15

Complexism and the Role of Evolutionary Art

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Summary. Artists have always learned from nature. A new generation of artists is adapting the very processes of life to create exciting new works. But art is more than the creation of objects. It is also a progression of ideas with a history and a correspondence to the larger culture.

The goal of this chapter is to take a step back from the details of the technology and the consideration of specific works, and to view evolutionary art in the broader context of all art. This kind of multidisciplinary discussion requires one to be multilingual, and this chapter will use the language of scientists, humanists, artists, and philosophers. While doing so we will quickly visit complexity science, postmodernism in the arts, and the conflict between the cultures of the humanities and the sciences.

With this as a backdrop, I will introduce a new approach I call complexism. Complexism is the application of a scientific understanding of complex systems to the subject matter of the arts and humanities. We will see that the significance of evolutionary art is that it takes complexism as both its method and content. Evolutionary art is a new kind of dynamic iconography: the iconography of complexism. And complexism offers nothing less than the reconciliation of the sciences and the humanities through a higher synthesis of the modern and the postmodern.

To a certain extent this chapter participates in the modernist tradition of the art manifesto. The art manifesto is a form of speculative writing where the artist-author posits a new revolutionary creative direction for a group of artists who share a set of common interests, as well as a new worldview that offers a radical break with the past. Writers of such manifestos have included Marinetti, Kandinsky, Schwitters, Moholy-Nagy, Gropius, Breton, and others [1].

Like other manifestos, this chapter includes forward-looking assertions about work not yet started let alone completed. I have tried to identify the more speculative parts of this chapter as being part of this complexist manifesto.

15.1 Complexity Science

With the founding of the Santa Fe Institute in 1984 serving as a significant milestone, for more than 20 years scientists from diverse fields have been working together in a new way to create a new multidisciplinary understanding of systems. Under the general rubric of “complexity science” and “complexity theory” various systems, and various kinds of systems, have been studied, compared, contrasted, and mathematically and computationally modeled. An abstract understanding of systems that spans the physical, biological, and social sciences is beginning to emerge [2].

Science generally proceeds in a reductive manner, the thinking being that by breaking down complicated phenomena into their figurative (or literal) atomic parts one gains predictive and explanatory power. The problem with reductionism, however, is that it doesn’t fully address the problem of putting the pieces back together again [3].

This is especially true of complex systems. When scientists speak of complex systems they don’t mean systems that are complicated or perplexing in an informal way. The phrase “complex system” has been adopted as a specific technical term.

Complex systems typically have a large number of small parts or components that interact with similar nearby parts and components. These local interactions often lead to the system organizing itself without any master control or external agent being “in charge.” Such systems are often referred to as being self-organizing. These self-organized systems are also dynamic systems under constant change, and, short of death or destruction, they do not settle into a final stable “equilibrium” state. To the extent these systems react to changes in their environment so as to maintain their integrity, they are known as complex adaptive systems [4].

In common language one is reminded of the saying that “the whole is greater than the sum of its parts.” The weather, for example, forms coherent patterns such as thunderstorms, tornados, and hot and cold fronts, yet there is no central mechanism or control that creates such patterns. Weather patterns “emerge” all over and all at once. In the near term weather can be predicted with some accuracy, but beyond more than a few days the weather becomes quite unpredictable.

The stock market is similarly a complex system with emergent properties. Billions of shares and transactions are linked in a finite chain of cause and effect, and patterns such as booms and busts emerge from the overall system. Yet no one factor dominates or “plans” the market. Even with all of the relevant information available to the public, the stock market generates surprising and unpredictable behavior.

15.1.1 Biology and Complexity Science

For most practical purposes a falling rock can be considered as a simple physical system, and modeled with a simple formula of mass, velocity, and gravitational force. A biological system, such as a frog, is much more difficult to model and is said to be complex. In sub-geological time a rock is relatively inert and its information state is limited to position, velocity, and spin. A frog is ever changing, and an attempt to measure every body function, the tension of every muscle, the activity of every neural connection and so on would be very daunting.

As a complex system a frog can be viewed as a very large collection of more atomic units; in this case, cells. And each cell, in turn, exhibits enormous genetic complexity by creating intricate switching networks and manufacturing diverse complex proteins. Somehow these local interactions combine and create coherent macro-behaviors that are described as being emergent and adaptive, and, indeed, as being life itself.

