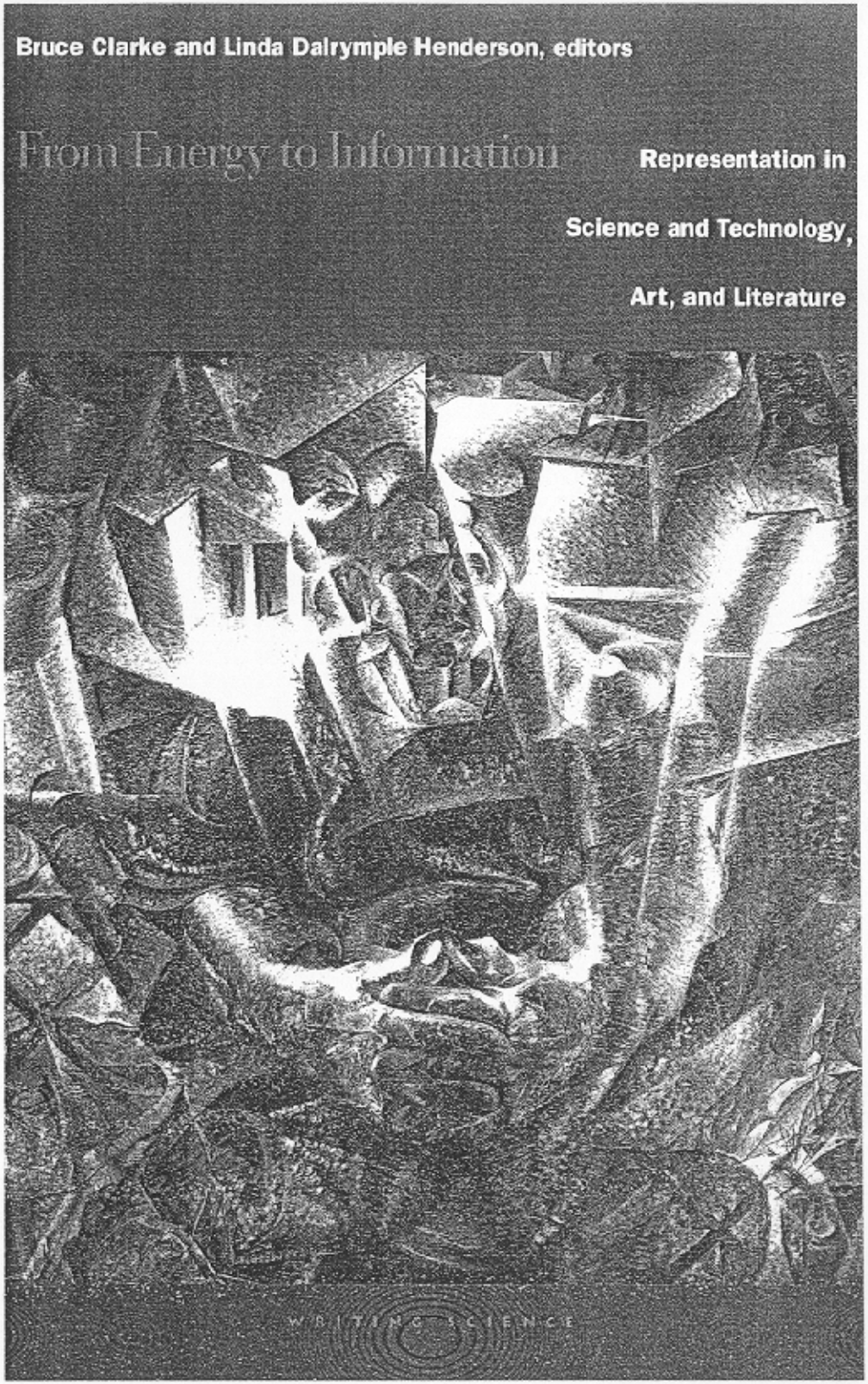

CHAPTER TWELVE

Cybernetics and Art: Cultural Convergence in the 1960s

EDWARD A. SHANKEN

In 1956, Hungarian-born artist Nicolas Schöffer created his first cybernetic sculpture *CYSP I* (figure 12.1), the title of which combined the first two letters of *cybernetic* and *spatio-dynamique*.[1] In 1958, scientist Abraham Moles published *Théorie de l'Information et Perception Esthétique*, which outlined "the aesthetic conditions for channeling media."[2] Curator Jasia Reichardt's exhibition *Cybernetic Serendipity* popularized the idea of joining cybernetics with art, opening at the Institute of Contemporary Art (ICA) in London in 1968, and traveling to Washington, D.C., and San Francisco between 1969–1970.

Not surprisingly, much artistic research on cybernetics had transpired between Schöffer's initial experiments of the mid-1950s and Reichardt's landmark exhibition over a decade later. Art historian Jack Burnham noted that these inquiries into the aesthetic implications of cybernetics took place primarily in Europe, whereas the United States lagged behind by "five or ten years."[3] Of the cultural attitudes and ideals that cybernetics embodied at that time in Britain, art historian David Mellor has written, "A dream of technical control and of instant information conveyed at unthought-of velocities haunted Sixties culture. The wired, electronic outlines of a cybernetic society became apparent to the visual imagination—an immediate future . . . drastically modernized by the impact of computer science. It was a technologically utopian structure of feeling, positivistic, and 'scientistic.'"[4]

The evidence of such sentiments could be observed in British painting of the 1960s, especially by a group of artists associated with Roy Ascott and the Ealing College of Art, such as Bernard Cohen, R. B. Kitaj, and Steve Willats.[5] Similarly, art historian Diane Kirkpatrick has suggested that Eduardo Paolozzi's collage techniques of the early 1950s "embodied the spirit of various total systems," which may possibly have been "partially stimulated by the cross-disciplinary investigations connected with the new field of cybernetics."[6] Cybernetics offered these and other European artists a scientific model for constructing a system of visual signs and relationships, which they attempted to achieve by utilizing diagrammatic and interactive elements to create works that functioned as information systems.

Stanford UP, 2002

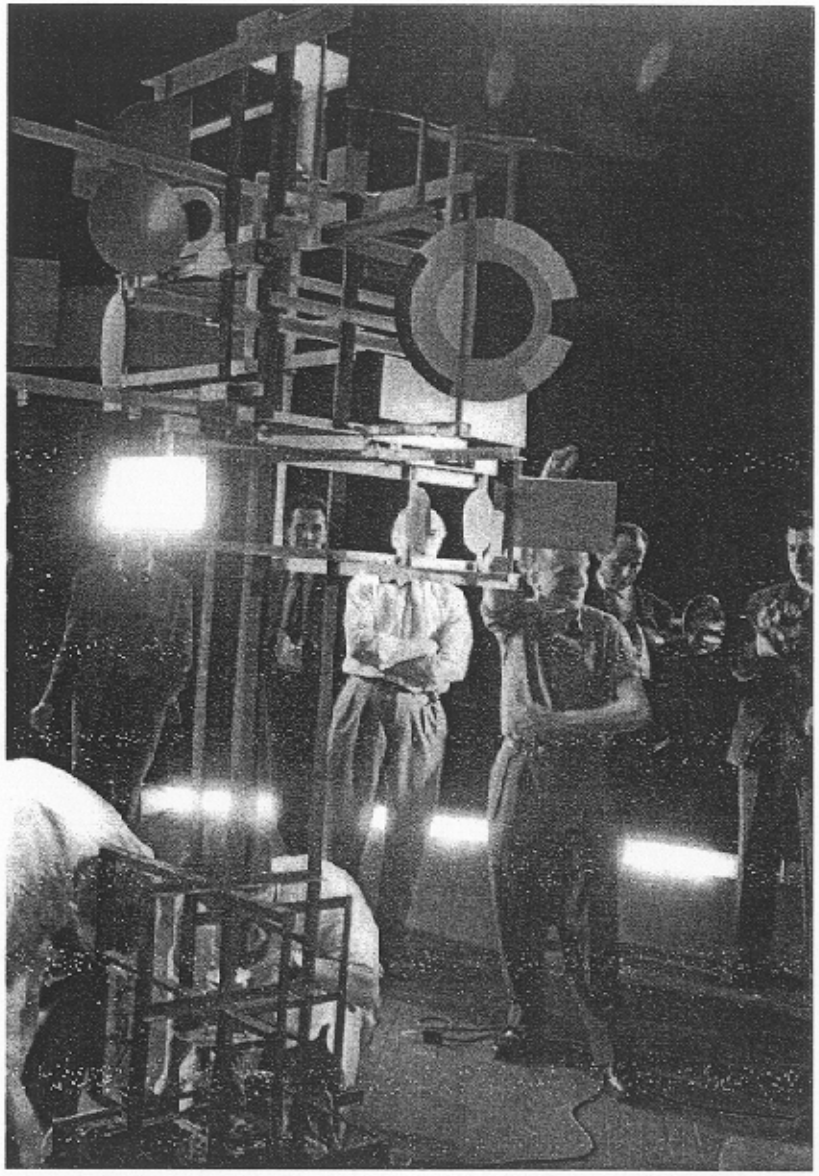

FIGURE 12.1. Nicholas Schöffer, *CYSP I*, 1956. Electronic, interactive sculpture. Shown on the stage of the Sarah Bernhardt Theater, Paris, where it performed with the Maurice Bejart ballet group, to a concrete music composition by Pierre Henry in 1956.

