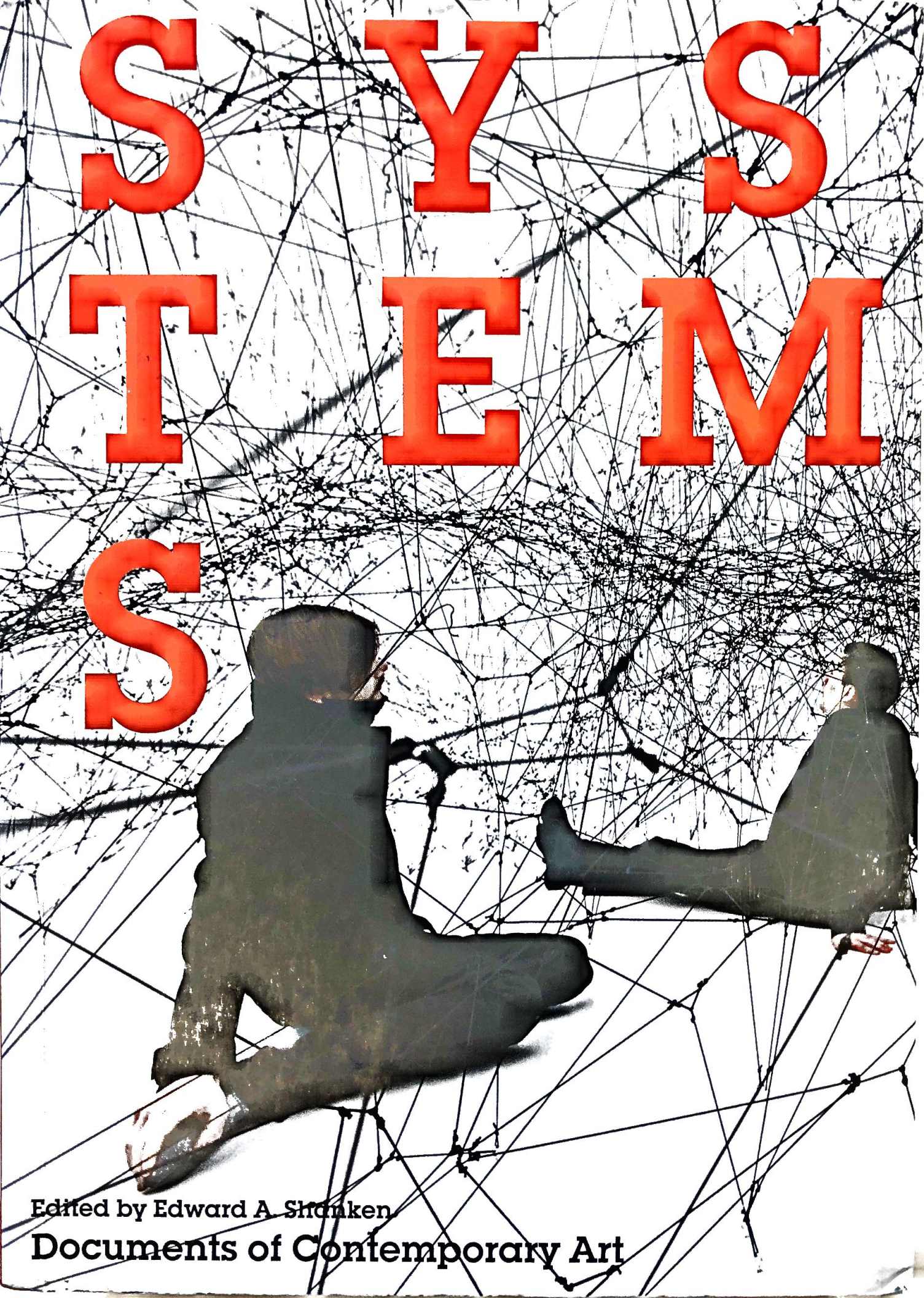
SYSTEMS



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Documents of Contemporary Art

We are now in transition from an object-oriented to a systems-oriented culture. Here change emanates not from things but from the way things are done