Complex systems are typically nonlinear,[1] so in terms of control the same amount of force may yield a smaller or larger change, sometimes in ways that may seem counterintuitive. Such systems may also be chaotic, so even the tiniest difference in a system's history can result in a massive future difference [5, 6]. In a sense, as the cells go through their local interactions, the frog is an emergent phenomenon. This notion of emergence, as well as the attention paid to autocatalytic cycles and connectionist models, makes complexity a key development area in the life sciences [7].

Complexity science is an antidote to the overly reductionist tendencies of 19th century science. Areas of application in the life sciences include evolution, brain function, animal societies, metabolism, and much more. More generally complexity science impacts physics, chemistry, economics, meteorology, computer science, and more. In that complexity science seeks to abstract an understanding of systems across all of these disciplines, the study of complexity is one of integration rather than specialization [8].

Complexity science thus offers more than an incremental increase in scientific understanding. It is revolutionary in that it reverses the top-down process of reductionism, and instead offers a synthesis of bottom-up processes. In a resonant way, complexity science is revolutionary in the way it eschews specialization, and instead attempts to establish commonalities across scientific disciplines with regard to systems [8].

The question to be considered later is, if complexity science offers a revolution in the sciences, does it also offer a revolution in the broader culture?

[1] The term "nonlinear" has multiple discipline-specific meanings that can confuse an interdisciplinary discussion. In the humanities nonlinear can mean (1) disconnected, illogical, or irrational, or (2) having multiple narratives, or (3) having a viewer-driven interactive narrative, or (4) being a non-chronological presentation. In the context of complexity science, nonlinearity references (1) mathematical expressions with exponential terms (e.g., "x^n") or (2) behaviors where "the whole is greater than the sum of the parts," or (3) situations where small continuous changes result in macro-level phase changes. Examples of (3) might include solid ice melting into liquid water with a slight increase in heat, or catastrophic material failure due to a slight increase in load.

15.1.2 Quantifying Complexity

It is one thing to compare a simple system with a complex system, and quite another to compare disparate complex systems. One scientific approach is to develop a functional definition of complexity so it can be quantified, allowing the comparison of complex systems.

The observation that the state of a frog entails much more information than the state of a rock might lead one to consider information as a measurement of complexity. An earlier related attempt to better understand the quantification of information was initiated by Claude Shannon in the form of information theory [9]. For the purposes of analyzing the capacity of a given communication channel, the core idea is that the more "surprise" a given channel can exhibit the more information it contains. A corollary to this is that low information communications contain redundancies that allow compression, and high information communications with little redundancy resist compression.

Consider the following informal examples presented without mathematical rigor. A channel that simply transmits the character "a" over and over again offers no surprise, and thus no information. It can also be compressed to a few characters, by using a symbol that means "an infinite number of the following" and then the character "a." A typical English language sentence carries more information because of the variability of characters used. Such a sentence can, however, be compressed to a degree because the English language is somewhat predictable and includes some redundancy. For example, if the characters "elephan" come out of the channel, chances are good that the next character will be "t." From the point of view of information theory, a channel that offers maximal information is one that transmits perfectly random characters. Because a random signal is, by definition, entirely unpredictable, it offers no redundancy and cannot be compressed.

It's easy to see that information as measured by Shannon's information theory is not a good proxy measure for our intuitive sense of a system's complexity. The DNA that determines the metabolism, neurology and other subsystems of a frog requires structure and regularity. Making random changes to the DNA of a fertilized frog egg will certainly increase its Shannon information, but at some point it will render the egg incapable of cell division. Our intuitive sense is that a living, growing, reproducing frog egg is more complex than a dead frog egg with highly unusual DNA. Contrary to this, the Shannon measure of information would give a higher score to the "dead" randomized DNA than the more regular "living" DNA. A high Shannon measure of information does not imply a high degree of complexity.

As noted by Murray Gell-Mann [10] another approach is to consider the algorithmic complexity (AC) of a given system. Algorithmic complexity is also called the algorithmic information content (AIC), and was independently developed by Kolmogorov [11], Solomonoff [12], and Chaitin [13].