This essay begins with a general overview on the origin and meaning of cybernetics, and then proceeds to examine the convergence of cybernetics with aesthetics, paying particular attention to connections between the scientific paradigm and several distinct tendencies in post-World War II experimental art that emerged independently of it. These complementarities are crucial in explaining not only why it was even possible for art to accommodate cybernetics, but why artists utilized cybernetics in particular ways. The discussion focuses on the artistic practice, art pedagogy, and theoretical writings of British artist Roy Ascott. In 1968, Ascott rightly described himself as "the artist responsible for first introducing cybernetic theory into art education [in Britain] and for having disseminated the concept of a cybernetic vision in art through various art and scientific journals."[7]

True to his "cybernetic vision," Ascott conceived of these various aspects of his praxis as interrelated components of a larger system comprising his total behavior as an artist. The conceptual continuities that run through his work as an artist, teacher, and theorist offer unique insights into the impact of cybernetics, not only on Ascott's *oeuvre*, but on art in general. The intersection of cybernetics and art provides access, moreover, into a richly textured convergence of cultural ideas and beliefs in the 1960s.

THE ORIGIN AND MEANING OF CYBERNETICS

The term *cybernetics* was originally coined by French mathematician and physicist André Marie Ampère (1775–1836) in reference to political science. In the 1940s, American mathematician Norbert Wiener, generally acknowledged as the founder of the science of cybernetics, recoined the term from the Greek word *kubernetes* or *steersman*—the same root of the English word *governor*. According to Wiener, cybernetics developed a scientific method using probability theory to regulate the transmission and feedback of information as a means of controlling and automating the behavior of mechanical and biological systems. Cybernetics also drew parallels between the ways that machines, such as computers, and the human brain process and communicate information. W. Ross Ashby's *Design for a Brain* (1952) and F. H. George's *The Brain as Computer* (1961) were important works in this regard and suggest the early alliance between cybernetics, information theory, and artificial intelligence.[8]

Emerging concurrently with the development of cybernetics, the closely related field of information theory was also concerned with the behavior of communication systems, and in particular, the accuracy with which source information can be encoded, transmitted, received, and decoded.[9] In gen-

eral, the theory pertained to messages occurring in standard communications media, such as radio, telephone, or television, and the signals involved in computers, servomechanisms, and other data-processing devices. The theory could also be applied to the signals appearing in the neural networks of humans and other animals. With regard to cybernetics, information theory offered models for explaining certain aspects of how messages flow through feedback loops.[10] A feedback loop enabled individual components of a system to dynamically communicate information back and forth. Wiener envisioned cybernetics as offering a method for regulating the flow of information though feedback loops between various interrelated components in order to predict and control the behavior of the whole system. Cybernetics could facilitate automation by enabling a system to become self-regulating and therefore maintain a state of operational equilibrium. In Europe and North America, the concept of *feedback* became a pervasive trope of the 1960s, entering into popular parlance as a common term for verbal exchange of ideas ("I want your feedback"), and, as will be discussed, becoming incorporated into pop music and experimental art via the feedback of musical instruments and video cameras.

To summarize, cybernetics brings together several related propositions:

1. phenomena are fundamentally contingent;
2. the behavior of a system can be determined probabilistically;
3. with regard to the transfer of information, animals and machines function in quite similar ways, so a unified theory of this process can be articulated; and
4. by regulating the transfer of information, the behavior of humans and machines can be automated and controlled.

Cybernetics makes a fundamental shift away from the attempt to analyze the behavior of either machines or humans as independent and absolute phenomena. The focus of inquiry becomes the dynamic and contingent processes by which the transfer of information among machines and humans alters behavior at the systems level.

ART, CYBERNETICS, AND THE AESTHETICS OF INTERACTIVE SYSTEMS

By Ascott's own account, he discovered the writings of Wiener, George, and Ashby in 1961, just before taking a position his mentor Victor Pasmore had secured for him as Head of Foundation Studies at Ealing College of Art. The work of these and other authors writing about cybernetics and related fields

captivated his imagination, catalyzing what Ascott described as an Archimedean "'Eureka experience'—a visionary flash of insight in which I saw something whole, complete, and entire."[11] Ascott's insight was a sweeping yet subtle vision of the potential artistic applications of the cybernetic principles of information, feedback, and systems.

With regard to the relationship he perceived between cybernetics and art, Ascott noted in retrospect that the "recognition that art was located in an *interactive system* rather than residing in a material object . . . provid[ed] a discipline as central to an *art of interactivity* as anatomy and perspective had been to the renaissance vision."[12] In the 1960s, he did not use the term *interactivity* (a term that in the 1990s became jargon for multimedia computing). But Ascott frequently used the words *interact*, *interaction*, *participate*, and *participatory* to express the idea of multiple levels of interrelations among artist, artwork, and audience as constituents of a cybernetic system. This interactive quality underlying Ascott's early vision of cybernetic art was founded on the concepts of process, behavior, and system. As he wrote in his 1967 manifesto "Behaviourables and Futuribles," "When art is a form of behaviour, software predominates over hardware in the creative sphere. Process replaces product in importance, just as system supersedes structure."[13]

Moving away from the notion of art as constituted in autonomous objects, Ascott redefined art as a cybernetic system comprised of a network of feedback loops. He conceived of art as but one member in a family of interconnected feedback loops in the cultural sphere, and he thought of culture as itself just one set of processes in a larger network of social relations. In this way, Ascott integrated cybernetics and aesthetics to theorize the relationship between art and society in terms of the interactive flow of information and behavior through a network of interconnected processes and systems. But Ascott's concern with enabling viewers to participate in the process of composing a picture predates his awareness of cybernetics. For example, in 1960 he created his first *Change Painting*, six Plexiglas (*perspex* is the British term) panels, each containing an abstract shape rendered in a painterly gesture. Each shape, according to the artist, was like a seed intended to capture the potential of myriad possibilities of a much larger idea distilled to its essence. These "ultimate shapes," as he has called them, were set in various layers of a grooved frame that permitted each panel to slide horizontally along its length. The variable formal structure of a *Change Painting* (figure 12.2) made possible a multiplicity of compositional states.

It was Ascott's intention that viewers could more actively participate in the creative process by determining the state of the artwork according to their subjective aesthetic sensibilities at a particular moment. Thus, both the work itself and one's experience of it unfolded over the duration of interact-

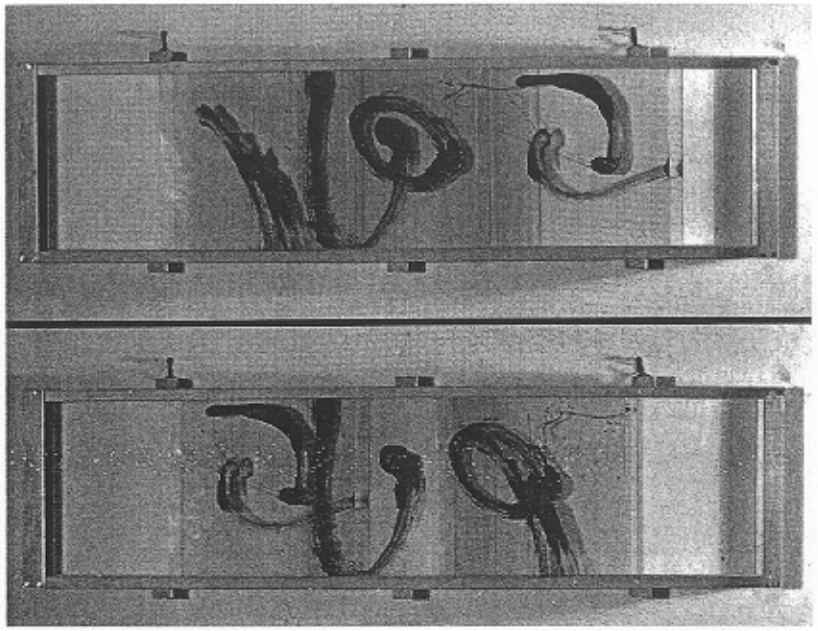

FIGURE 12.2. Roy Ascott, *Change Painting*, 1960. Wood, plexiglas, and oil, 66 × 21 in. Two different states.

ing with it. Each work depended on an exchange of information between the artist, the viewer, and the object. The ongoing, cumulative result of these interactions represented the potential of the work's infinite number of compositional possibilities. Although the principles of contingency, feedback, and control could be used to explain Ascott's *Change Painting*, the artist was not yet familiar with these concepts within the context of cybernetics. Nonetheless Ascott's theoretical and artistic concerns resulted in the expression of related ideas in visual form, indicating how scientific ideas and artistic ideas are complementary, and can arise independently from many common sources of human knowledge and social exigency.

