholars have explored the influence of the field of cybernetics on scientific thought and disciplines. However, from the inception of the field, “cyberneticians” had explicitly envisioned applications reaching beyond the purview of scientific disciplines; cybernetics was remarkable for its portability and potential application in a wide variety of contexts. This article explores connections between cybernetics and experimental music from 1950-1980, which was a period of experimentation with electronic techniques in recording, composition, and sound production and manipulation. Examples include musicians, engineers, instrument builders, composers, and scientists in collaboration with musicians who invoked cybernetic themes in their work. These uses of cybernetics were more diverse than accounts of cybernetics within the sciences suggest, presenting a major difficulty in addressing cybernetics as a homogeneous or monolithic discourse. In particular, cybernetic discourse in music often exhibited themes of openness and indeterminacy, rather than the “command and control” of the “closed world.”

Keywords: cybernetics; music technology; computer music; experimental music; electronic music

Since I have always preferred making plans to executing them, I have gravitated towards situations and systems that, once set into operation, could create music with little or no intervention on my part. That is to say, I tend towards the roles of planner and programmer, and then become an audience to the results.

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Brian Eno, liner notes to 1975 album *Discreet Music*

Brian [Eno] is a born cybernetician. He will take the most unlikely juxtapositions and philosophical ideas and throw them together into this kind of conceptual stew of his and produce this unfathomable, but fascinating animal. And he will continually stop and reevaluate the work that’s been done and then throw it in an entirely unexpected direction.

David Bowie, quoted in Sischy (1995)

**Introduction**

“Cybernetics” emerged as an area of academic study and popular interest shortly after the end of World War II, largely based on publications by Norbert Wiener, who coined the term in 1948. It was concerned with broad themes including command and control, systems, and analogies between organisms and machines, including computers. In the academy, members of a wide range of disciplines researched and articulated cybernetic concepts, and cybernetics came to constitute “one of the dominant intellectual paradigms of the postwar era” (Turner 2006, 27). The field of cybernetics has also attracted attention in science studies, particularly with regard to the application of cybernetics and its cousin, information theory, in “hard” scientific fields (Bowker 1993; Edwards 1996; Kay 2000) and in the social sciences (Heims 1991; Pickering 2002; Light 2003). Yet from the inception of the field in the late 1940s, cyberneticians had explicitly envisioned wide sociocultural applications extending beyond the purview of scientific disciplines. Indeed, many cybernetic concepts, including the ones discussed in this article, such as control and determinacy/indeterminacy, human and machine interaction and analogy, information, and systems orientation, were seen by cyberneticians, the public, and artists alike as having broad social significance beyond their “technical” meanings or applications in science or art.

In this article, I emphasize cybernetics’ role and adoption in one of the humanities (music), rather than the physical or human sciences (Saper 2001; Wilson 2002). (This is in part an artificial distinction, because in some cases composers and musicians were intimately associated with practitioners of the sciences of cybernetics; see below for the example of Herbert Brün and Heinz von Foerster’s collaboration.) I ask why cybernetic
principles and applications may have held appeal for people in experimental music circles, with the aim of exploring implications of cybernetics’ appearance in this site for the consideration of cybernetics as a field by science studies. The uses of cybernetics by experimental musicians, instrument builders, and composers were more diverse than how science studies accounts have presented cybernetics, and I argue that this diversity suggests a major difficulty in addressing cybernetics as a homogenous or monolithic discourse, contrary to its treatment in some science studies accounts.

Following Paul Edwards’ Foucauldian use of the term, I take discourse to mean a self-elaborating “heterogeneous ensemble” that combines techniques and technologies, language, and practices, and which emphasizes the reality of competition between and among discourses (1996, 37-41). In particular, the treatment of cybernetics as “closed” in the sense discussed by Edwards does not match the use of cybernetics by musicians and composers. In viewing cybernetics primarily in relation to the sciences, science studies analysts have neglected to see how “open” or indeterminate cybernetic discourse could also be.

In this article, I use the term “experimental music” to refer to broadly music that pushes existing boundaries in terms of genre, sound, style, material practice, or expectation of audiences. It is not a specific genre itself, as it encompasses a shifting range of practices over time. Throughout much of the twentieth century, experimental music often overlapped with electronic music, since musicians and composers seeking unique sounds and modes of musical production often looked to electronic technologies to aid them in their explorations. While experimental music of course existed before cybernetics, its course during this period did resonate strongly at times with cybernetic ideas. The resonance between ideas undergirding experimental and electronic music composition and construction in the 1950s-1970s and cybernetic theories may be a result of prevalent, complex, and interrelated ideas about human–machine interaction and relationships, ideas about communication and control, and changing aesthetics. Materially, this was a period of experimentation with electronic techniques in recording, composition, and sound production and manipulation. A precursor to the electronic manipulations of this period could be found in musique concrète, which involved the cutting and splicing of recorded magnetic tape; this experimentation, which began in the 1940s, enabled the artist to “[move] sound around in time in space,” which in turn “jumpstarted an obsessive quest for new and different electronic music technology” (Holmes 2002, 77-9). The early 1960s saw the introduction of compositions (some by Herbert Brün, discussed below) that were designed for (traditional) instruments and
electronic sounds on tape (Chadabe 1997, 278). Both materially and philosophically, then, experimental music is defined by “actions the outcome of which are not foreseen” (Cope, 1976).

N. Katherine Hayles has suggested that the meaning of cybernetics changed over time, and she sketches three “waves” of cybernetics. Although the cybernetic devices and relationships envisioned in my examples vary, many seem to have roughly in common what Hayles has termed “second wave” cybernetic principles; they are united around a conception of cybernetics that regards “autopoiesis,” or the self-making of a complex system, as central. In her discussion of the waves, Hayles first outlines a principle of homeostasis and refers to this as “first wave” cybernetics, arguing that the “ghost of homeostasis” is still present in autopoiesis (1994, 462). According to Hayles, homeostasis was defined as the ability of an organism to maintain itself in a stable state; this concept was elaborated by physiologist Walter Cannon in the 1920s, whose work influenced Norbert Wiener (1999, 298, n. 20). Thus, an organism or a system was seen as a closed circle of corrective feedback (1994, 446). However, for Hayles, the equilibrium-seeking aspect of cybernetic theory gave way to a more reflexive notion of “turning a system’s rules back on itself so as to cause it to engage in more complex behavior,” which privileged “change over constancy, evolution over equilibrium, complexity over predictability” (1994, 446). In the examples below, I argue that most of the applications of cybernetics by musicians, composers, and so on, are concerned with self-making and the interplay of agency between composer, audience, machine, and the musical piece or performance itself and thus resemble Hayles’ second-wave cybernetics. Hayles dates the origin of the second wave to about 1960-1965 (1999, 131).