Any system that can be expressed as a deterministic algorithm can be mapped into a smallest possible program running on a general-purpose computer. (Such a computer may be considered "Turing complete" if one relaxes the formal requirement of infinite storage). In this context it is understood that by "program" we mean both the machine instructions executed and stored data processed. The algorithmic complexity of the system under consideration is simply the length of this shortest possible program without reference to the execution time.

Some systems, such as fractals, require infinite time to generate because they have infinite detail. But we don't normally think of fractals as having infinite complexity. They are simple in the sense that they exhibit self-similar structure at every scale. And, in fact, a fractal algorithm can be very compact indeed. So one might hope that AC is a good candidate for a measure of what we intuitively consider complexity. Perhaps the larger the algorithmic complexity, the more complex the system.

Unfortunately, in the case of random processes we run into the same paradox as we see in information theory. Returning to our informal example, a program to produce the character "a" over and over again can be quite short, simply a print statement within an infinite loop. The machine instructions and data to produce an English language text will be somewhat larger, but given the redundancies in the English language itself, the program can implement data compression not unlike that one would find in a ".zip" file. Nevertheless, such a program would still have a larger AC than the previous single character example. Finally, consider a program that must reproduce a string of specific random characters of equal length. The machine instructions and data would be longer still because the string would lack the redundancies of natural language, and would resist any compression scheme.

Much like the Shannon information measure, the algorithmic complexity measure is not a good proxy for our intuitive sense of complexity. A book's complexity comes from its structure and regularity as much as its diversity, and a random string of equal length is intuitively less complex. In a sense all random strings of characters are the same, and as one "randomizes" a book it becomes less complex as its intelligible coherence collapses into noise.

The Shannon information measure and algorithmic complexity both increase as a system approaches randomness. But our intuitive sense is that complexity peaks somewhere in between highly ordered highly redundant systems and highly disordered structure-less systems. In genetics and evolution, the successful complex system (species) will strike a balance between order (highly accurate DNA replication and repair) and disorder (the occasional mutation or variation through sexual crossover operations).

What is needed is something like Murray Gell-Mann's notion of "effective complexity." With effective complexity systems that are highly ordered or disordered are given a low score, indicating simplicity, and systems that are somewhere in between are given a high score, indicating complexity. Gell-Mann explains:

> "A measure that corresponds much better to what is usually meant by complexity in ordinary conversation, as well as in scientific discourse, refers not to the length of the most concise description of an entity (which is roughly what AIC is), but to the length of a concise description of a set of the entity's regularities. Thus something almost entirely random, with practically no regularities, would have effective complexity near zero. So would something completely regular, such as a bit string consisting entirely of zeroes. Effective complexity can be high only in a region intermediate between total order and complete disorder." [10]

To measure effective complexity Gell-Mann proposes to split a given system into two algorithmic terms, with the first algorithm capturing structure and the second algorithm capturing random deviation. The effective complexity would then be proportional to the size of the optimally compressed program for the first algorithm that captures structure. To implement effective complexity as a practical matter Gell-Mann points out that this process is exactly what a complex adaptive system does as it learns (models) its environment. Aspects that are random, or noise, are forgotten and aspects that exhibit structure are compressed (abstracted and generalized). Structural aspects that resist compression are experienced as being complex.

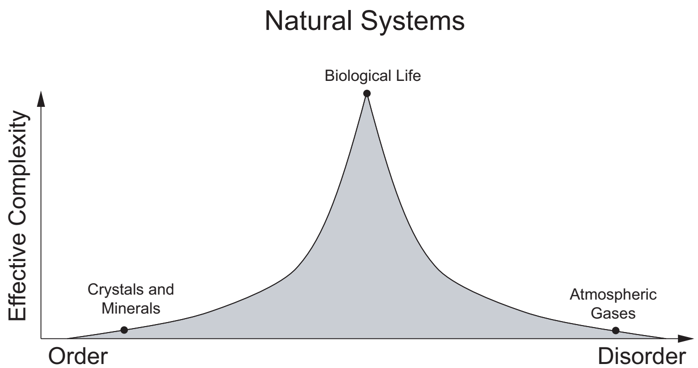

Fig. 15.1. The effective complexity of a system increases between order and disorder

As shown in Fig. 15.1. highly ordered systems from nature such as crystals, or highly disordered systems such as atmospheric gases, yield low measures of effective complexity. The robust complex adaptive systems found in nature, the living things biology takes as its subject matter, are represented at the apex of the curve. Note that the contours of the graph are meant to suggest a nonlinear increase in complexity as one progresses away from either highly ordered or highly disordered systems. Also note that the finite apex of the curve is meant to imply that the structural component of a system expressed as a program cannot be of infinite length.