Jack Burnham, 'Systems Aesthetics', 1968

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Introduction//Systems Thinking/Systems Art

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'.[1]

As the epigraph above suggests, systems theory and cybernetics were not limited to science and engineering but penetrated deeply into the arts and culture. The screaming electronic feedback of Jimi Hendrix's guitar at Woodstock (1966) appropriated the US National Anthem as a counter-cultural battle cry. Steina and Woody Vasulka used all manner and combination of audio and video signals to generate electronic feedback, which they conceived of as a new artistic medium: '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 ...' (*see section 2: Cybernetic Art, Architecture and Design*)[2] Les Levine described his interactive video installation *Contact: A Cybernetic Sculpture* (1969) as '... a system that synthesizes man with his technology ... the people are the software.' The 'personality' of this 'responsive mechanism', he continued, 'reflects the attitudes of the viewers ... The circuit is open.'[3] Art critic Jack Burnham described how 'we are now in transition from an *object-oriented* to a *systems-oriented culture*. Here change emanates, not from *things*, but from *the way things are done*' (*section 3: Systems Aesthetics*). Artist and theorist Roy Ascott echoed those sentiments: 'Today we are concerned less with the essence of things than with their behaviour; not what they are but what they do. This [...] vision of our time is ultimately cybernetic' (*section 2*). These experiments and attitudes represent some early foundations of the artistic explorations of systems. But the cultural significance of cybernetics is not limited to the 1960s. Although by the late 1970s it had become so ingrained and ubiquitous as to be almost invisible, it has persisted and grown for over half a century and is still going strong. Artists and scholars continue to respond with remarkable creativity and vision to emerging fields of systems-oriented science. Like their precursors, they are grappling with and deploying successive waves of technological media and corresponding social practices in ways that expand perception and cognition. In doing so they offer far-reaching insights into the systemic interrelatedness of all things. They demonstrate, moreover, the importance of integrative thinking and artistic forms of knowledge production

and critique in a global economy fuelled by the algorithmic processing of big data, in which wealth is generated by Google Adsense clicks, government surveillance is reaching Orwellian proportions, and global warming is creating extreme weather conditions that threaten cities and ecosystems.

Despite the current state of affairs, the impact of systems theory and cybernetics on all aspects of human endeavour is difficult to estimate – or overestimate. And one hopes that evolved forms of systems analysis will provide potent tools that can help correct some of the global perils resulting from an overly narrow conceptual framework that cannot see the forest for the trees. Indeed, since the mid 1990s, numerous factors (including advances in computational science, networking and visualization that facilitated the simulation of complex systems) led researchers to refocus attention explicitly on systems theory and cybernetics, generating artistic and scholarly reappraisal and further elaboration. The growing number of art exhibitions and academic publications on the topic since the mid 2000s demonstrates an ongoing fascination with its aesthetic, intellectual and scientific history, as well as its contemporary significance in understanding current problems and modelling potential futures.

Before returning to the importance of systems thinking[4] for the arts, some historical background on systems theory and cybernetics will be helpful. Biologist Ludwig von Bertalanffy first proposed general systems theory in the 1930s as an approach to understanding open systems (ones that continuously interact with their environment or surroundings). Systems theory emphasizes holism over reductionism, organism over mechanism and process over product. In contrast to traditional western scientific approaches to knowledge, it shifts attention from the absolute qualities of individual parts and addresses the organization of the whole in more relativistic terms, as a dynamic process of interaction among constituent elements. The broadly interdisciplinary field of cybernetics offered a rigorous technical foundation for systems theory, and became synonymous with it.