Below, I identify four categories of uses of cybernetics in musical practice. Some of the examples I use to illustrate the categories can and do fit into more than one category, but I attempt to trace out differences between them to highlight the diversity of applications of cybernetics and, borrowing from Hayles, to make an attempt at classifying the recurring themes in these applications. The evidence I have assembled focuses on only a few key figures, but it will serve to illuminate each of the themes.

**Human-Machine Integration**

In his 1948 book *Cybernetics: Or, Communication and Control in Animal and Machine*, Norbert Wiener wrote of the “unity of the set of
problems centering about communication, control, and statistical mechanics, whether in the machine or in living tissue . . . .” (1948, 19). Here and elsewhere, he and other cyberneticists emphasized conceptual similarities in feedback systems in organisms and machines; both humans and machines could be described in terms of information, feedback, and control (Gerovitch 2002, 53). Wiener held that the electronic circuits of computing machines were “precise analogues” to “neuronic circuits and systems” (1948, 22). He wrote that “it became clear to us that the ultra-rapid computing machine, depending as it does on consecutive switching devices, must represent an ideal model of the problems arising in the nervous system” (1948, 22, emphasis added).

Wiener was by no means the only proponent of human-machine equivalence. At the Josiah Macy, Jr. Foundation-sponsored conferences on cybernetics, a conference series that met ten times from 1946 to 1953, and which was instrumental in the formulation and refinement of cybernetic ideas, a variety of participants struggled to forge connections between their research in different disciplinary areas and the central ideas of cybernetics (Heims 1991; Hayles 1999, 7, 50-1;). Hayles writes, “[T]he result of this breathtaking enterprise was nothing less than a new way of looking at human beings. Henceforth, humans were to be seen primarily as information-processing entities who are essentially similar to intelligent machines” (1999, 7, emphasis in original; see also Edwards’ 1996 discussion of “cybernetic psychology,” 178-87). Thus, a central element of cybernetic discourse involves the equation of machines and organisms as functionally equivalent and as capable of being integrated into systems that include members of each category. According to Slava Gerovitch, “Cybernetics did not describe computers metaphorically in terms of brains; the brain itself was conceptualized in logical and engineering terms and these concepts then returned to computing, serving as a basis for the impressive ‘discoveries’ of man-machine analogies” (2002, 94). Paul Edwards refers to this as “human-machine integration,” in which humans and machines were comprehended in similar terms, so that human-machine systems could be engineered into a complex system that would maximize the performance of both kinds of components (see Edwards’ discussion of “cyborg discourse” 1996, 147).

A common thread in many of the musicians’ uses of cybernetics is the achievement of integration of the human mind with the electronic machine in their works. Below I note some examples of musicians, composers, and instrument builders whose work was built on the idea of the “mind-like character” of electronic technologies (Edwards 1996, 21); this work confronted changes in imagining brought on by electronics and early computers.
Bebe (1927-2008) and Louis Barron (1928-2007) were trained composers and pianists with an interest in electronic music. Louis also was an electronics hobbyist and a ham radio operator. They met in the late 1940s in California and married in 1948. For a wedding present, they received a tape recorder from a German friend, which according to Bebe was one of the first tape recorders imported into the United States (Vale and Juno 1994, 194). Bebe recounted that she and Louis knew of the work of Pierre Henry (b. 1927) and Pierre Schaeffer (1910-1995) in France, on musique concrète (an early form of electronic music using tape splicing and manipulation techniques to construct compositions with found sounds), as well as Karlheinz Stockhausen’s (b. 1928) compositions in electronic music in Germany. Looking back, Bebe stated: “Immediately we became aware of the possibilities. We did the usual experiments: slowing the tapes down, running them backwards, and adding echo. Louis started building circuits to make sound—ohmigod, every move took forever, but it was so exciting!” (Vale and Juno 1994, 194-5, emphasis in original). The Barrons were convinced that they were engaged in a new and significant form of musical production.

About 1950, the Barrons moved to Greenwich Village, New York City, where they were active in an experimental music community, collaborating with John Cage and others, while running a very early electronic music studio out of their home (Holmes 2002, 118). In their partnership, Bebe did much of the composing and production, while Louis did most of the circuitry design (Holmes 2002, 120). They used their circuitry techniques to score Anaïs Nin’s 1952 film *The Bells of Atlantis*. The Barrons aspired to larger projects than experimental film productions and “plotted their assault” on Hollywood, successfully snaring the opportunity to compose the score for MGM’s 1956 science fiction film *Forbidden Planet* (Greenwald 1986, 54). This film is notable because by most accounts it features the first all-electronic soundtrack in a mainstream Hollywood film; in fact, “soundtrack” may not even be the correct term, because the Barrons “complete[ly] obliterate[d] . . . distinctions between music and effects.”¹ The sounds for the film were all rendered using custom-built circuits designed by the Barrons.

According to Bebe, Wiener’s ideas about cybernetics were a direct source of inspiration:

Wiener’s The Human Use of Human Beings was published in 1951. Mimicking those experiments done to animals to put them in a state of stress, we would do basically the same things to those circuits, and you could hear them
literally shrieking! It was like they were alive, and with a lifespan of their own. What we did was pretty elementary: we would attach resistors and capacitors to activate these circuits (obviously, we were changing the resistance) and negative and positive feedback was involved—Wiener talks about all that. The same conditions that would produce breakdowns and malfunctions in machines, made for some wonderful music. The circuits would have a “nervous breakdown” and afterwards they would be very relaxed, and it all came through in the sounds they generated. (Bebe Barron in Vale and Juno 1994, 200, emphasis in original)

The Barrons felt that each circuit had a distinct “personality,” which it expressed through its sonic tendencies, as well as a “lifespan,” after which they would tend to burn out, never again to be revived (Greenwald 1986, 58; Vale and Juno 1994, 195). The Barrons also referred to Cybernetics in the liner notes to Forbidden Planet:

We design and construct electronic circuits which function electronically in a manner remarkably similar to the way that the lower life-forms function psychologically. There is a comprehensive mathematical science explaining it, called “Cybernetics” . . .