The notion of effective complexity is closely related to our intuitive sense of complexity in biological systems. In the next section we will see how effective complexity also creates a context for understanding evolutionary art.

15.2 Evolutionary Art as Generative Art

The term "generative art" has gained popularity over the last decade. In an earlier paper I offered what is now perhaps the most widely quoted definition:

> "Generative art refers to any art practice where the artist uses a system, such as a set of natural language rules, a computer program, a machine, or other procedural invention, which is set into motion with some degree of autonomy contributing to or resulting in a completed work of art." [14]

The key element in generative art is the use of an external system to which the artist cedes partial or total subsequent control.

Some additional observations are worth making. First, note that the term generative art is simply a reference to how the art is made, and it makes no claims as to why the art is made this way or what its content is. Second, generative art is uncoupled from any particular technology. As will be seen in the examples that follow, generative art may or may not be "high tech."

Third, a system that moves an art practice into the realm of generative art must be well defined and self-contained enough to, in principle, operate autonomously. This doesn't, however, rule out art that is entirely handmade. This only means that control over some aspect of producing the art is handed over to an external system, and there are implicit decisions made which are not left up to the moment-to-moment intuitive choices of the artist. For example, ancient art based on tiling patterns is generative because the placements of individual tiles are not decisions made by the artisan, but rather are dictated by a manually executed symmetry-based algorithm.

Clearly evolutionary art is a type of generative art. The genetic information and competitive evolutionary process is an external system to which the artist cedes control. In some cases the artist retains tighter control by personally acting as the fitness function, and choosing in each round of breeding which individuals will reproduce, and which individuals will be removed from the gene pool. In other cases the artist will express his or her judgment as an abstraction in the form of an algorithmic fitness function, and will then allow the breeding cycle to run free. In what follows we will see that evolutionary art occupies a special position in the spectrum of generative art.

15.2.1 Generative Art in the Context of Complexity Science

Complexity science has given us a way of sorting out systems in the abstract. There are two kinds of simple systems, those that are highly ordered and those that are highly disordered. Complex systems exist in the middle ground between order and disorder.

Since generative art turns on the artist's use of a system, the insights gained from complexity science can also be used to sort out generative art.

15.2.2 Highly Ordered Generative Art

In every time and place for which we can find artifacts, we find examples of the use of symmetry in the creation of art. Reasonable people can disagree as to at what point the use of symmetry can be considered an autonomous system. But even among the most so called primitive peoples examples abound in terms of the use of geometric patterns in textiles, symmetric designs about a point, repeating border designs, and so on. Many of these are well documented by authors like Hargittai and Hargittai [15] and Stevens [16]. Additionally Washburn and Crowe have shown how specific art objects can be analyzed in terms of abstract symmetry classes, and how such classification can be a useful anthropological tool in understanding human societies [17].

The artistic use of tiling, in particular, is nothing less than the application of abstract systems to decorate specific surfaces. Leading the most notable examples in this regard are perhaps the masterworks found in the Islamic world. It is perhaps no coincidence the Islamic world also provided one of the significant cradles of mathematical innovation. It is also worth noting that the word "algorithm" has its roots in the Islamic world.

Highly ordered systems in generative art also made their appearance in innovative 20th century art. A popular contemporary tile artist, and student of the Islamic roots, was M.C. Escher. While lacking in formal mathematical training, it is clear that he had a significant understanding of the generative nature of what he called "the regular division of the plane." Without the use of computers he invented and applied what can only be called algorithms in the service of art [18].

In addition, minimal and conceptual artists such as Carl André, Mel Bochner, Donald Judd, Paul Mogenson, Robert Smithson, and Sol LeWitt used various simple highly ordered geometric, number sequence, and combinatorial systems as generative elements in their work [19, 20].