The first wave of cybernetics focused on how systems could maintain a steady state (homeostasis) through feedback loops, which enabled self-regulation. For example, self-regulating control mechanisms consisting of feedback loops maintain human body temperature at 98.6 degrees Fahrenheit (37 degrees Celsius). Similarly a home thermostat measures and responds to fluctuations in temperature, triggering the climate control system to either heat or cool interior air in order to maintain the desired temperature. Drawing on engineer Warren Weaver's formulation of Information Theory, cybernetics established a science of control and communication that applied to the apparent goal-seeking behaviour of both animals and machines. In this regard, cybernetics was vital to, and enriched by, early research on artificial intelligence and robotics. It supplied a theoretical model to construct and to control mechanical systems that exhibit life-like behaviours,

for example the McCulloch-Pitts' artificial neuron, Grey Walter's autonomous robotic 'tortoises', and Ross Ashby's Homeostat, all of which were presented at the field's fertile breeding ground, the annual Macy Conferences held in New York between 1946 and 1953. Participants represented in this volume include Weaver and his colleague Claude Shannon, anthropologist Gregory Bateson, physicist Heinz von Foerster and mathematician Norbert Wiener. Wiener coined the term 'cybernetics' from the Greek root for 'governor' and played an important role in defining the field through his influential scientific and popular publications.

The second wave of cybernetics, championed by von Foerster, insisted on including the observer as an inextricable part of the system – a second order phenomenon – thus introducing a radical sense of reflexivity. Scientists were recognized as active participants in their own scientific experiments and inextricable from them. This observation (of the recursive nature of observation) led to the constructivist position that 'the world as we know it is our invention'. Cybernetics and systems theory fundamentally challenged conventional approaches to the production of knowledge, provoking a paradigm shift that rippled throughout all academic disciplines. These shifts in mindset seeped into popular culture through a broad range of artistic practices and exhibitions and via publications such as *Radical Software* and the *Whole Earth Catalog*, the first issue of which (1968) included a section devoted to 'Understanding Whole Systems'.

Literary critic N. Katherine Hayles identifies a third wave of cybernetics, associated with the emergent behaviour of complex systems, which focused on 'getting the system to evolve in new directions' (*section 1: Foundations*). Cellular automata theory, first proposed by John von Neumann in the 1940s, established the foundations for self-replicating, dynamical systems. Mathematician John Conway's 'Game of Life' (1970), demonstrated the potential of simple cellular automata to generate unexpectedly complex behaviour, providing a mathematical system (a universal Turing machine) capable of simulating complex systems. In 1968, artist Norman White independently demonstrated a physical computing model of cellular automata. In *First Tighten Up the Drums*, digital circuits generated complex behaviours similar to non-linear dynamic systems: a grid of lights illuminated in unpredictable patterns resembling rain dripping down a windowpane. In the 1980s, Christopher Langton used cellular automata to simulate living systems, a field of research known as artificial life (A-Life), which he hoped would enable scientists to 'locate life-as-we-know-it within the larger picture of life-as-it-could-be'.[5] Also in the 1980s, biologists Humberto Maturana and Francisco Varela extended their influential theories of autopoiesis, structural coupling and embodied cognition to draw third-order phenomena of language and society into this reflexive fold (*section 1*). As a result, the scientist – and science itself – became inextricable from the complex linguistic and cultural

systems that mediate the production of knowledge and the attribution of meaning and value. As discussed below, autopoiesis, A-Life and related concepts and techniques have pervaded art practice and theory.

In 1956, artist Nicolas Schöffer explicitly introduced cybernetic concepts into his responsive sculpture *CYSP I*, the title of which is an acronym joining the first two letters of the word 'cybernetics' and 'spatiodynamic'. By 1960, Roy Ascott had begun to incorporate the ideas of cybernetics into his artistic practice, later expanding these ideas into his teaching and theoretical writing, influencing generations of artists, including students Stephen Willats (*section 2*), Brian Eno (*section 4: Generative Systems*) and Christa Sommerer and Laurent Mignonneau (*section 4*). As described by Usman Haque (*section 2*), the landmark exhibition 'Cybernetic Serendipity' at the Institute of Contemporary Arts in London (1968) included psychologist and cybernetician Gordon Pask's sculpture *Colloquy of Mobiles*, which generated complex behaviours as its elements interacted with each other and with the audience. Pask was an early innovator of human-machine interface design and conversation theory, which he integrated into educational technology, fields that remain vital research areas for artists and scientists.