In scoring Forbidden Planet . . . we created individual cybernetic circuits for particular themes and leit motifs [sic], rather than using standard sound generators. Actually, each circuit has a characteristic activity pattern as well as a “voice.” (Barron and Barron 1956)

In likening their instruments and the effects created by them to cybernetic biological processes, and to the human/biological voice, the Barrons emphasize that they were striving for an “organic” quality of sound, albeit through the use of electronic circuits. The Barrons cite a particular model of cybernetic principles in which the electrical circuits they built were explicitly likened to the neural “circuitry” of an organism. According to the Barrons, though they were building “nervous systems,” the sounds they created seemed to elicit an “emotional” response from human listeners, which seemed to imply an organic integration of sorts between the circuits they had built and the humans who responded to them.

Herbert Brün (1918-2000), a German-born composer who fled Nazi Germany for Palestine in 1936, continuing on to the United States in the 1940s, was also interested in combining the human, creative process of composition with electronic circuitry. Brün had begun his work with electronics in the 1950s and in the early 1960s was touring the United States, lecturing
at universities. In 1962, he was approached by IBM executives asking him to write a letter describing his ideas for using computers in composition. He wrote the letter and then forwarded a copy of it to Lejaren Hiller (composer of the Iliac Suite, one of the earliest significant pieces composed using a computer) at the University of Illinois. Brünn recalled, “When I arrived at the University of Illinois, Hiller already had a software package [MUSICOMP] for the IBM 7094 . . . . It was extremely intelligent, far beyond the technology of the time—you could apply it to today’s machines and it would not be boring . . . .” (Chadabe 1997, 277).

Brünn was clearly excited by the composition possibilities he saw in working with computers. Yet his propositions were not without controversy. Speaking of the motivation for a 1964 piece, Soniferous Loops, Brünn said, “My desire was to prove to myself and to Hiller and to other colleagues that I could program a computer with their software so that they would recognize it as a piece by Brünn. It was a polemic. The idea was in response to rumours that personality can’t get through, that you can’t compose with a machine. I wanted to show that that’s bullshit” (Chadabe 1997, 278). Here, Brünn set out to prove to colleagues that the human personality could be integrated with and made to “show through” a machine, an idea that was not readily accepted in the world of composition. He was also invoking a cybernetic ideal in his description of the software as “intelligent,” indicating a commonality between human and machine “minds.”

While at Illinois, Brünn was not restricted to the music department, as he also collaborated with cybernetician Heinz von Foerster on several interdisciplinary courses in heuristics and cybernetics at the Biological Computer Laboratory (1968-1974). Brünn was also an active participant in the 1966 session on “Music by Computers,” organized by von Foerster, which occurred as part of the 1966 Fall Joint Computer Conference, held in San Francisco. Later in his life, Brünn was a trustee of the American Society of Cybernetics and was awarded the Norbert Wiener medal by the Society in 1993 for achievements in the field of cybernetics.

John Cage (1912-1992), a prominent American experimental composer who worked in electronic, minimalist, and process-generated music, was an admirer of cybernetic theory. A student, John Brockman, recalled: “In 1965 John Cage handed me a book to read. It was Cybernetics by Norbert Wiener” (Edge.org 1998). For Cage, who was also deeply drawn to both Eastern philosophy and the writings of Marshall McLuhan, “[W]e live as the effect of electronic inventions by means of which our central nervous systems have been exteriorized . . . . The world we live in is now a global mind” (Cage, 1970, 170). Cage underscores his point that there has been
a shift in the mind from the mental or natural to the exterior, the electric, and
the machine, stating that “[F]ormerly by disciplines of yoga, zazen medita-
tion, the arts . . . . , one could make life endurable by changing his mind,
yet] now that change of mind is socialized” (1970, 170). It may not be clear
from his use of the word “socialized,” but by this Cage means that the mind
extends beyond the individual to the global mind or the “common head,”
which is bound together by electric communication and technology
(1970, 171). Elsewhere, he stated that “[O]ur present technology, according
to McLuhan, is the extension of the central nervous system, so we’re in a
situation of a greater number of ideas and interconnection of ideas” (Lohner
2001, 268). Cage also referred to the possibility of “a computer that acted
more like nature than like human beings,” indicating a strong impulse on
his part to collapse boundaries between the “natural” and the machine in
his thinking (Pritchett et al. 2001, 198). Cage did not use computers in his
work until the 1980s, and then he did not employ them heavily. Instead, for
Cage, the human-machine integration ushered in by electronic technologies
was already occurring in the global consciousness, which he shared, and
thus his creative work was already affected by it, even without the use of
computers. Cage was however actively interested in creating music using
tape-splicing techniques, and he had long experimented with using circuits,
oscillators, and amplification in his compositions.

Information

One of the principle tenets of cybernetic theory was related to the sup-
posed ability of a cybernetic system to detect, through communication and
feedback, signals, or messages containing “information.” According to
Wiener in Cybernetics, “the message is a discrete or continuous sequence
of measurable events distributed in time—precisely what is called a time
series by statisticians” (1948, 16). Wiener goes on to explain a precise and
technical use of the term “information” in this context. A message could be
said to contain information if what was being transmitted was not com-
pletely determined by its place in the time series, yet it conformed to some
sort of statistical regularity; in other words:

[T]he amount of information [is] the unit of information . . . that [is] trans-
mitted as a single decision between equally probable alternatives . . . . Just
as the amount of information in a system is a measure of its degree of
organization, so the entropy of a system is a measure of its degree of disorganization; and the one is simply the negative of the other. (1948, 18)

Bell Labs mathematician Claude Shannon was concerned with coding information for transmission across a channel, and through this work wrote about the concepts of information or entropy in the English language; Wiener himself also independently developed the notion of the mathematical equivalence between entropy and information (Kline 2004). Shannon discussed the problem of information in language in his foundational 1948 paper, “A Mathematical Theory of Information” and later elaborated these ideas in a 1950 paper, “Prediction and Entropy of Printed English”; with the help of Warren Weaver, Shannon also presented his work for a popular audience (1949). He stated that entropy is a statistical parameter that indicates how much information is produced on average for each letter of text in the language, while redundancy is the measure of the degree of constraint on the language. As examples, he cites the frequency of the letter E in English, as well as the likelihood of U following Q (Shannon 1948; Shannon 1951, 50).

Shannon and Weaver’s discussion provided fodder for a 1956 article in Scientific American that exclusively focused on the relationship of this theory to music (Pinkerton 1956). Writing for a popular audience, the author calculated the amount of information per note in simple melodies and states that redundancy is necessary to have tuneful melodies. He argued that “melody, rhythm and harmony can all be fitted into a statistical scheme .... A set of tables could be constructed which would compose Mozartian melodies or themes which would out-Shostakovich Shostakovich” (1956, 86).