Generative art based on highly ordered systems seems ubiquitous, but can we say that generative art is as old as art? Many are familiar with the discoveries of representational cave paintings some 35,000 years old that depict animals and early man's daily life. But in 1999 and 2000 a team led by archaeologist Christopher Henshilwood of the South African Museum in Cape Town uncovered the oldest known art artifacts. Etched in hand-sized pieces of red ochre more than 70,000 years old is an unmistakable grid design made of triangular tiles that would likely be recognizable as such to Escher or generations of Islamic artists.

While the etchings, like most ancient archaeological finds, are not without controversy, many find them compelling examples of abstract geometric thinking with an artistic response. In a related article in Science anthropologist Stanley Ambrose of the University of Illinois, Urbana-Champaign says "This is clearly an intentionally incised abstract geometric design ... It is art." [21].

Two stone etchings alone cannot make the case that generative art is as old as art itself. But around the world, and throughout history, there is overwhelming evidence of artists turning to systems of iterative symmetry and geometry to generate form. Early generative art may seem unsophisticated because it is highly ordered and simple, but our complexity inspired paradigm for generative art has an important place for highly ordered simple systems.

15.2.3 Highly Disordered Generative Art

One of the earliest documented uses of randomization in the arts is a musical dice game invented by Wolfgang Amadeus Mozart. Mozart provides 176 measures of prepared music and a grid that maps the throw of a pair of dice, and a sequence number (first throw, second throw, etc.) into the numbers 1 through 176. The player creates a composition by making a sequence of random dice throws, and assembling the corresponding measures in a sequential score. Perhaps Mozart knew intuitively that purely random music isn't terribly interesting because he found a primitive way to mix order and disorder. The short pre-composed measures provide order, and the throw of the dice provide disorder [22].

Randomization in the arts came into its own primarily in the 20th century. As a young artist Ellsworth Kelly used inexpensive materials such as children's construction paper along with chance methods to create colorful collages. He was inspired to do this after observing the random patchworks that would develop in the repair of cabana tents on the French Riviera [23].

The writer William Burroughs famously used his Dada inspired "cut-up" technique to randomize creative writing. Less well known are Burroughs experiments in visual art using shotgun blasts to randomly scatter paint on, and partially destroy, plywood supports [24]. Occasionally Carl André would use a random spill technique rather than his more typical highly ordered assembly systems [19].

Perhaps the most famous advocate for the random selection of sounds in music was John Cage [25, 26]. As mentioned earlier, generative art is a long-standing art practice, but different artists may choose the same generative technique for wholly different reasons. For John Cage the motivation for randomization was a Zen inspired acceptance of all sounds as being equally worthy. For André the intent was in part to focus attention on the properties of the materials, but also to assault art-world expectations regarding composition.

It is important to remember that what generative artists have in common is how they make their work, but not why they make their work, or even why they choose to use generative systems in their art practice. The big tent of generative art contains a diversity of intent and opinion.

15.2.4 Generative Art Systems in the Context of Effective Complexity

While the term "generative art" is somewhat foreign to the art-world mainstream, both highly ordered and highly disordered generative art is bound tightly to the canon of art history. What seems lacking in the humanities is a broad understanding of systems and systems based art.

In part, it is this lack of a broad view of systems that has slowed the acceptance of complexity based generative art in the mainstream. The context can be made clear by a simple adaptation of the earlier graph. It's worth noting that some generative art systems are used to create a final static art object, and in other cases it is the actual generative system that is put on display. In any case, what are being sorted out here are the generative art systems themselves, and not necessarily the end results.

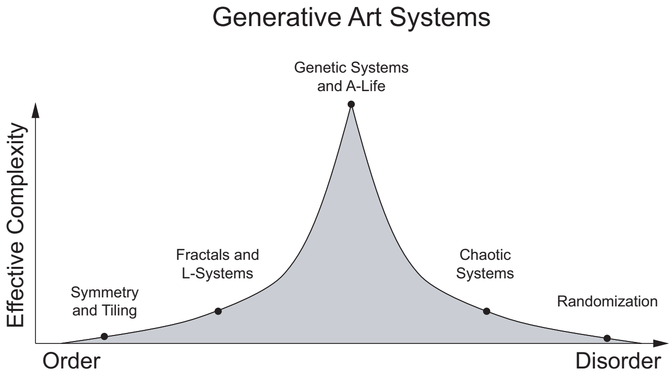

Fig. 15.2. Effective complexity used to organize various generative art systems

It has already been noted that both highly ordered generative art such as that based on symmetry and tiling, and highly disordered generative art based on randomization, are of very low complexity. Before turning to evolutionary art it is worth considering generative systems that move away from high order or disorder, but do not achieve high complexity.