In 1966 Lawrence Alloway curated 'Systemic Painting' at the Guggenheim Museum, using the term to signify a cool, non-expressionistic approach to exploring the formal possibilities of an image through repetition, as in the work of Jo Baer, Agnes Martin, Robert Ryman, and others later associated with Minimalism. A related approach characterized the 1970s Systems Group in Britain, whose modular, constructivist-inspired work was re-examined at Southampton City Art Gallery in 2008. Members included Jeffrey Steele and Malcolm Hughes, co-founders of the Experimental Program which introduced computers into the studio at London's Slade School of Fine Art in order to extend 'the scope of an idea within the terms of its original proposition'.[6] The Systems Group influenced subsequent generations of artists working with diverse techniques, including Paul Brown and Ernest Edmonds (Experimental Program alumni who use computers) and Susan Tebby (who studied with Hughes and Edmonds and uses conventional media). Similarly, James Whitney's handmade film *Yantra* (1957) looks computer generated, as do his brother John Whitney's subsequent analogue films made with a military surplus gun-controller, suggesting that digital aesthetics preceded digital art (*see Zabet Patterson in section 2*).

Burnham's *Artforum* essays 'Systems Aesthetics' (1968) and 'Real Time Systems' (1969) (*section 3*) provided a critical framework for understanding the diverse range of emerging, systems-oriented art practices, while laying a theoretical foundation that continues to inspire artists. 'Systems Aesthetics' acknowledged the historic roots of 1960s systems art in the modular work of Bauhaus master Moholy-Nagy (e.g. the 'telephone paintings' of the early 1920s)

and in constructivist Victor Vasarely's 1950s proposals for mass-produced art. Equally, Burnham saw it percolating in the growing disavowal by artists Ad Reinhardt, Donald Judd, Robert Morris and Les Levine of the formalist determinism of concrete objects, which was being subsumed by a growing emphasis on 'list structures' in dynamic, open-ended and responsive artworks. As he wrote, 'information, in whatever form conveyed, becomes a viable aesthetic consideration' ('Systems Aesthetics', 34). Pointing to Hans Haacke (*section 3*) as an exemplar, Burnham explained that 'real-time systems gather and process data from environments, in time to effect future events within those environments' ('Real Time Systems', 29). Haacke's real-time systems included a variety of 'plugged' and 'unplugged' media, addressing a range of natural and social systems, as did Stephen Willats' application of systems thinking to actual social intervention (*section 2*). This lineage has continued in the institutional and sociological critiques levelled by Mark Lombardi's diagrammatic 'Narrative Structures' drawings of the 1990s, Josh On's website *They Rule* (2004), and UBERMORGEN.COM et al's 'Google Will Eat Itself' (*section 4*). Similarly, it characterizes the ecological projects by artists such as Agnes Denes, David Dunn, and Newton and Helen Mayer Harrison since the 1970s, and by Beatrice da Costa, Yolande Harris, Natalie Jeremijenko, Michael Mandiberg, Andrea Polli and Aviva Rahmani since the 1990s. Indeed, from the mid 1990s to the late 2000s, Burnham's systems aesthetics had been revisited and reinterpreted to such an extent that the phenomenon of its recuperation became the subject of historiographic research in its own right (*see my text in section 3*). Following exhibitions, symposia and publications at Tate Modern in 2005 and Whitechapel Gallery in 2007, systems aesthetics reappeared (again) in US mainstream contemporary art contexts in the fiftieth anniversary issue of *Artforum* (September 2012), in which Burnham's 1968 and 1969 essays and the 'Software' exhibition he curated (1970) were subject to another round of enthusiastic reappraisals (*see Caroline Jones in section 3*).