Cybernetic scientists, musicians, and composers also drew on these discussions, referring to the degree of redundancy, entropy, and information contained in musical compositions. The introduction to a 1969 volume entitled Music by Computers, which was based on proceedings from a 1966 conference, deals directly with this issue. Heinz von Foerster (1911-2002), an Austrian émigré to the United States, was a physicist by training who, through his participation in the Macy Conferences and his interest in reflexivity in complex systems, was an architect of the field of cybernetics. Hayles calls von Foerster “a transitional figure linking first- and second-wave cybernetics” (1999, 132); indeed her “waves” echo von Foerster’s own characterization of reflexivity in cybernetics as being “second-order cybernetics” (Hayles 1994, 442). He taught biophysics and electrical engineering at the University of Illinois, and where he interacted with, among
others, Herbert Brün. In his introduction to the 1969 conference volume, von Foerster wrote:

Let us consider the sounds that are stored on the records attached to this book [including Herbert Brün’s Infraudibles]. Are these sounds music? A century ago this question would have been unanimously answered in the negative. Today, however, we would have to be more cautious. Why is it that a sizable number of people are willing to pay admission to a concert that to an audience of two generations ago would have been cacophony rather than euphony?

... [This] is most clearly understood in information-theoretical terms, namely, as a gradual reduction in the redundancy of works of music, or expressed differently, as a continuous increase in the complexity of sound and composition, hence an increase in the amount of auditory information transmitted during a given interval or time. (von Foerster and Beauchamp 1969, 8-9)

This discussion continues with a description of the evolution of musical instruments, starting with the lyre and flute, through increasing complexity in arrangements, instrumentation, and tonal systems, inferring that greater complexity and freedom from constraints of tradition (which is equivalent to richness of information) was potentially correlated with maximum euphony. Thus, for von Foerster, computers entered contemporary composition “not as ancillary tools but as essential components in the complex process of generating auditory signals that fulfill a variety of new principles of a generalized aesthetic” (von Foerster and Beauchamp 1969, 10). In this volume, the information-theoretical aspect of music is presented as a matter-of-fact way of approaching the subject. With the exception of the section on aesthetics, the papers themselves tend to discuss practical problems or solutions regarding use of computers or algorithms in composition. Von Foerster’s points about value of information theory for approaching both language and music present a backdrop the rest of the volume. Not only were both language and music believed to be reducible to symbols, meant to be processed using computers, and potentially most interesting when containing high degrees of information, but “[t]he search for those new principles, algorithms, and [aesthetic] values, is, of course, in itself symbolic for our times,” von Foerster concluded (1969, 8).

System and Process Orientation

As noted above, N. Katherine Hayles writes of three “waves” of cybernetics, arguing that the focus of cybernetic theory shifted over time.
According to Hayles, cyberneticians’ original focus on homeostasis, feedback, and information as a signal (first wave) gave way to the idea of self-organization, or autopoiesis, in complex systems (second wave), and then to simulation and virtuality (third wave; 1994, 444, passim). Her description of “second wave” cybernetics is useful to introduce the idea of process orientation in music: “… [S]elf-organization is seen as the engine driving systems toward emergence. Interest is focused not on how systems maintain their organization intact, but rather on how they evolve in unpredictable and often highly complex ways through emergent processes” (1994, 463). Likewise, the idea of composition, involving formalized rules and plans, was challenged by experimental musicians and composers, who were not interested in orienting around a “product” that would be achieved by traditional composition but instead a process of creating music through the interaction of performers, audience, and environment. Examples of this shift in orientation can be seen in a variety of instances, and I do not mean to suggest that cybernetics was entirely responsible for process-oriented music. At the same time, a number of prominent musicians and composers claimed to have been inspired by cybernetics or to have incorporated cybernetic principles into their music-making.

Andrew Pickering has discussed the work of Gordon Pask (1928-1996), a psychologist and cybernetician who created a cybernetic device called the “Musicolour machine.” Here, I borrow from Pickering’s account of Pask’s invention (2002). Pask was interested in staging theater productions in which the audience interacted with the performance. The Musicolour used a microphone pickup to convert the sound output from a musical instrument, which then was processed through more circuitry and thus controlled a light show whose patterns were influenced by the musical tones. Significantly, the processing that generated the light show was designed to vary unpredictably and thus be “opaque and inscrutable” to the performer; if the musical performance became too repetitive, the machine would “get bored and cease to respond, encouraging the performer to try something new” (2002, 427). As Pask stated, “[The performer] trained the machine, and it played a game with him. In this sense, the system acted as an extension of the performer with which he could cooperate to achieve effects that he could not achieve on his own” (2002, 427). Thus, the Musicolour performances had no set goal but were in each case to create a dynamic system that incorporated the machine, the performers, and the environment to which each responded. These interactions, which by their nature tended to vary from performance to performance, constituted the “piece” being performed.
A 1966 *Cybernetica* article by Roy Ascott, an artist and theorist interested in creative applications of cybernetics, focuses primarily on visual art, but also includes a discussion of music. He cites the writings of John Cage: “If music is conceived of as an *object*, then it has a beginning, middle, and end, and one can feel rather confident when he takes measurements of time. But when it (music) is a *process*, those measurements become less meaningful . . . .” He goes on: “. . . [W]e must arrange our music so that people realize that they themselves are doing it, and not that something is being done to them” (Cage in Ascott 1966, 262, emphasis in original). Thus, the entire process of composition and performance is conceived of as enrolling the performers, the instruments, and the audience into a “system” of experience that is distinct, and experienced as subjectively unique, and yet is part of an ongoing process.

Brian Eno (b. 1948) is a renowned composer/performer who is recognized for contributions in experimental and rock genres. After two albums, he left the 1970s art-/glam-rock outfit Roxy Music to pursue his solo career, which tended toward both pop and more experimental work. Eno is well known for pioneering “ambient” music, which he describes as “[music that] is able to accommodate many levels of listening attention without enforcing one in particular: it must be as ignorable as it is interesting” (Holmes 2002, 263). During the 1970s, Eno developed a strong interest in cybernetics and published a 1976 article discussing cybernetics, “systems theory,” and music. Revisiting the essay in the 1990s, he wrote that “For me the essay was important because it was my personal discovery of complexity theory—the idea that a complex, self-consistent system can derive from very simple initial conditions, and quickly assume organic richness” (1996, 333).