Because it predates his awareness of cybernetics, Ascott's initial research into the durational aspects of art and his pursuit of audience participation and interactivity must be understood in other contexts. A number of mid-century contemporary artists in Britain participated in the exploration of art's temporal dimension. Mellor has observed that "the timetable of the performed painting/action became a key document [for artists] and the notion of the art work as notated event in time underlay John Latham's first theorizing of the 'event-structure'" around 1954.[14] Art historian Kristine Stiles has

traced one of the roots of this tendency to the performative aspects of *art informel* painting first demonstrated to a large audience by Georges Mathieu in Paris in 1954, and later in London at the ICA in 1956.[15]

Certainly Stiles is correct that the genealogy from gestural abstraction to happenings to the performative elements of interactive art offers important insight into the growing concern in the 1960s with the temporal dimension of the plastic arts. By Ascott's own estimation, the work of the New York school, and Jackson Pollock's web-like compositions in particular, greatly influenced his own thinking about art. While the abstract expressionist ethos of unbridled expression of the unconscious was too romantic for Ascott's temperament, Pollock's physical, corporeal involvement in and around his paintings established an important model for experimenting with the process by which art comes into being. In addition, the interconnecting skeins of Pollock's dripped and poured paint came to suggest, for the younger artist, ways in which art functions metaphorically within connective networks of meaning.[16] Pollock's decision to take the canvas off the easel and paint it on the ground altered the physical working relationship between artist and artwork from a vertical plane to a horizontal one, in which the artist looked down on the canvas from a bird's eye view. In so doing, this method of working contributed to the reconceptualization of painting from a "window on the world" to a cosmological map of physical and metaphysical forces.

In this regard, Ascott was drawn to the conceptual orientation of Marcel Duchamp's diagrammatic works. For example, *3 Standard Stoppages* (1913–1914) also mapped a horizontal relationship between artist and artwork. Moreover, it exemplified the method of chance operations that Ascott would employ in subsequent works. Duchamp's *Network of Stoppages* (1914), which can be interpreted as artistic analog to the decision-trees of systems theory, offered a model for the interconnected semantic networks of form and text that Ascott presented in his solo exhibition at the Molton Gallery in London in 1963. Similarly, the *Large Glass* (figure 6.12) was interpreted by Jack Burnham as Duchamp's visual map of the structural foundations of western art history and the internal semiological functioning of art objects through a diagrammatic and transparent form.[17] Though widely disputed, Burnham's cabalistic interpretation of the *Large Glass* is particularly relevant with respect to Ascott's work. For Ascott also drew on mystical sources and used cartographic imagery and transparent media to examine the semiological function of art. Further, the transparency of the *Large Glass*—always including the viewer's changing point of view and context—has been interpreted by Ascott as a precursor to the interactive interfaces of digital computer networks, including his own telematic art projects such as *La Plissure du Texte* (1982) and *Aspects of Gaia* (1989).[18]

Also predating Ascott's awareness of cybernetics, D'Arcy Wentworth Thompson's theories of biomorphology and Henri Bergson's vitalist philosophy deeply impacted the artist's concern with the temporal aspects of art as a durational process of organic unfolding. For example, the "seeds" or "ultimate shapes" with which Ascott sought to capture the essence of potentiality in *Change Painting* may be related to Thompson's ideas of organic development and Bergson's concept of *élan vital*, the vital impetus the philosopher theorized as the animating factor essential to life.[19] Similarly, the durational and mutable aspects of these works were indebted to Bergson's concept of *durée*, which theorized a form of consciousness that conjoined past, present, and future, dissolving the diachronic appearance of sequential time, and providing instead a unified experience of the synchronic relatedness of continuous change. In this light, Ascott's interactive visual constructions of the early 1960s can be interpreted as models in which potential forms could creatively evolve, revealing the multiple stages of their nature (as in the growth of a biological organism), over the duration of their changing compositional states. Ascott conceived of the infinite combination of these compositional transformations as comprising an aesthetic unity, a metaconsciousness or Bergsonian *durée*, including all possible combinations of temporality and consciousness.

ART AND CYBERNETICS: CONVERGENCES AND COMPLEMENTARITIES

Although rooted in a combination of earlier aesthetic, biological, and philosophical models, Ascott's *Change Painting*, which varied as the result of the systematic feedback of information between viewer and artwork, can be seen as a visual analog to the cybernetic theories that the artist would later adopt. Yet one would be hard-pressed to identify a tenable link between cybernetics on one hand, and Pollock, Duchamp, Thompson, and Bergson on the other. Because artists notoriously draw on an enormously wide range of sources, mapping cybernetics onto the history of art is an imprecise science at best. Many twentieth-century artists experimented with process, kinetics, interactivity, audience-participation, duration, and environment, and their work can be explained without recourse to cybernetics. Instead, they relied primarily on aesthetic tendencies that became increasingly central to artistic practice in the post-World War II period.

Nevertheless, a historical approach offers much insight into the aesthetic context in which cybernetics gained currency among artists like Ascott, who were experimenting with the ideas of duration and interaction in the 1960s.

While cybernetics offered a flexible theory that was adaptable to a wide range of applications in the sciences, social sciences, and humanities, it might be argued that in the absence of a complementary aesthetic context, there would have been no common ground for the accommodation of cybernetics to artistic concerns. It is safe to say that the particular ways artists utilized that scientific theory depended, in part, on extant correspondences between aesthetics and cybernetics. The following discussion identifies some of the art historical sources for the convergences and complementarities between aesthetics and cybernetics at mid-century.

If the impressionists began an exploration of the durational and perceptual limits of art, the cubists, reinforced by Bergson's theory of *durée*, developed a formal language dissolving perspectival conventions and utilizing found objects that represented wrinkles in time and space.[20] Early twentieth-century experiments with putting visual form into actual motion included Duchamp's *Bicycle Wheel* (1913) and Naum Gabo's *Kinetic Construction* (1920). Gabo's motorized work in particular, which produced a virtual volume only when activated, made motion an intrinsic quality of an art object's form, further emphasizing the inextricability of time from perception. By the 1950s, experimentation with duration and motion by artists such as Schöffer, Jean Tinguely, Len Lye, and Takis gave rise to the broad, international movement known as kinetic art. Schöffer's *CYSP I*, for example, was programmed to respond electronically to its environment. The motion of viewers and performers triggered its own behavior over time. In this work, Schöffer drew on aesthetic ideas that had been percolating for three-quarters of a century and intentionally merged them with the relatively new field of cybernetics.

The spirit of interactivity and audience engagement gave birth in the 1960s to *nouvelle tendence* collectives working with diverse media to explore various aspects of Kinetic Art and audience participation, including groups such as Groupe Recherche d'Art Visuel (GRAV) in Paris and ZERO in Germany. French artist Jacques Gabriel exhibited the paintings *Cybernétique I* and *Cybernétique II* in "Catastrophe," a group show and happening organized by artist Jean Jacques Lebel and gallerist Raymond Cordier in Paris in 1962. Gabriel's text published on the poster publicizing the event stated, "L'Art et le Cybernétique, c'est la même chose" (Art and cybernetics are the same thing). As another example, artist Wen-Yeng Tsai's *Cybernetic Sculpture* (1969) was comprised of stainless-steel rods that vibrated in response to patterns of light generated by a stroboscope and to the sound of participants clapping their hands.