In the early twentieth century, precursors to systems thinking can be seen percolating in the twelve-tone technique of Arnold Schoenberg, whose *Theory of Harmony* (1922) eschews traditional aesthetic conceptions of beauty and proposes instead an elaborate system of presentation, setting the stage for serial music and other parametric and generative systems of art production, sonic and visual. Its influence can be seen in the work of John Cage, Alvin Lucier, Iannis Xenakis (*section 4*) and Brian Eno (*section 4*), all of whom were well-versed in cybernetics, and who, in turn, have influenced subsequent generations of composers, artists and architects. Lucier's 1965 'Music for Solo Performer' incorporated electro-encephalography (EEG) to create a systemic bio-feedback loop between the performer's state of mind and the sound produced. With the

advent of consumer EEG headsets, one can expect emerging artists to build on the pioneering work of Lucier, David Rosenboom, Richard Teitelbaum and Nina Sobell. In addition, systems thinking may have contributed to expanding the frame of art to include the total environment, as in Cage's silent composition *4'33"* and happening *Theatre Piece N.1* (both 1952), Xenakis' design for the Philips Pavilion (1958) and his *Polytopes* (1967–73) and *Diatope* (1978), Bernhard Leitner's sound environments, and Eno's multimedia software program and installation *77 Million Paintings* (2006), presented as a large-scale projection on the Sydney Opera House (1958–73), Jørn Utzon's architectural landmark inspired by natural systems.

Systems theory was an important influence on visionary architects including Buckminster Fuller (*section 5: Environmental and Social Systems*), Cedric Price (*section 2*), Paolo Soleri and the Archigram collective. Fuller's concern with sustainable urban metastructures was an important influence on Soleri and Archigram, which shared with Price a concern with creating flexible or, to use Pask's term, 'underspecified' environments that used emerging technological media to respond cybernetically to their inhabitants. As Haque, William J. Mitchell and Michael Weinstock (*section 2*) suggest, systems theory is not an outmoded way of thinking but continues to offer architecture and design new possibilities for functional and formal invention.

This generative approach heralded by Schoenberg finds visual parallels in Richard Paul Lohse's 1944 *Continually interpenetrating range of colours based on a serial system from 1–12*. Lohse, in turn, anticipates the conceptual, systemic and generative work of artists ranging from Sol LeWitt to Sonia Landy Sheridan in the 1960s and 1970s, to more contemporary works of digital art (*see section 4*). In the lineage of White and Pask but informed by the work of Maturana and Varela, in Ken Rinaldo's *Autopoiesis*, complex systemic behaviour emerges through interactions between members of a group of robotic sculptural elements and the audience. In 1990 artist Michael Joaquin Grey in collaboration with Randy Huff programmed genetic algorithms into a supercomputer to generate life-like forms analogous to actual species. In the early 1990s, ecologist Tom Ray's Tierra project used A-Life to simulate evolution, a technique used by artists including Karl Sims, Jane Prophet, and Christa Sommerer and Laurent Mignonneau. Mitchell Whitelaw and Geoff Cox note a divide between generative art which focuses on the emergent properties and potentials of formal systems and that which focuses on the critical cultural implications of the institutionalization of software. The field of bio-art, as exemplified by the Tissue Culture and Art Project, also draws on the generative aesthetic heritage, often using biological material and laboratory techniques to create awareness of and instigate critical discourse about the implications of emerging biotech practices.

Over and above Jack Burnham's theories, systems thinking has had an impact on art criticism and theory in myriad ways. Niklas Luhmann is widely recognized as the most prominent voice in establishing an explicitly systems theoretical philosophy, including insightful studies of art as a social system. But the concept of art as a social system was already present in philosopher Arthur Danto's influential 1964 essay 'The Artworld'. Danto opened the floodgates for institutional analyses of art that focus less on the objects themselves than on the larger communities or systems of discourse in which they circulate and gain meaning and value. Pierre Bourdieu's field theory shares this general approach, offering incisive commentary on the systemic relationship between art, artists, art critics, power and capital. Nick Prior applies Bourdieu's schema to the counter-cultural phenomenon of glitch music and proposes the addition of actor network theory (ANT) in order to account for the important role of technology, absent in Bourdieu's framework but vital for the analysis of glitch. ANT is itself a highly systemic form of cultural analysis. Like cybernetics, it draws parallels between human and non-human actors, both of which can exercise agency that affects the behaviour of a social system. In his analysis of art and the relationship between scientific knowledge and humanistic knowledge, Bruno Latour, a primary theorist of ANT, provides a systemic reading of artworks and systems of interpretation. If, while reading Bourdieu, Prior and Latour (*in section 5*), one substitutes the word 'system' for 'field' or 'network', the relationship of their work to systems theory becomes clear.