Eno also makes a point about process orientation, using the example of the work of experimental composer Cornelius Cardew (1936-1981), with whom Eno worked in the late 1960s in San Francisco. According to Eno, the use of the “fade” effect on Cardew’s recordings is significant, as it “implies that not that the piece has finished, but that it is *continuing out of earshot*” (1996, 340, emphasis in original). Cardew even underscored this point by recording pieces with fade *beginnings*, which are more atypical in recorded music than the fade-out ending, which may be commonly found not only experimental music but in the rock genre. For Eno, the use of the fade production technique at either end of a piece indicates that “the music is a section from a hypothetical continuum and . . . . it does not exhibit strong ‘progress’ from one point (position, theme, statement, argument) to a resolution” (1996, 340). This material technique is consonant with the
idea that a musical recording may reflect a process rather than a finite composition; it suggests that the listener is only hearing a portion of a larger, or perhaps endless, piece of music.

Brün also composed works, including *Infraudibles* and *Mutatis Mutandis* (both 1968), which emphasized the process of making the music instead of a particular musical result. Of *Infraudibles*, he wrote: “Instead of approaching again the aesthetic question: ‘Which process will generate the desired audible event and thus music?’ it attempts to deal with the political question: ‘What audible events would be generated by desirable processes, and thus music?’” (Chadabe 1997, 278). Unlike Eno and Cage, he was less interested in the philosophical idea that the pieces are parts of a “hypothetical continuum” no matter when or where in time and space they occur, but instead he was interested in setting the right conditions (literally in his case, programming computers with certain instructions that are also allowed to “mutate”), which generate a conducive process for creating music. Like Eno, Cage, and Pask, the focus of Brün’s attention was not on the musical product.

**Control and Determinacy/Indeterminacy**

Paul Edwards writes of what he calls a “closed world discourse,” characterized by “global surveillance and control through high-technology military power” (1996, 1). Edwards argues that a main feature of the closed world, concomitant with an emergent meaning of computers in this period, was the performance of control functions by machines with regard to other machines and by extension on global events and social organization. The closed world was “a chaotic and dangerous space rendered orderly and controllable by the powers of rationality and technology” (1996, 72). Edwards notes the “deep linkages” between these notions of control to Wiener’s and Shannon’s theories regarding communication and information (1996, 67). The idea of control was additionally an important one to people working in experimental and electronic music who had adopted cybernetic theories about communication in human-machine systems. Yet in the examples below, the juxtaposition of control with an element of either randomness or autopoiesis was often seen as a more satisfying means of music production than the use of control alone, whether electronic networks or computers were involved in composition. The idea of the “control machine,” which blended both human agents and electronic networks or formalized
communication mechanisms, engaged these artists’ imaginations as they experimented with notions of control, purpose, and agency. These ideas are related to the concept of process-orientation, but the composers’ and musicians’ dialogues with the idea of control are significant in their own right.

Eno was very taken with the possibilities of autopoiesis in musical production. He had immersed himself in the work of cybernetician Stafford Beer, which he had found fruitful in developing both his process-orientation (above) and his ideas about self-making systems (1996, 333; see Pickering 2002 for a description of Beer’s work as a cybernetician). Here, I quote him at length, discussing what interests him in a portion of a composition called The Great Learning by Cardew:

Cybernetics and systems theory are the mechanisms by which you can explain this piece. It has strong parallels with biological systems, which again aren’t governed by external controls. How do systems like this keep themselves intact? In fact, all systems of this nature are what’s called autopoietic, which means they tend to maintain their own identity.

In the old method of composing, you specify the result you want, and then you present a number of exact instructions to get there. The Cardew piece is radical because he doesn’t do all that, and yet it happens. The behavior remains governed. Political systems are all doing what the old composers were doing. By a system of laws and constraints, they attempt to specify behavior. They’re all saying, “What kind of society do we want?” Then they say, “All right, so let’s constrain this behavior here, and let’s encourage this behavior here.” They’re trying to govern a highly complex system by rote. And you don’t need to do that. Instead of trying to specify what you want in full detail, you only specify somewhat; then you ride on the dynamics of the system in the direction you want to go. There are certain organic regulators; you don’t have to come up with them, you just have to let them operate.

One of the central ideas of cybernetics is that the system itself will inevitably produce a certain class of results . . . . (Eno in Armbruster 1984, 219-20)

In a specific discussion of what happens in the piece, Eno notes the following:

[Cardew’s] score is extremely simple; there’s no notation and very few instructions. Somehow or other, the piece always comes out sounding very beautiful, and very similar from one performance to the next. I started trying to investigate why this piece of music worked as it did, because there are
many other pieces of modern music that try to do the same thing and fail. I thought, “How has he constructed this thing so that it regulates itself in this way?” Because basically that’s what it does. There’s a whole system of automatic regulators that come into being during a performance of the piece. For example, one instruction says, “Sing any note you can hear.” That means that your choice of notes is governed by the available notes in the environment, the notes the other people are singing. In any large space, you always get an acoustic resonance building up, the resonant frequency of the room, and if you have a lot of people singing, the probability is that any note hitting the resonant frequency will sound slightly louder than the other notes. So given that instruction, the chances are slightly in favor of your singing that note. So what happens when this piece begins is that it very quickly settles down around a drone, and the drone is on the resonant frequency of the room. That’s one of the things that happens, and it’s not specified in the score. Cardew probably didn’t even know that it was going to happen. (Eno in Armbruster 1984, 219-20)

Thus, what is most striking to Eno is that even though the piece is relatively not directed or controlled by the composer or the performer, the piece tends to regulate itself so that performances are always relatively similar. Eno argues against unfettered indeterminacy, instead contending that an experimental composition tends toward a class of goals rather than a particular goal, and that this tendency “is distinct from the goalless behavior (indeterminacy) idea . . . .” (1996, 335). To Eno, what makes the piece experimental versus traditional is the fact that the composer and performer relinquish a large degree of control over the piece; the music then is allowed to tend “toward its own organization, and toward its own capacity to produce and control variety . . . .” (1996, 335). It is significant that Eno makes this point not only about experimental music but about the organization of society more generally as well.

Cage was an early proponent of “chance music,” in which elements in the piece are left to chance. Cage was interested in exploring the continuum between exactitude and disorder, but he did not wish to control the outcome of his pieces. For Cage, this included measures to enhance randomness and eliminate the personal tastes of the composer and the performers. His work on chance music began about 1950, when he began to strive to make musical compositions that were “free of individual taste and memory (psychology) and also of the literature and ‘traditions’ of the art . . . .” (Chadabe 1997, 269). It was around this time that Cage was captivated by a translation of the *I-Ching* or “Book of Changes,” the ancient Chinese book of divination and wisdom. The book contains instructions for action based on the
results of six coin tosses of three coins. Cage based his 1951 *Music of Changes* on twenty-six aspects (duration, tempo, dynamics) of composition for which he had used the *I-Ching* to “create” or dictate each aspect of the composition. Cage said of experimental music generally that “the word ‘experimental’ [is taken] to mean making an action the outcome of which is not foreseen,” and he challenged others to use this value in their work (Cage in Ascott 1966, 262).