Beginning in the early 1950s, Western concert music also employed the compositional tactic of engaging the audience more directly in a work, an aesthetic strategy that, through cross-fertilization, played a major role in the

development of participatory art internationally. Again, while not directly related to cybernetics, these musical experiments can be interpreted loosely as an independent manifestation of the aesthetic concern with the regulation of a system through the feedback of information amongst its elements. The most prominent example of this tendency premiered in 1952, American composer John Cage's *4'33"*. Written for piano but having no notes, this piece invoked the ambient sounds of the environment (including the listener's own breathing, a neighbor's cough, the crumpling of a candy wrapper) as integral to its content and form. As has been well documented, Cage's lectures at the New School influenced numerous visual artists, notably Allan Kaprow, the founder of happenings, and Yoko Ono and George Brecht, whose "event scores" of the late 1950s anticipated Fluxus performance.[21]

Also related to developments in experimental music, the visual effects of electronic feedback became a focus of artistic research in the late 1960s when video equipment first reached the consumer market. Following the pioneering work of composers like Cage, Lejaren Hiller, Karlheinz Stockhausen, and Iannis Xenakis in the 1950s, by the mid-1960s, audio feedback and the use of tape loops, sound synthesis, and computer-generated composition had became widespread in experimental music. Perhaps most emblematically, the feedback of Jimi Hendrix's screaming electric guitar at Woodstock (1969) appropriated the National Anthem as a counterculture battlecry. The use of electronic feedback in visual art includes Les Levine's interactive video installations such as *Iris* (1968) and *Contact: A Cybernetic Sculpture* (figure 12.3), in which video cameras captured various images of viewers that were fed back, often with time-delays or other transformations, onto a bank of monitors.

A similar approach was taken in *Wipe Cycle* (1969) by Frank Gillette and Ira Schneider. As Levine noted, *Iris* "turns the viewer into information. . . . *Contact* is a system that synthesizes man with his technology . . . the people are the software." Schneider amplified this view of interactive video installation, stating that, "The most important function . . . was to integrate the audience into the information," and Gillette added that it "rearranged one's experience of information reception."[22] Woody and Steina Vasulka also experimented with a wide variety of feedback techniques, using all manner and combination of audio and video signals to generate electronic feedback in their respective or corresponding media. "We look at video feedback as electronic art material. . . . It's the clay, it's the air, it's the energy, it's the stone. . . . It's the raw material that you . . . build an image with."[23] In these ways, twentieth-century experimental art tended to focus on temporality, to put art into motion, to utilize the concept of feedback, and to invoke interaction with the viewer. In general, such work emphasized the artistic process as opposed to the product and accentuated the environment or context (especially the social context) as opposed to conventional content. These tendencies helped to form the aesthetic context in which cybernetics converged with art.

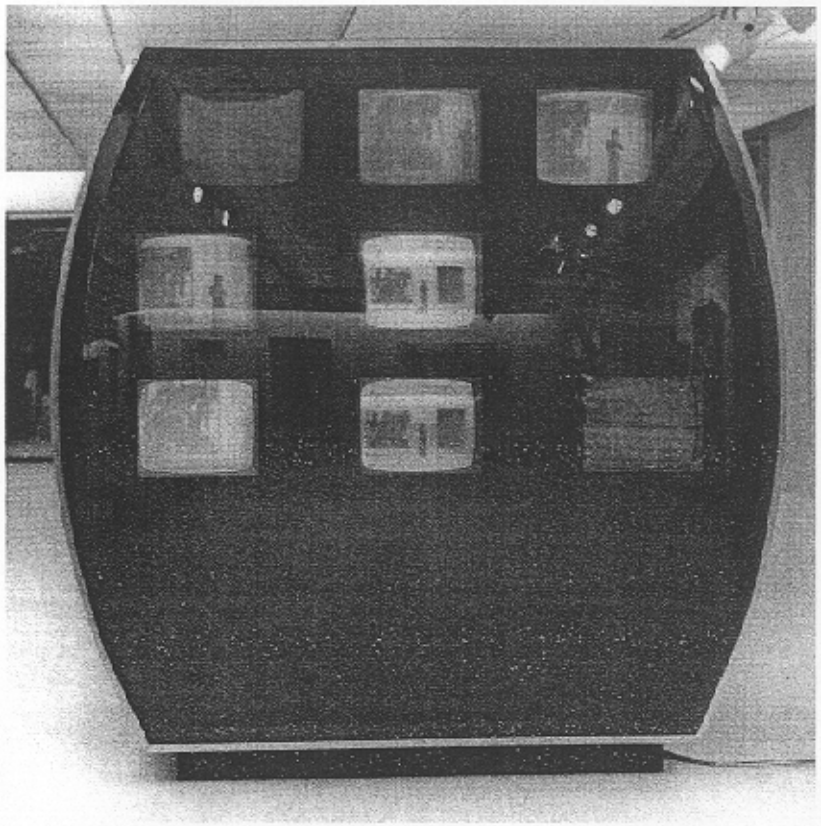

FIGURE 12.3. Les Levine, *Contact: A Cybernetic Sculpture*, 1969. Interactive video installation. Photo © Les Levine.

EARLY ALLIANCES AND FURTHER COMPLEMENTARITIES

Ascott's 1963 solo exhibition, *Diagram Boxes & Analogue Structures*, at the Molton Gallery in London, offers an early example of combining cybernetics and art. By this time, Ascott had assimilated cybernetics as a primary theoretical foundation for merging Bergsonian ideas with constructivism and kinetic art, while at the same time employing the use of diagrams and text as a formal element, developing an original way to apply artistic and scientific

theories to generate visual form. Like Schöffer's "spatiodynamic" sculptures of the early 1950s (which were also based on constructivist principles), Ascott's work added a durational, kinetic element, further extending this lineage in a temporal dimension.[24]

Ascott's statement in the exhibition catalog exemplifies how cybernetics was part of a complex amalgam of aesthetic, philosophical, and scientific ideas that led to his creation of interactive, changeable works of art: "Cybernetics has provided me with a starting point from which observations of the world can be made. There are other points of departure: the need to find patterns of connections in events and sets of objects; the need to make ideas solid . . . but interfusable; an awareness of change as fundamental to our experience of reality; the intention to make movement a subtle but essential part of an artifact."[25] In this passage, the artist explicitly states that cybernetics provided a conceptual framework for interpreting phenomena artistically. Akin to Bergson's concept of durée, he recognizes "change" as fundamental, suggests the modular, concrete aesthetic of constructivism, and shares concerns in common with earlier and synchronous developments in contemporary art internationally, which sought to vitalize art through movement, enactment, and performative elements.

Ascott extended this search for "patterns of connections" to draw parallels between the forms of art and the forms of science, for example, the "ultimate shapes" in his *Change Painting* and the analog wave patterns that represent and carry information in communications systems. He developed a taxonomy of "analog forms," which, like waveforms, were meant to symbolize and convey universal qualities, potentials, intentions, and strategies. In works like *Video Roget* (1962), a moveable calibrator at the center of the piece enabled the relationships among the analog forms (and categories of meaning) to be varied by the user. On the page preceding the reproduction of *Video Roget* in the exhibition catalog, the artist provided a related diagram on tracing paper, entitled *Thesaurus* (1963). The reader could interact with the *Thesaurus* by superimposing it on the image of *Video Roget* to reveal suggested meanings of the individual analog forms and the possible feedback loops among them (figure 12.4).

Ascott extended the parallel he drew between the forms of art and science to include nonwestern systems of knowledge as well. The phrase "to programme a programming programme" appears on a 1963 sketch for the 1964 construction *For Kamynin, Lyubimskii and Shura-Bura*, dedicated to the Russian computer scientists. Yet despite the scientific jargon, in this work and others from the 1960s and 1970s, Ascott visually suggested equivalences between *I Ching* hexagrams, binary notation of digital computers, scatterplots of quantum probability, wave frequencies, and biomorphic shapes (figure 12.5).