Ordered systems that offer more complexity than simple applications of symmetry include fractals and Lindenmayer (or L-) systems. Fractals are mathematical objects first discovered by Benoit Mandelbrot that exhibit self-similarity at all scales. Fractals have been applied to generative art in the creation of abstract patterns as well as simulating natural objects such as clouds, riverbanks, mountains, and other landforms [27].

L-systems are grammar-based systems of axioms and production rules developed by Lindenmayer and Prusinkiewicz that can simulate the growth of branching structures in plants. L-systems have been applied to generative art in the creation of abstract patterns as well as 2D and 3D renderings of artificial trees, bushes, and flowers [28].

What fractals and L-systems have in common as systems is a structural algorithm component that is not quite as compressible as simple symmetry relationships, but is highly recursive and thus much more compressible than one might assume from the visual result.

Near the other end of the spectrum generative artists have explored chaotic feedback systems. Like all chaotic systems, those used by artists are deterministic but exhibit a nonlinear sensitivity to initial conditions. This is sometimes called "the butterfly effect" as in the hypothetical example that a butterfly in India flaps its wings and this later results in a tornado in Texas [29].

While the long-term results of a chaotic system may be so unpredictable as to seem random there is short-term predictability. The feedback mechanism is a simple structural algorithm that is highly compressible. From the point of view of effective complexity chaotic feedback systems are a bit more complex than, and not quite as disordered as, absolute randomization.

Artists who have used chaotic feedback include early video artists Steina and Woody Vasulka. The Vasulkas created dynamic systems by creating a video signal loop where the camera is pointed directly into its own display [30]. And in 1963, Hans Haacke's "Condensation Cube" (first titled "Weather Cube") displayed ever-changing patterns of evaporation and condensation the same year that Ralph Lorenz discovered chaos in weather systems [31].

15.2.5 Complex Generative Art and the Unique Position of Evolutionary Art

While systems such as the economy and the weather are indeed complex, complexity scientists frequently cite examples from life itself as being the most complex known systems, and especially the most complex adaptive systems. Evolutionary art, and other biologically inspired art, exploit models of systems that are at the apex of the effective complexity curve.

By all rights, evolutionary art should be able to transform the larger culture by offering non-specialists a new understanding of complex systems, and indeed of life itself. But while those in the arts and humanities have accepted various forms of generative art in bits and pieces, they have yet to recognize generative art as a full spectrum of complexity relationships. Without such recognition the true importance of evolutionary art is lost.

A primary observation of this manifesto is this sad fact: despite a relatively recent superficial embrace of trendy technology-based art, the arts and humanities in the 20th century have developed a growing antipathy towards science at the level of fundamental philosophy. Until the sciences and the humanities can be reconciled, it is likely that evolutionary art will be denied its crown as one of the most complex forms of generative art, and robbed of its culturally transformational power.

The following section will outline the split between the sciences and the humanities, and will offer the hope that complexity theory itself may hold the key to their reconciliation.

15.3 The Growing Rift Between Science and the Humanities

The first popular airing of the growing 20th century rift between the humanities and science is usually attributed to C.P. Snow's 1959 Rede lecture "The Two Cultures." In this lecture he captures a difference in attitude that has only become greater in the intervening years.

> "Literary intellectuals at one pole – at the other scientists, and as the most representative, the physical scientists. Between the two a gulf of mutual incomprehension – sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding. They have a curious distorted image of each other. Their attitudes are so different that, even on the level of emotion, they can't find much common ground.
> ...
> The non-scientists have a rooted impression that the scientists are shallowly optimistic, unaware of man's condition. On the other hand, the scientists believe that the literary intellectuals are totally lacking in foresight, peculiarly unconcerned with their brother men, in a deep sense anti-intellectual, anxious to restrict both art and thought to the existential moment. And so on." [32]

Critics will point out that Snow's full critique is intellectually superficial and overly concerned with practical matters such as education reform and combating poverty. But if one interprets "anti-intellectual" as "anti-rational" in the above quote, at least part of Snow's critique seems to be a prescient concern about the coming conflict between philosophically rational modernism (science) and irrational post-modernism (the humanities).