Cage encouraged curtailment of individual agency in composition and performance. In this way, he hoped to force a result, but not one that could necessarily be foreseen by the composer. Instead, he attempted to enroll the audience as well as the composer and the performers, seeking to realize pieces using the interaction between agents, under the assumption that through the combination of disparate elements, indeterminacy could lead to pieces that even the artist might not have imagined. When asked to reflect on agency and control in a broader sense, he explained that he believed that “Everything always works out to something, but it’s not necessarily for the best . . . .” (Duckworth 1989, 23, emphasis in original). This represents a tension for Cage, who even as he was adamant about the artist’s relinquishment of control, was ambivalent as to whether this might lead to an ideal, utopian outcome, or not. In Cage’s writings, he moves freely between indeterminacy in music and indeterminacy in society.

Cage’s ideas about indeterminacy and chance music were quite influential. The Barrons had worked with Cage in early 1950s Greenwich Village. Bebe later recalled:

> We explored the idea that we didn’t want to control the circuits. . . . Nevertheless, John Cage declared that we were “disgustingly orchestral and musical” in our approach—which was amazing because actually we had less control; we didn’t want the control and in fact had rejected the control—yet it came out sounding “musical.” And I never could understand how that happened, yet it did sound quite musical in many ways—much more so than John Cage’s music! (Vale and Juno 1994, 199-200, emphasis in original)

Bebe also noted that “We never could predict the movement of [the circuits], the patterns of them. *It really wasn’t like composing music at all*” (Holmes 2002, 121, emphasis added). For the Barrons, as well as Cage and Eno, an important aspect of the experimentation in their music was precisely this desire to limit the control that was associated with traditional composition. Ironically, the Barrons were met with outcomes that they considered “musical,” in spite of their best efforts to allow the circuits to determine the pieces!
Conclusions

Norbert Wiener used “cybernetics” in 1948 to refer to “the entire field of control and communication, whether in the machine or in the animal” (1948, 19). However, this is sufficiently vague to encompass vast amounts of research and theory; in these examples, I have examined how cybernetics was actually used by artists. A difficulty I encountered in researching this topic was the fact that on one hand, there seemed to be somewhat of a paucity of primary sources that explicitly linked cybernetics to experimental and electronic music. On the other hand, I often found myself looking at sources whose rhetoric seemed quite in keeping with cybernetic theories, but I could not find an explicit link between the source material and people or ideas that were known to be “cybernetically active.” This presented me with the methodological problem of making decisions about whether, or how, to include sources for whom I could not find evidence of having drawn on cybernetic ideas. I decided against building an argument that relied on material whose explicit cybernetic heritage was dubious and thus have only included as evidence source material that makes explicit reference to cybernetics.

This raises the issue of how to most fruitfully consider scientific concerns as they are translated for or appropriated into arts contexts. While seeking an explanation for this phenomenon is not the main point of this article, references in art practice to science abound, ranging from cybernetics in this example to the use of viral DNA in textile art (Ornes 2007) to modern artists’ interest in the fourth dimension (Henderson 1983). Fred Turner’s work on what he has termed the “cybernetic counterculture” of the 1950s and 1960s indicates some of what may have been at stake for musicians and artists (as well as music listeners and art fans) in engaging with cybernetic theories: “How could they keep the world from being destroyed by nuclear weapons or by the large-scale, hierarchical governmental and industrial bureaucracies that had built and used them? And how could they assert and preserve their own holistic individuality in the face of such a world?” (Turner 2006, 43). Turner also writes that, “[C]ybernetics and systems theory offered an ideological alternative . . . . Any in the counterculture saw in cybernetics a vision of a world not built around vertical hierarchies and top-down flows of power, but around looping circuits of energy and information . . . .” (Turner 2006, 38). And of course, prominent figures’ interest in cybernetics extends beyond scientists and musicians, including for example Stewart Brand (Turner 2006) and Marshall McLuhan (Kline, 2009); Norbert Wiener’s books were widely consumed.
Thus, the issue of popular interest in cybernetics is a part of this story as well; unlike some scientific concerns that might be appropriated by arts practitioners without much public interest, cybernetic discourse was widespread. In general, the social and aesthetic concerns of artists who read scientific theories into their work, and the interactions between these communities, provide an important site for inquiry.

In any event, whether expressed in an explicitly cybernetic framework or not, ideas about human-machine integration, indeterminacy, and control were appealing to many experimental and electronic musicians. It could be the case that cybernetics was too malleable to mean anything specific enough to matter; yet I suspect that there is something more complicated at work. Experimental/electronic music existed prior to the diffusion of cybernetic texts and ideas, yet many ideas that captivated these musicians and composers during this period resonate strongly in places with cybernetic ideas. Indeed, cybernetic ideas are slippery and “seductive” as noted by Pickering (2002, 413).

More than merely a methodological problem, this difficulty in identifying what in the source material could be safely considered “cybernetics” and what could not points to a difficulty that plagued the practitioners of the field of cybernetics, and more recently, has plagued analysts of the field of cybernetics. As early as the mid-1960s, cyberneticians including Warren McCulloch, Julian Bigelow, and Heinz von Foerster became concerned about the issue of cybernetic research becoming watered down in terms of rigor, about the issue of the term’s potential appropriation, and/or the population of the field by “cranks, dilettantes, and people who are not scientific in their approach, are misinformed, and unrealistic” (March 30, 1965, Julian Bigelow to Paul Henshaw; see also March 16, 1965, Warren McCulloch to John, Jack, and Bob, Warren S. McCulloch papers, American Philosophical Society; see also Kline, 2009). Wiener himself had expressed worry over the “overpublicizing” of cybernetics as early as 1952 (January 22, 1952, Robert S. Morison Diaries, Rockefeller Archives Center, Tarrytown, NY). Therefore, even people who used the language of cybernetics could not be assumed to be practitioners of cybernetics in the eyes of the people who had nurtured the field in its early days.