Strains of systems thinking can be identified throughout history and across cultures, from the I Ching to the Mayan calendar and from Buddhism to the Kabbalah. The broad appeal of systems thinking in the 1960s dovetails with the growing popularity of eastern philosophy at that time. It is not surprising, therefore, that some leading proponents of systems thinking – including, in this volume, Ascott, Burnham and Nam June Paik in the arts and Fritjof Capra, Donella Meadows and Varela in the sciences – became deeply engaged with non-western systems of thought. As such, the scientific aspects of systems theory and their impact on and implications for art demand a broader conception of systems thinking as a cultural phenomenon. For example, Charlie Gere and Fred Turner have explored the relationship of cybernetics to 1960s counter-cultural movements and the foundations of personal computing. Gere notes that in a 1972 *Rolling Stone* article, systems thinker Stewart Brand, the founding editor of *Whole Earth Catalog*, proclaimed that 'computers were coming to the people', which he thought was 'good news, maybe the best since psychedelics'.[7]

In the aftermath of World War II, systems theory provided an alternative philosophical perspective that many thinkers hoped could avoid the disastrous effects of modern technology, emblematized by the nuclear annihilation of Hiroshima and Nagasaki. At the same time, cybernetics was applied to massive air

defence systems such as SAGE (Semi-Automatic Ground Environment), the iconic cybernetic Cold War computer system represented in dystopian cinema treatments such as *Dr Strangelove* and *Fail Safe* (both 1964). Perhaps its potential for peace or war, for humanitarian good or industrial excess – and the tensions generated by those oppositions – has motivated scientists and artists to emphasize the validity of systems theory for cultural, social, ethical and ecological considerations. This response is clear in many selections in this volume. Capra espouses the inevitability of an ethical sensibility resulting from systems thinking. Meadows offers a remarkable set of systems-thinking maxims to live by, culled through experience. Similarly, Bateson had recourse to the kind of 'wisdom' he associated with art and claimed that in 'a world of circuit structures' art can correct 'a too purposive view of life and mak[e] the view more systemic'. The epistemic challenges posed by second-order cybernetics pushed von Foerster to become as much a philosopher as a scientist, corroborating Latour's claim that 'no discipline is the final arbiter of any other'. Indeed, the fundamentally interdisciplinary nature of cybernetics from its inception, and the ongoing insistence of many of its practitioners on the vital importance of working across fields, suggests that the silo mentality of individual disciplines itself is a major hindrance and that the complex problems of our time can only be solved through transdisciplinary research, such as that of sound artist and composer David Dunn and the mathematician and physicist Jim Crutchfield (*section 5*). As Werner Heisenberg observed, 'the most fruitful developments frequently take place at those points where two different lines of thought meet.' Perhaps contemporary forms of systems thinking can serve as the common ground that enables committed thinkers and doers from diverse backgrounds and perspectives to integrate their ideas and methods in synergetic forms of cultural practice that spark new forms of creativity and innovation – innovation not just as the 'next big thing' in Silicon Valley but as constituting more subtle and perhaps more insidious and profound shifts in the conception and construction of knowledge and society.

1 David Mellor, *The Sixties Art Scene in London* (London and New York: Phaidon Press, 1993) 107.

2 Steina and Woody Vasulka, in Jud Yalkut, *Electronic Zen* (1973), unpublished manuscript, 28–30.

3 Gene Youngblood, *Expanded Cinema* (New York: Dutton, 1970) 340.

4 In contrast with the scientific terms 'systems theory' and 'cybernetics' I use the term 'systems thinking' to refer more generally to the related epistemological frame or mindset.

5 Christopher Langton, 'Artificial Life' (1989), in Langton, ed., *Artificial Life* (Redwood City, California: Addison-Wesley, 1992) 1.

6 Ernest Edmonds, quoting Jeffrey Steele (1967), in introduction, *Automatic Art: Human and Machine Processes that Make Art* (London: GV Art, 2014) 4.

7 Charlie Gere, *Digital Culture* (London: Reaktion, 2002; 2nd edition, 2009) 129.