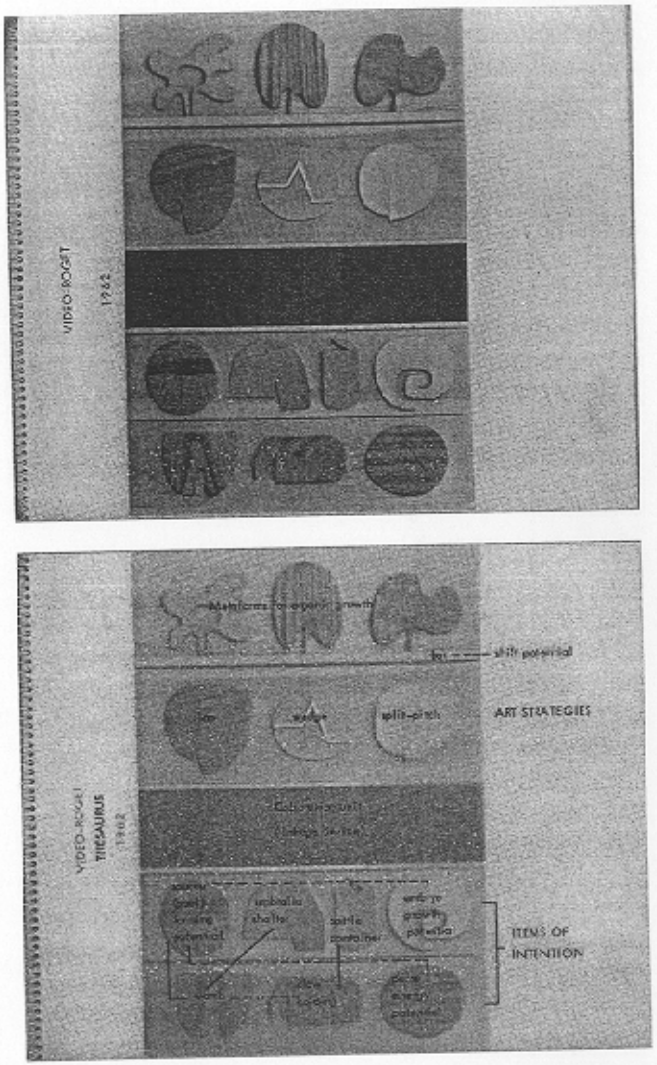

FIGURE 12.4. Roy Ascott, *Video Roget* and *Thesaurus*, 1963. Illustration of *Video Roget* (1962) and tracing paper overlay. Source: Roy Ascott, *Diagram Boxes and Analog Structures* (exhibition catalog, Molton Gallery, London, 1963).

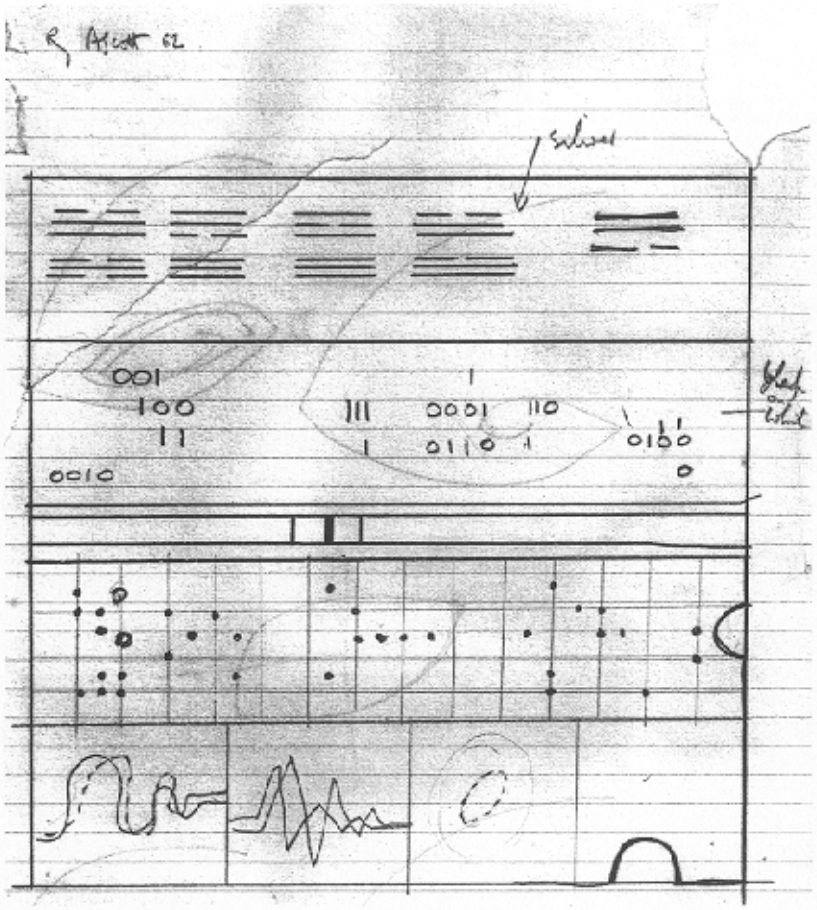

FIGURE 12.5. Roy Ascott, untitled drawing, 1962. 7⅞ × 9 in. approx. Note *I Ching* hexagrams in upper register, followed by binary notation, scatter-plots, and wave-forms. A "calibrator" in the middle suggests the ability to juxtapose or combine various permutations of these systems of information representation.

Two years later Korean-born artist Nam June Paik drew a striking parallel between Buddhism and cybernetics:

> Cybernated art is very important, but art for cybernated life is more important, and the latter need not be cybernated. . . .
>
> Cybernetics, the science of pure relations, or relationship itself, has its origin in karma . . .
>
> The Buddhists also say
>
> Karma is samsara
>
> Relationship is metempsychosis[26]

In a similarly nonhierarchical way, Ascott's theoretical-artistic propositions about the future combined recent advances in science and technology with ancient systems of knowledge. Like an appropriate response to a *koan*, an apparent paradox that cannot be resolved by logical formula, Ascott's amalgamation of science, art, and mysticism never sought an unequivocal resolution of these seemingly irreconcilable systems of knowledge. Rather, having intuited the paradoxical nature of knowledge, he attempted to better understand the underlying systems by which meaning is constructed.

CYBERNETIC SYSTEMS, SEMANTIC SYSTEMS, AND THEIR DISCONTENTS

In works like *Video Roget (Thesaurus)*, Ascott equated visual forms (through which meaning is formally derived) with semantic systems (through which meaning is derived via taxonomic relationships) by drawing both into the principle of contingency that Wiener attributed to the operations of cybernetics. In a two-page diagram (drawn like an electric circuit) in his 1963 exhibition catalog, Ascott wrote, "This Thesaurus is a statement of my intention to use any assembly of diagrammatic and iconographic forms within a given construct as seems necessary." By explicitly stating his intention to use text in his "constructs"—*to use text in and as art*—Ascott strategically expanded the range of what counted as art to include diagrammatic, iconographic, and textual forms as inter-related parts of a cybernetic art system. The universe of potential meanings of such works was to be derived taxonomically and discursively through multi-layered processes in which the flow of information between artists and the objects they make, the semantic systems which govern the reception of works of art, and the actual responses of viewers were all mutually contingent.

Ascott's concern with the semantic complexities of visual representation and the relationship between art and text in the mid 1960s presaged the conceptual art practice of American Joseph Kosuth and the British collective Art & Language in the late 1960s. Indeed, their work shared Ascott's interest in the taxonomic relations through which semantic meaning is—or fails to be—generated. Art & Language attempted to subvert the logic of art objects through the use of textual interventions, in order to interrogate what British art historian Charles Harrison has referred to as the modernist "beholder discourse."[27] To that end, Mel Ramsden's *Elements of an Incomplete Map*

(1968), for example, incorporated four annotated volumes of *Roget's Thesaurus*. Like Ascott's *Video Roget (Thesaurus)* (1963), Ramsden's work suggested equivalences between the way in which language signifies meaning in an interconnected rhetorical system like a thesaurus, and the way in which form signifies meaning in an interconnected visual system. Ascott's cybernetic art employed the further strategy of creating an interactive situation that undermined conventional subject-object relationships between art and audience, thereby raising similar questions about spectatorship.

But whereas Ascott genuinely believed in cybernetics as a "practical and intellectual tool" for the creation of art, the members of Art & Language were much more skeptical, and applied scientific principles to art in a tongue-in-cheek manner, suggesting a parallel between the dogma of cybernetics and the dogma of modernist aesthetics. For example, in *Key to 22 Predicates: The French Army* (1967), Terry Atkinson and Michael Baldwin offered a key to abbreviations for the French Army (FAA), the Collection of Men and Machines (CMM), and the Group of Regiments (GR). Using logic reminiscent of Lewis Carroll, the artists then described a variety of relationships amongst these elements as part of a system (of gibberish): "The FA is regarded as the same CMM as the GR and the GR is the same CMM as (e.g.) 'a new order' FA (e.g. morphologically a member of another class of objects): by transitivity the FA is the same CMM as the 'new shape/order one.'"[28]

This ironic description—through a looking glass, so to speak—mocked the manner of cybernetic explanations with pseudo-scientific acronyms. It reduced to absurdity the systematization of relationships between individuals, groups, and institutions that Ascott employed in defining his theory of a cybernetic art matrix in the 1966–1967 essay, "Behaviorist Art and the Cybernetic Vision." Similarly, in Harold Hurrell's artwork, *The Cybernetic Art Work that Nobody Broke* (figure 12.6), a spurious computer program for interactively generating color refused to allow the user to interact beyond the rigid banality of imaginary binary input demanded by the black and white text that was the work's only physical manifestation. If the user put in a number other than 0 or 1, the program proffered the message: "YOU HAVE NOTHING, OBEY INSTRUCTIONS!" If the user put in a non-number, *The Cybernetic Art Work That Nobody Broke* told him or her that there was an "ERROR AT STEP 3.2."[30]