It is an obvious point that science studies scholars may benefit from consideration of electronic and experimental music as another site where cybernetics-inflected discussions of human-machine integration, information, autopoeisis, and determinacy/indeterminacy, control, and complexity may be found, which has been overlooked as science studies has focused on these topics’ occurrences in the social and natural sciences. It is certainly
appropriate to “follow the actors,” attending to the bulk of cybernetic research and theory that was indeed oriented around the sciences (Latour 1987). But as prominent cyberneticians such as von Foerster and Pask began to musical experimentation in what they understood to be cybernetic ideas and practices, and as John Cage cropped up in Cybernetica, it seems worthwhile to extend the science studies analysis of cybernetics to include its relationship to electronic and experimental music. Perhaps less obviously, the appearance of cybernetics in experimental and electronic musicians’ language, music, and instrumentation may also tell us something more about what cybernetics was (or perhaps what it was not), if we listen.

Discourse may be constituted through social construction of theory and social connections between actors, according to Paul Edwards (1996, 236). In some cases, the links between people are clear, such as the professional relationship between Brün and von Foerster, and the Barrons’ work with Cage. In other cases, the discourse linkages may have been perpetuated by artists reading Wiener, McLuhan, or Beer, and there is evidence to suggest this was the case in the examples of the Barrons, Cage, and Eno. The point is that the discourse communities of scientific cybernetics practitioners and experimental musicians, composers, and instrument builders did not necessarily overlap in terms of materiality or practice, and in some cases, the origins of musicians’ cybernetic interests are not clear, yet they could and did use the language of cybernetics.

Geof Bowker has argued that cybernetics was a “universal” discipline and that its rhetoric and concepts served as obligatory and distributed passage points, enabling its operation as either a “primary [scientific] discipline, directing others . . . or as a discipline providing analytical tools indispensable to the development and progress of others” (1993, 122). Bowker argues that cybernetics held the appeal, for a time, of offering “a general approach to the world” (1993, 116). Bowker rightly notes that in the natural and social sciences, the language of cybernetics could “be yanked out of one context . . . and plugged into another . . . with the translation into the language of cybernetics doing the work of glossing the discontinuity” (1993, 116). The example of experimental music might be seen as an instance of cybernetic language being “translated” to patch in to yet another context (yet Bowker might not accept this characterization since he does not address cybernetics outside the sciences).

In any event, the example of experimental and electronic music demonstrates that cybernetics was more than a universal language within the sciences. Some members of the experimental arts community who used cybernetic language or claimed to make use of cybernetic ideas could not
be viewed as practitioners of or contributors to cybernetic science. The boundary work by McCulloch and Bigelow around this issue indicates that scientific cyberneticians were aware of this problem, though I have not seen any references to musicians in particular as a group that threatened the status of scientific cybernetics (Gieryn 1983). (Indeed the collaboration of some artists like Brün was welcomed, and a musical component of the 1968 London “Cybernetic Serendipity” art exhibition was celebrated in the American Society of Cybernetics newsletter: “Viewers who wish to create their own complex music patterns will find themselves at home with electronics keyboards and weird associated gadgetry . . . Far out audio chambers in a variety of fiberglas [sic] shapes look like alien creatures along one side of the hall for music buffs to clamber into to sit, legs akimbo, and listen to the eerie sounds of a computer attempting to ‘out-beat’ Beethoven” [ASC newsletter 1968, 3]; Reichardt, 1968.) Bowker’s insistence that cybernetics engendered an economy within the sciences does not “translate” well to consideration of cybernetics outside the sciences, and he does not address the boundary work by cyberneticians over the boundary of science and non-science during the period he examines. Julian Bigelow’s refusal to participate in the founding of the American Society for Cybernetics in 1964 demonstrates that this was a serious concern (March 30, 1965, Julian Bigelow to Paul Henshaw, Warren S. McCulloch Papers, APS).

Bowker’s emphasis on cybernetics as a universal language also causes him to elide what Hayles has described, the changes in the meanings of cybernetics over time, and what I have argued for above, the (sometimes subtle) variations in cybernetic themes (see also Kline, 2009). I argue that the Barrons’ approach to their circuitry, the information theorists’ quest for ever-increasing complexity, Pask’s Musicolour, Cage’s process-orientation, and of course Eno’s explicit discussion of autopoietic systems all most resemble Hayles’ second wave of cybernetic thinking. Yet even seen as being unified by autopoiesis and self-making of systems, cybernetic theories were robust for these people, allowing the four different themes discussed above to flourish.

It is worth noting that, as Hayles states, some features of autopoiesis in these examples do contain traces of homeostasis. I would argue that Cardew’s piece as discussed by Eno has tendencies that not only are those of self-making systems but also in certain ways resemble systems which seek stasis. This highlights a slippage in the use of cybernetic discourse, while at the same time leaving ample room for both “waves” of cybernetics to be active, even concurrently, in the minds of individual cyberneticians. Yet I am not sure that human-machine integration, information,
process-/systems-orientation, determinacy/indeterminacy are precisely the “same” cybernetics; they were related and linked to one another in discourse and in the minds of these musicians and composers, but they were also distinct from one another. And a dynamic range of ideas about musical composition, performance, and instrumentation, were explicitly linked to cybernetics.

Trevor Pinch and Karin Bijsterveld (2003) argue that debates over new music technologies and the boundaries they supposedly violate provide the analyst with breaches in musical culture; in each of these moments, these breaches tell us about conventional, normative frameworks, and attitudes toward machines that are otherwise taken for granted. In particular, the boundary between what the division of labor should be between machines and humans is often a site of contestation, for actual labor practices as well as in terms of artistic capabilities, aesthetics, technical skill, and interpretative work. This argument brings to mind Herbert Brün’s “polemic” aimed at his colleagues over whether he could make his computer-programmed compositions reveal or display the human personality integrated into them. The 1956 Scientific American article and the 1968 Cybernetic Serendipity art exhibit also contest the boundary between human and machine; particularly evocative is Pinkerton’s droll suggestion that calculations and machines may someday “out-Shostakovich Shostakovich.” Additionally, the Barrons encountered significant resistance from the musicians’ union to their film score; to avoid conflict, they had to refer to their product not as “music” but as “electronic tonalities” in the liner notes to Forbidden Planet, for example (Murphy 2006, 114). More generally, it is quite apparent that experimental and electronic music was a site in which the boundaries between human and machine were called into question, played with, and stretched.

Cybernetic theories were also capable of focusing potent anxiety about the future of humankind generally. Following his World War II research, Norbert Wiener suffered an acute crisis of faith over his participation in scientific research because of its potential applications in wartime. He reacted by reaching out to physiology and the social sciences, whose enterprises were, he felt, “most remote from war and exploitation,” and devoting himself to popular meditations on cybernetic theory and philosophy (Wiener 1948, 28; Wiener 1954, 1964). Peter Galison writes that, “In the years that followed [his involvement in wartime research and the deployment of the atomic bomb], Wiener repeatedly stressed the power of cybernetics to save, enslave, or destroy humanity” (1994, 254). For Wiener and other cybernetic thinkers, building the future of scientific and social research on a cybernetic
foundation was no less potent than to enable control of the universe. Needless to say, for many, including Wiener, this potential was dangerous.