Philosophically, science is rooted in the values of the Enlightenment and modernity. This includes a metaphysics of naturalism and realism, and an epistemology which trusts both experience and reason as a means to knowledge. Science is indeed a relatively optimistic enterprise in that it posits that real progress and real improvements in understanding are achievable.

As the humanities have adopted an increasingly postmodern attitude they have grown comparatively pessimistic. Veering towards a radical relativism, the postmodern humanities actively argue against progress, and against sense experience and reason as a means to knowledge. At the extreme the entire Enlightenment/scientific project is reduced to mere social construction, no better or more certain than the mythologies of other cultures now or in other times [33, 34].

15.3.1 Postmodern Antipathy Towards Science

Postmodernism, deconstruction, critical theory and the like introduce notoriously elusive, slippery, and overlapping terms and ideas. Most adherents would argue that this must be the case because each is not so much a position as an attitude and an activity; an attitude of skepticism and activity that is in the business of destabilizing apparently clear and universal propositions [35].

Where modern art aspires to progress towards the absolute, postmodern art celebrates the circulation of a plurality of ideas while denying any notion of ultimate progress towards singular totalizing views. In his foundational treatise "The Postmodern Condition" [36] Lyotard cites both political and linguistic reasons why, in his view, this must be so. In his formulation of deconstruction Derrida emphasizes this break with structuralism. He denies the notion that language corresponds to innate or specific mental representations, let alone the noumenal world. Rather, at most, language is an unfixed system of traces and differences. And, regardless of the intent of the author, texts (i.e., all media including art) always reveal multiple, possibly contradictory, meanings [37].

As part of the art manifesto aspect of this chapter I will now make a number of observations regarding postmodernism. First, it's worth noting that the effect of postmodernism on art has included a number of changes for the better. Postmodernism has offered a useful corrective to the theoretical rigidity of some modern art criticism. Postmodernism has created the basis for many new threads in art such as identity art, the leveling of high and low art, and the development of political art as activism. Most of all postmodernism has promoted racial, ethnic, and sexual diversity in art in a way that perhaps modernism should have, but seldom achieved.

But postmodern art has also introduced significant problems by keeping the world at an ironic arm's length and viewing sincerity as a naive indulgence of the past. Some find postmodern art to be overly political to the point of blind reductionism. And postmodern art at times seems to be a snake eating its own tail, as it produces increasingly insular art about art (about art,...).

Perhaps most unfortunately, art students are steeped in postmodernism without explicit exposure to its derivation and development. And, worse yet, they are not offered the philosophical alternatives. These students may take required science classes, but very few will study the philosophy of science from the point of view of Enlightenment values. And so generations of art students now take as axiomatic the conclusions of postmodern writers, most often in the form of slogans such as:

- Science is not objective discovery, it is merely social construction (after Lyotard).
- Language has no fixed meaning. There are only traces and word games (after Derrida).
- The author is dead, and any meaning is created by the reader (after Barthes).
- There is no truth, merely discourse and (political) power (after Foucault).

At this point postmodernism has become for most young artists uninspected received wisdom, and a conceptual box from which they can find little escape.

The schism between the arts and humanities reached a new high with the so-called “science wars” of the 1990s. Anxious to bolster the standing of postmodernism in the face of ongoing scientific progress, those in the humanities began to critique the scientific method as part of “science studies.” Science studies both attempts to destabilize scientific knowledge, and at the same time co-opt concepts from 20th century science that could be interpreted as epistemological challenges. Targets for postmodern appropriation include Einstein’s theory of relativity, quantum mechanics, the Heisenberg uncertainty principle, Gödel’s theorem, and more [34].

Most of those scientists who cared to comment at all typically labeled such writing as non-science at best, and nonsense at worst [34, 38]. The debate reached fever pitch when physicist Alan Sokal’s essay, published in the fashionable academic journal “Social Text,” was revealed as a content-free parody of postmodern writing. It was intended to demonstrate by way of a hoax the lack of rigor in postmodern science studies [34, 39].