Harrison has interpreted these experiments as "flailing about—products of the search for practical and intellectual tools which had not already been compromised and rendered euphemistic in Modernist use."[31] But they may be interpreted equally as ironic critiques of artists' failures to address the incommensurability of science and art, and as parodies of the rigid confines within which claims for interactive participation might transpire. Such in-

```
THE CYBERNETIC ART WORK THAT NOBODY BROKE


TYPE ALL PARTS
1.1 TYPE "YOU HAVE RED"
1.2 TYPE "YOU HAVE GREEN"
1.3 TYPE "YOU HAVE BLUE"
1.4 TYPE "YOU HAVE YELLOW"
1.5 TYPE "YOU HAVE NOTHING, OBEY INSTRUCTIONS!"


3.05 PRINT#
3.06 TYPE # FOR PP=1:1:3
3.1  PRINT "TYPE EITHER 1 OR 0 IN BOTH A AND B."
3.2  DEMAND A
3.3  DEMAND B
3.4  DO STEP 1.1 IF A=0 AND B=0
3.5  DO STEP 1.2 IF A=0 AND B=1
3.6  DO STEP 1.3 IF A=1 AND B=0
3.7  DO STEP 1.4 IF A=1 AND B=1
3.8  DO STEP 1.5 IF A>1 OR A<0 OR B>1 OR B<0
3.9  DO STEP 3.05


DO PART 3
TYPE EITHER 1 OR 0 IN BOTH A AND B.          A=1
        B=1
YOU HAVE YELLOW


TYPE EITHER 1 OR 0 IN BOTH A AND B.          A=3
        B=3
YOU HAVE NOTHING, OBEY INSTRUCTIONS!


TYPE EITHER 1 OR 0 IN BOTH A AND B.          A=1
        B=0
YOU HAVE BLUE


TYPE EITHER 1 OR 0 IN BOTH A AND B.          A=1
        B=1
YOU HAVE YELLOW


TYPE EITHER 1 OR 0 IN BOTH A AND B.          A=0
        B=0
YOU HAVE RED


TYPE EITHER 1 OR 0 IN BOTH A AND B.          A=R
ERROR AT STEP     3.2
        R              IS UNDEFINED.
```

FIGURE 12.6. Harold Hurrell, *The Cybernetic Artwork that Nobody Broke*, 1969. Text for lithographic print. Source: Charles Harrison, *Essays on Art & Language* (London, 1991).

sights offered a valuable critical perspective on Ascott's cybernetic art theory and practice (and that of other similar-minded artists). At the same time, the resistance of Art & Language to the purposeful conjunction of art and technology can be interpreted as a reactionary manifestation of the collective's rejection of media-based art.

CYBERNETICS AND ART PEDAGOGY

Ascott's theories of art and cybernetics also directly informed his creation of a method for teaching art based on the same principles—a cybernetic pedagogy. In 1964, he described the continuum between his work in the studio and his work in the classroom, which he felt complemented each other: "In trying to clarify the relationship between art, science and behaviour, I have found myself able to become involved in a teaching situation without compromising my work. The two activities, creative and pedagogic, interact, each feeding back to the other. Both, I believe, are enriched."[32] It is no coincidence that he used the language of cybernetics to suggest how his art practice and pedagogy interacted, "each *feeding back* to the other," as part of a mutually reinforcing system. As artist and critic Eddie Wolfram wrote in 1968, "I do not know of any other artist/teacher who projects such a high incident of integration between his teaching ideas and the art-hardware that he makes."[33]

In the classroom, cybernetics offered a clear model for reconceptualizing art and education and their roles in a larger social system, by suggesting the organization of art education curricula in terms of a behavioral system of feedback and control. The course of study Ascott implemented at Ealing beginning in 1961 focused on these cybernetic principles. Students collaborated as elements of a system that regulated their artistic behavior as an integrated whole. For example, as Ascott explained, forming groups of six, each student would be "set the task of acquiring and acting out . . . a totally new personality, which is to be narrowly limited and largely the converse of what is considered to be their normal 'selves.'"[34] A student's preconceptions about his or her personality, strengths and weaknesses as an artist, and about the nature of art itself, were not only thrown into question, but were actively transcended through the forced adoption of different behavioral characteristics and a rethinking of art-making and art as process and system. His or her individual behaviors had to be integrated into a coherent group process, and each member would be "of necessity interdependent and highly conscious of each other's capabilities and limitations" in order to accomplish together the "set goal of producing . . . an *ordered entity*."[35] In this way, students learned about the principles of cybernetics by applying them to art. Their own behavioral interactions became part of a cybernetic art system in which the controlled exchange of information organized the overall structure.

British composer Brian Eno, who was a student of Ascott's at Ipswich from 1964 to 1966, offered a first-hand account of his teacher's pedagogical methods, and their impact on him:

> One procedure employed by Ascott and his staff was the "mindmap." In this project each student had to invent a game that would test and evaluate the responses of the people who played it. All the students then played all of the games, and the results for each student were compiled in the form of a chart—or mindmap. The mindmap showed how a student tended to behave in the company of other students and how he reacted to novel situations. In the next project each student produced another mindmap for himself that was the exact opposite of the original. For the remainder of the term he had to behave according to this alternative vision of himself.[36]

Eno further noted: "For everybody concerned this . . . extraordinary experience . . . was instrumental in modifying and expanding the range of interaction each student was capable of."[37]

Moreover, in Ascott's Groundcourse, students were introduced to other experimental artists and intellectuals in a variety of disciplines. One powerful example of the influence of this guest lecture program was the impact on the young British musician Peter Townshend of artist and holocaust survivor Gustav Metzger's presentation on destruction in art. Townshend, who would later form the rock band The Who, has credited Metzger's theory with giving him the idea to destroy musical instruments onstage at Who concert performances—a performative gesture that visually symbolized the anger and rebellion of a generation.[38] Stiles has theorized this transference of ideas from Metzger to Townshend as an example of the process by which the most advanced conceptual developments in experimental visual art are transmitted in insidious ways to become incorporated into popular culture.[39] Such a theory of the operations of art in culture offers a model for understanding how Ascott's cybernetic conception of art entered into the popular imagination.

"BEHAVIOURIST ART AND THE CYBERNETIC VISION"

As with the relationship between his artistic and pedagogical practices, so Ascott has identified substantial systematic feedback (in the cybernetic sense of the term) between his work writing aesthetic theory and his work as an artist and teacher.[40] Ascott's essay "Behaviourist Art and the Cybernetic Vision" exemplifies his theories on, and larger social ambitions for, the appli-

cation of cybernetics to art.[41] As his theoretical point of departure, Ascott joined the principles of cybernetics with emerging theories of telecommunications networks. In opposition to conventional discourses on the subject-object relationship between viewer and artwork, Ascott declared the objectives of art to be the *processes* of artistic creation and reception.

Indeed, process became an increasingly central area of artistic inquiry in the late 1960s and 1970s, laying the conceptual groundwork for the popular use of interactive electronic media that would follow. As Stiles has noted:

> In their writings and works, many artists became increasingly aware of how process connects the superficially independent aspects and objects of life to an interdependent, interconnected network of organic systems, cultural institutions, and human practices. However awkwardly these artists' works anticipated the end of a century that witnessed the advent of massive electronic communication systems like the Internet, their research was vital in visualizing process as a means to align art with the future.[42]

For his part, Ascott theorized the close relationship between the current aesthetic concern with process and the possibilities that cybernetics, computers, and telecommunications held for the future of art and culture.

Ascott's goal in "Behaviourist Art and the Cybernetic Vision" was ambitious: the theorization of a cybernetic system for educating society. In this text, he proposed a new paradigm of art which "differs radically from [the determinism of] any previous era" and would be distinguished by its emphasis on ambiguity, mutability, feedback, and especially behavior.[43] These visionary prospects were incorporated into what he called the Cybernetic Art Matrix (CAM), an elaborate, integrated system for enhancing his cybernetic vision throughout culture. When Ascott devised CAM in 1966, he thought of it as an interrelated system of feedback loops designed to serve professional artists and the general public. It established a model in which the flow of information and services, as well as the behavior of individuals, groups, and society, was self-regulating throughout the whole. CAM was intended to provide a variety of functions, such as facilitating interdisciplinary collaboration between geographically remote artists and scientists, providing a pragmatic art education curriculum for the young, and enriching the lives of "the new leisured class" by enhancing creative behavior and providing amenities and modes of aesthetic play. Ascott used symbolic formulas and numerous acronyms to identify particular niches within CAM, and to explain methodically how the various layers were connected within the system.