In the applications of cybernetics discussed above, the issue of control is one that the artists approach with ambivalence. It would seem that the attitude toward control is often a discourse that is neither a “closed world” nor anxious one; instead, the deliberate application of cybernetics is more open and indeterminate. This sensibility allows uncertainty and the systems concatenating human and nonhuman agents and events to be neither fully determined nor fully autonomous. In addition, in many of the above examples, the lines between music or art and the rest of society are deliberately blurry; Eno and Cage wrote specifically of social systems being organized by the same principles as musical systems, and Cage in particular would not separate the two even for a moment. Cybernetics alone was not responsible for these artists’ approaches to the issue of control and determinacy, but it perhaps became a way to focus them. The possibility of openness that these musicians and composers interpret to be part and parcel of cybernetics stands in contrast to the “closed world” discussed by Edwards. The new possibilities afforded by electronics and computers provided both a material and imaginary link for experimenters interested in pursuing new structures and new sounds. The hope and promise attached to the possibility of computers, noted above by Brün and von Foerster, are also a common rhetoric that occurs repeatedly in these sources (see Turner 2006 for more on the shifting meanings of computers and computing).

Media theorist and cultural critic Marshall McLuhan’s ideas appear repeatedly in these sources, and McLuhan had read cybernetics and viewed Wiener’s work favorably (Kline, 2009). While McLuhan was not a “cybernetician” per se, the centrality of “electric speed” and the relationship of electric technologies to the human nervous system in his writings are worth noting: “Having extended or translated our central nervous system into the electromagnetic technology, it is but a further stage to transfer our consciousness to the computer world as well” (1964, 67). McLuhan further states, “Our private and corporate lives have become information processes because we have put our central nervous systems outside ourselves in electric technology” (1964, 60). I argue that the artists’ references to McLuhan and the way that his arguments are treated as self-evidently true provide evidence that his ideas about a “cybernated” society are just beneath the surface for some of these people in their conceptions of what they were producing as experimental musicians.

Cybernetics thus offered a malleable and popular vocabulary for discussing and creating music to reflect a range of topics considered important
by experimental music practitioners. The use of the language of cybernetics in the field of music by people who were not practitioners of the sciences of cybernetics bolsters Bowker’s claim that the cyberneticians’ strategic development of a universal language was successful, but perhaps it was too successful. Ronald Kline (2009) has drawn attention to the fact the cyborg, later a popular concept for both cyberneticians and analysts of cybernetics in science studies (Haraway 1991), was not a component of cybernetics as envisioned by main cyberneticians until the mid-1960s. The cyborg’s appearance in many contexts illustrates the broader point that cybernetics was ripe for not only translation but wholesale appropriation, and it could mean many things to many people. Cybernetics offered a means to frame the ambiguities, anxieties, and potentials inherent in issues pertaining to control and complexity in art and music, the relationships between humans, machines, and the environment, and the relationship of art and music to the society at large (including ideas in the sciences). Edwards has referred to the “open horizon of an unpredictable and increasingly complex postmodern world” (1996, 252); one wonders whether Brian Eno was raising these issues in the title of his 1978 album Before and After Science.8 David Cope writes of John Cage that “Encouraged by the words of social philosopher Marshall McLuhan [and others] . . . ., Cage has developed a personal philosophy expressed clearly in his sweeping statement: ‘Everything we do is music’” (Cope 1976, 197). Clearly, cybernetics was more than science, as early as the 1950s, and certainly by the 1960s.

Notes

1. Greenwald (1986, 57); Taylor (2001, 94). Often films would use acoustic/traditional instruments for earth settings and humans, and electronic sounds for space and space creatures; the Barrons ignored this convention in this film.

2. Here, I wonder whether Bebe is referring to Wiener’s discussion of animal reflexes and Pavlov’s research with animals, Human Use of Human Beings (1954, 68-9). The first edition of Human Use of Human Beings was actually published in 1950, not 1951 as Bebe stated.

3. Cage was active the New York City arts/countercultural scene in the 1960s and 1970s, and this statement bears a resemblance to other contemporary techno-utopian sentiments, like these lines from Richard Brautigan’s 1967 poem “All Watched Over by Machines of Loving Grace”:

I like to think (and/the sooner the better!)/of a cybernetic meadow/where mammals and computers/live together in mutually/programming harmony .....

4. Cybernetica was an international scientific journal devoted to discussions of applications of cybernetic theory, founded in 1958.

5. For example, though she does not explicitly mention cybernetics, Suzanne Ciani said the following when discussing her synthesizer, the Buchla 200: “Every change in voltage or
triggering of an event was accompanied by a correlating red light. These myriad lights gave constant feedback of exactly what was going on in this complex system and seemed to communicate intelligently. One could set up self-generating textures that would vary constantly, randomly, musically. It was a machine of the highest order, a companion, a partner, a friend, and a lover.” Quoted in Kettlewell, 2002, 143-4. Another example of this is the work of composer Conlon Nancarrow (1912-1997), who sought to eliminate the human performer because humans were not virtuosic enough to perform his compositions, leading him to compose for player piano.

6. Although not important in the story of cybernetics and music, McCulloch and Bigelow were major figures in the field of cybernetics. Bigelow (1913-2003) was an electrical engineer at Princeton who participated in the Macy conferences; he is most famous for his collaboration with John von Neumann to build ENIAC. McCulloch (1899-1969) was a cybernetician and neurophysiologist at MIT, who with Walter Pitts described neural networks (1943); he was also active in the Macy conferences and helped found the American Society for Cybernetics in the 1960s.

7. Rockefeller Foundation administrator Robert Morison wrote of Wiener: “[He is] not quite as upset as yesterday, but worried about . . . the overpublicizing of cybernetics (for which he is largely responsible) and his own future.” RF, 12.1, Diaries, Box 47, 1952, pp. 13, January 22, 1952.

8. This album was more on the pop end of Eno’s work, but some of the lyrics were generated using what Eno called “oblique strategies,” used to jog the mind during the process of generating music. The artwork for this album was created by Eno’s artist friend Peter Schmidt, who shared an interest in working this way and helped inspire Eno to create his deck of cards that contained the strategies. See MacDonald (1977).

References


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