Ascott envisioned technology as playing a vital role in implementing his cybernetic vision, as a means to enhance human creativity on the individual level and to enable collaborative interaction among participants from diverse

fields and geographic locations. For example, the artist conceived of the computer as "a tool for the mind, an instrument for the magnification of thought, potentially an intelligence amplifier. . . . The interaction of artifact and computer in the context of the behavioral structure, is equally foreseeable. . . . The computer may be linked to an artwork and the artwork may in some sense be a computer."[44] In this description, largely informed by H. Ross Ashby's 1956 article, "Design for an Intelligence Amplifier," Ascott's conception of the computer was not simply as a tool for generating images, but rather as an integral component in an interactive, behavioral system.[45]

Ascott's artistic concern with the behavioral implications of cybernetics gradually moved away from the localized environments of his *Change Painting* and other kinetic constructions, and expanded into the possibilities of geographically remote interaction. Inspired in part by the global village prophesied by Canadian media theorist Marshall McLuhan, Ascott envisioned the emergence of art created interactively with computers and through interdisciplinary collaborations via telecommunication networks: "instant person to person contact would support specialized creative work. . . . An artist could be brought right into the working studio of other artists . . . however far apart in the world . . . they may separately be located. By means of holography or a visual telex, instant transmission of facsimiles of their artwork could be effected . . . Distinguished minds in all fields of art and science could be contacted and linked."[46]

What Ascott theorized in 1966 can be described in contemporary language as interactive multimedia in cyberspace. These ideas have become cornerstones of the communications, electronics, and entertainment industries' development and marketing of online services, computer games, and a vast array of software and peripherals in the 1990s and 2000s. Here is another example in which conceptual ideas theorized in the spaces of experimental art later became popularized and commercialized in other modes of cultural production.

THE CYBERNETIC SIXTIES: A LEGACY

Cybernetics had a decisive impact on art. That impact was mediated by the aesthetic context that coincided with the emergence of cybernetic theory in the late 1940s, and by the complementarities between cybernetics and central tendencies of twentieth-century experimental art. Given the emphasis of post-World War II art on the concepts of process, system, environment, and audience participation, cybernetics was able to gain artistic currency as a theoretical model for articulating the systematic relationships and processes

among feedback loops including the artist, artwork, audience, and environment. In the absence of that common ground, it is possible that cybernetics might not have been accommodated to art, or that it would have been accommodated in a very different way.

Roy Ascott's *Change Painting* exemplifies how ideas derived from aesthetics, biology, and philosophy could result in the creation of a visual analog to cybernetics, even though the artist was not yet aware of that scientific theory. More generally, this example shows how various fields and disciplines can independently produce homologous forms in response to a more or less common set of cultural exigencies. Ascott's work as an artist, teacher, and theorist also indicates how the flexibility of cybernetics allowed that theory to be applied to a wide range of social contexts. However, this programmatic quality in the application of cybernetics gives reason for pause: Given that related ideas had already been incorporated into mid-century aesthetics, artists had a wealth of ideas from which to derive and develop formal strategies, pedagogical methods, and theoretical exegeses. In other words, the accomplishments that were made in visual art under the banner of cybernetics might very well have been achieved in the absence of that scientific model. Cybernetics, however, possessed the authority of science, and for better or worse, Ascott brought that seal of approval to bear on his work. Ironically, while Ascott's CAM theory adopted a rigid cybernetic language and organizational schema, his creative imagination was far from limited to the domain of scientifically provable facts and formulas. Instead, he incorporated a wide array of ideas from diverse systems of knowledge, with the result that cybernetics was transformed in his hands from science into art.

Cybernetics also offers a model for explaining how ideas that emerged in the domain of experimental art eventually spread into culture in general. Ascott conceived of this transference in terms of multiple series of interconnected feedback loops, such that information related to the behavior of each element is shared and exchanged with the others, regulating the state of the system as a whole. Such is the case with Ascott's own theorization in 1966 of interdisciplinary collaborations over computer networks, a concept that became the central focus of his theory and practice in 1980, and subsequently has been popularized through web-based multimedia at the turn of the century.

Ascott drew on cybernetics to theorize a model of how art could transform culture. He was particularly insistent that cybernetics was no simple prescription for a local remedy to the crisis of modern art, but represented the potential for reordering social values and reformulating what constituted knowledge and being. In 1968 he wrote: "The art of our time tends towards the development of a *cybernetic vision*, in which feedback, dialogue and involvement in some creative interplay at deep levels of experience are paramount. . . . The cybernetic spirit, more than the method or the applied science, creates a continuum of experience and knowledge which radically reshapes our philosophy, influences our behaviour and extends our thought."[47] Here, Ascott staked a passionate and ambitious claim for the significance of art as a cybernetic system. Ultimately he believed that cybernetic art could play an important role in altering human consciousness, and thereby transform the way people think and behave on a social scale. Indeed, cybernetics has become so enmeshed into the fabric of the industrialized West that it is difficult to imagine conceiving of phenomena in terms not mediated by the principles of feedback and systems.

Norrman and Richard Menke have shown: Ralf Norrman, *Techniques of Ambiguity in the Fiction of Henry James*, Acta Academiae Aboensis, Series A, 54: 2 (Abo: Abo Akademi, 1977), pp. 139–40; Richard Menke, "Telegraphic Realism: Henry James's *In the Cage*," *PMLA* 115 (2000), 975–90.

12. Andrew Moody in "'The Harmless Pleasure of Knowing': Privacy in the Telegraph Office and Henry James's 'In the Cage,'" *The Henry James Review* 16 (1995), 53–65, provides useful historical context for concerns about privacy in a telegraph service.

13. Ralf Norrman in "The Intercepted Telegram Plot in Henry James's 'In the Cage,'" *Notes & Queries* 24 (1977), 425–27, carefully traces out the possibility that the girl's "correction" distracted Lady Bradeen from making the correction she likely intended.

14. Jennifer Wicke, "Henry James's Second Wave," *The Henry James Review* 10 (1989), 146–51.

15. Carl Freedman discusses the cultural context for the novels of the 1960s, "Editorial Introduction: Philip K. Dick and Criticism," *Science-Fiction Studies*, 15 (1988), 121–30. See also Scott Durham in "P. K. Dick: From the Death of the Subject to a Theology of Late Capitalism," *Science-Fiction Studies* 15 (1988), 173–180.

16. The instability in the subject is often preceded by a rift in the family corporation, as in *We Can Build You*, and in a different way in *The Simulacrum*.

17. Kim Stanley Robinson, *The Novels of Philip K. Dick* (Ann Arbor: UMI Research Press, 1984), p. 61.

18. In *Networking*, Laura Otis describes Samuel Morse's belief that telegraph signals traveled at 200,000 times the speed of light. By the time of Tiptree's story, no such illusions about simultaneity were possible.

19. As Andrew Moody in "The Harmless Pleasure of Knowing" and Ric Savoy in "'In the Cage' and the Queer Effects of Gay History," *Novel* 28 (1995), 284–307, both note, upper-class patrons feared that telegraphists might learn information they could use to blackmail their wealthy clients. Tiptree's story suggests that by the late twentieth century the concern had shifted from the individual agent to the corporation.

20. I am indebted to Carol Wald for her astute reading of this story in which she closely analyzes the significance of the waldo as a potentially independent agent, unpublished manuscript.

21. Gardner Dozois comments on the importance of future time in the narrative voice in *The Fiction of James Tiptree, Jr.* (San Bernadino, Calif.: Borgo Press, 1984).

CHAPTER 12

I would like to thank Kristine Stiles for her intellectual and scholarly guidance, which has helped me transform energy to information. Final preparation of this work was supported by a Henry Luce–ACLS Dissertation Fellowship in American Art. This essay is dedicated to the memory of my loving grandparents, Pauline and Benjamin Shanken.

1. Guy Habasque, "From Space to Time," in Marcel Joray, ed., *Nicolas Schöffer*, trans. Haakon Chevalier (Neuchatel, Switzerland: Editions du Griffon, 1963), pp. 10–17. The artist had conceived of his first "spatio-dynamic" tower in 1954.

2. Jack Burnham, *Beyond Modern Sculpture: The Effects of Science and Technology on the Sculpture of this Century* (New York: George Braziller, 1968), p. 344.

3. Ibid., p. 343.

4. David Mellor, *The Sixties Art Scene in London* (London: Phaidon Press, 1993), p. 107.

5. Cohen and Kitaj taught with Ascott at Ealing, where Willats was a student.

6. Dianne Kirkpatrick, *Eduardo Paolozzi* (Greenwich, Conn.: New York Graphic Society, 1971), p. 19. See for example, Paolozzi's *Collage Mural* (1952).

7. Roy Ascott, "Letter to the Editor," *Studio International* 175:902 (July–August 1968), 8.

8. W. Ross Ashby, *Design for a Brain* (New York: John Wiley, 1952); F. H. George, *The Brain as Computer* (Oxford: Pergamon Press, 1962).

9. Warren Weaver and Claude E. Shannon, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1949).

10. Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society* (New York: Avon Books, 1954), pp. 23–24.

11. Roy Ascott, Interview with the author, September, 1995, Montreal.

12. Roy Ascott, "Interactive Art," unpublished manuscript, 1994, p. 3; my emphasis.

13. Roy Ascott, "Behaviourables and Futuribles," in Kristine Stiles and Peter Selz, eds., *Theories and Documents of Contemporary Art: A Sourcebook of Artists' Writings* (Berkeley: University of California Press, 1996), p. 489. Stiles's chapter "Art and Technology" offers a good overview of art and technology in the post-1945 period and a selection of theoretical writings by artists including Ascott, Schöffer, Tinguely, Takis, Piene, GRAV, and Paik.

14. Mellor, *The Sixties Art Scene*, p. 19. Mellor identified 1959 as the date of Latham's theorization of "event structure." Latham claims to have conceived of it much earlier, and certainly prior to Mathieu's performance at the ICA in 1956. John Latham, interview with the author, February 8, 1998, Los Angeles.

15. Kristine Stiles, "The Destruction in Art Symposium (DIAS): The Radical Social Project of Event-Structured Art." Ph.D. dissertation, University of California, Berkeley, 1987. On the neglected significance of George Mathieu, see Kristine Stiles, "Uncorrupted Joy: International Art Actions," in *Out of Actions: Between Performance and the Object 1949–1979* (Los Angeles: Los Angeles Museum of Contemporary Art, 1998), pp. 286–89.

16. Roy Ascott, "Is There Love in the Telematic Embrace?" *Art Journal* 49:3 (Fall 1990), 242.

17. Jack Burnham, "Duchamp's Bride Stripped Bare: The Meaning of the *Large Glass*," in Jack Burnham, *Great Western Salt Works: Essays on the Meaning of Post-Formalist Art* (New York, George Braziller, 1974), pp. 89–117.

18. Ascott, "Is There Love?"

19. See D'Arcy Wentworth Thompson, *On Growth and Form* (c. 1942; Cam-

bridge: Cambridge University Press, 1963); and Henri Bergson, *Creative Evolution* (New York: Henry Holt, 1911).

20. The Bergsonian principles of *durée* and *élan* vital gained currency in artistic practice among cubist painters in the 1900s in France, experienced a resurgence of importance for sculptors in Britain beginning in the 1930s, and became an enduring theoretical model for Ascott beginning in the 1950s. See Mark Antliff, *Inventing Bergson: Cultural Politics and the Parisian Avant-Garde* (Princeton: Princeton University Press, 1993), p. 3; Burnham, *Beyond Modern Sculpture*; and Ascott, "The Construction of Change," *Cambridge Opinion* (January 1964), pp. 37–42.

21. Kristine Stiles, "Performance and Its Objects," *Arts* 65:3 (November 1990), 41.

22. Gene Youngblood, *Expanded Cinema* (New York: Dutton, 1970), pp. 340–43.

23. Jud Yalkut, *Electronic Zen: The Alternative Video Generation* (1984), unpublished manuscript, pp. 28–30.

24. On the relationship of Schöffer's spatio-dynamic and cybernetic sculptures to constructivism, see Popper, *Kinetic Art*, pp. 134–40.

25. Ascott, *Diagram Boxes and Analogue Structures* (London: Molton Gallery, 1963).

26. Nam June Paik, "Cybernated Art," in *Manifestos*, Great Bear Pamphlets (New York: Something Else Press, 1966), p. 24. Reprinted in Stiles and Selz, *Theories*, pp. 433–34. Samsara is the cycle of life and death. Metempsychosis is the transmigration of souls.

27. Charles Harrison, *Essays on Art & Language* (London: Basil Blackwell, 1991). Subsequent quotes on Art & Language are from this text.

28. Harrison, *Essays*, p. 52. I am indebted to Harrison for bringing my attention to this and other works regarding the application of cybernetics to art.

29. Roy Ascott, "Behaviorist Art and the Cybernetic Vision," *Cybernetica: Journal of the International Association of Cybernetics* (Namur) 9:4 (1966), pp. 247–64; 10:1 (1967), pp. 25–56.

30. Harrison, *Essays*, p. 58.

31. Ibid., p. 56.

32. Ascott, "The Construction of Change," p. 37.

33. Eddie Wolfram, "The Ascott Galaxy," *Studio International* 175:897 (February 1968), 60–61.

34. Ascott, "The Construction of Change," p. 42.

35. Ibid., p. 41; emphasis in original.

36. Brian Eno, Russell Mills, and Rick Poynor, *More Dark than Shark* (London: Faber and Faber, 1986), pp. 40–41.

37. Ibid. Currently Ascott is the Director of the Centre for Advanced Inquiry in the Interactive Arts (CAiiA) at the University of Wales, Newport, which he founded in 1994.

38. Stiles, "The Destruction in Art Symposium."

39. Ibid. As Stiles has noted, Metzger organized the *Destruction in Art Symposium*, and Ascott served as a member of the honorary organizing board.

40. Ascott, Interview with the author, May 25, 1995, Bristol.

41. Ascott, "Behaviourist Art."

42. Kristine Stiles, "Process," in Stiles and Selz, *Theories*, p. 586.

43. Ascott, "Behaviourist Art," p. 25.

44. Ibid., pp. 28–29.

45. H. Ross Ashby, "Design for an Intelligence Amplifier," in Claude E. Shannon and J. McCarthy, eds., *Automata Studies* (Princeton: Princeton University Press, 1956), pp. 215–34. In regard to computers as interactive behavioral systems, Ascott noted his admiration for the work of Gustav Metzger, whom he knew in London, and Nicolas Schöffer. Interview with Ascott, May 25, 1995, Bristol.

46. Ascott, "Behaviourist Art," p. 47.

47. Roy Ascott, "The Cybernetic Stance: My Process and Purpose," *Leonardo* 1 (1968), 106.

PART 5 INTRODUCTION

1. On non-Euclidean and *n*-dimensional geometries as well as their significance for relativity theory and cyberspace, see the new introductory essay in Linda D. Henderson, *The Fourth Dimension and Non-Euclidean Geometry in Modern Art*, new edition (Cambridge, Mass.: MIT Press, 2002). See also Rudolf v.B. Rucker, *Geometry, Relativity and the Fourth Dimension* (New York: Dover, 1977); Thomas Banchoff, *Beyond the Third Dimension: Geometry, Computer Graphics, and Higher Dimensions* (New York: Scientific American Library, 1990); *Tony Robbin, Fourfield: Computers, Art, and the 4th Dimension* (Boston: Bullfinch Press, 1992); and Margaret Wertheim, *The Pearly Gates of Cyberspace: A History of Space from Dante to the Internet* (New York: Norton, 1999).

2. On the emergence and significance of cyberspace and virtual reality, see Michael Benedikt, ed., *Cyberspace: First Steps* (Cambridge, Mass.: MIT Press, 1991), with essays by contributors to the current volume Marcos Novak, "Liquid Architectures in Cyberspace," pp. 225–54, and David Tomas, "Old Rituals for New Space: *Rites de Passage* and William Gibson's Cultural Model of Cyberspace," pp. 31–47; Michael Heim, *The Metaphysics of Virtual Reality* (New York: Oxford University Press, 1993), and *Virtual Realism* (New York: Oxford University Press, 1998); Pierre Lévy, *Collective Intelligence: Mankind's Emerging World in Cyberspace* (New York: Plenum Press, 1997), and *Becoming Virtual: Reality in the Digital Age* (New York: Plenum Press, 1998).

CHAPTER 13

1. George P. Landow, *Hypertext: The Convergence of Contemporary Critical Theory and Technology* (Baltimore: Johns Hopkins University Press, 1992); George P. Landow and Paul Delaney, eds., *The Digital Word: Text-based Computing in the Humanities* (Cambridge, Mass.: MIT Press, 1993); Roger Chartier, *The Order of Books:*