15.3.2 Postmodernism and Science-Inspired Art

For better or worse postmodernism, deconstruction, and critical theory are the dominant worldviews within which contemporary art theory and criticism operates. Not surprisingly most mainstream artists who approach scientific concerns do so with skepticism, irony, and political antagonism. The few artists who actively embrace scientific ideas find themselves in a sort of conceptual no-man’s-land between the warring factions, and somewhat estranged from both sides.

Blais and Ippolito exhibit this alienation in their survey of some 50 technology-artists called “At the Edge of Art.”[2] Coming from the subcultures of the museum and the academic art world, they express a kind of ambivalence as they praise expressive work using technology, and yet can’t quite bring themselves to call it art.

[2] The author of this chapter is one of the artists profiled.

> "Far from the traditional epicenters of artistic production and distribution, creative people sitting at computer keyboards are tearing apart and rebuilding their society's vision of itself. Though they may call themselves scientists, activists, or entrepreneurs rather than poets or artists, many of these visionaries are playing the roles of Dante or Da Vinci. Unlike the Soviet artist-engineers or Happening participants of the past century, who pushed artistic practice to the edge from within the avant-garde, many of the most innovative creators of the new century hail from other disciplines." [40]

One might think that with the rise of "new media" and technology-based art artists could find shelter from postmodern skepticism. But contemporary commentary on technology-based art is firmly rooted in the postmodern critique.

One example of this is Lovejoy's "Postmodern Currents – Art and Artists in the Age of Electronic Media." This book documents the late 20th century history of media art, and is something of a standard text in art schools. Lovejoy reiterates the popular claim that somehow contemporary media technology is the physical manifestation of postmodern theory.

> "George Landow, in his Hypertext: the Convergence of Critical Theory and Technology, demonstrates that, in the computer, we have an actual, functional, convergence of technology with critical theory. The computer's very technological structure illustrates the theories of Benjamin, Foucault, and Barthes, all of whom pointed to what Barthes would name "the death of the author." The death happens immaterially and interactively via the computer's operating system." [41]

The supposed influence of critical theory on computer architecture would no doubt come as a surprise to the engineers who actually create the technology without any need to consult the guiding principles of postmodernism. And the quote is hardly an isolated idea. As the title indicates, postmodernism is the conceptual thread upon which Lovejoy strings all manner of (often unrelated) examples of technology art.

Another example is Wilson's encyclopedic survey "Information Arts – Intersections of Art, Science, and Technology." This publication includes all manner of art using digital technology, especially those which somewhat recursively address science and technology as subject matter. His embrace of postmodernism as a context for the artistic exploration of science is less committed, but he leaves no doubt about its nearly universal effect on the field, and is candid about his use of critical theory as an organizing principle for his book.

> "In recent years, critical theory has been a provocative source of thought about the interplay of art, media, science, and technology. Each of the major sections of this book presents pertinent examples

of this analysis. However, in its rush to deconstruct scientific research and technological innovation as the manifestations of metanarratives, critical theory leaves little room for the appearance of genuine innovation or the creation of new possibilities. While it has become predominant in the arts, it is not so well accepted in the worlds of science and technology." [42]

"Not so well accepted" indeed.

The point here is not to say that Lovejoy and Wilson alone set art, and especially technology-related art, in a postmodern context. They, as careful commentators surveying technology-based art, have correctly identified postmodern ideas as dominating the field. Postmodernism continues as the currently operative paradigm in the arts, even the high-tech arts.

15.3.3 Postmodernism in Crisis

As a central part of the art manifesto aspect of this chapter I'm asserting that it is time to go beyond postmodernism. Like all waves of philosophical skepticism, postmodernism taken to its ultimate conclusion leads to an intellectual and existential dead-end. And, indeed, even in the arts and humanities there is a vague sense that postmodernism has been "played out." There are, however, few suggestions and no consensus as to what comes next. The problems, though, are glaring.

First, postmodernism is guilty of what is termed a performative contradiction. Postmodernism, as a form of skepticism, seeks to undermine all claims to knowledge by demonstrating that all propositions are merely consensual realities and word games constructed by, and relative to, a given culture. But such a claim is so epistemologically corrosive that it also undermines the ability of would-be postmodernists to make the claim in the first place. In other words, if postmodernism must allow that it too is merely a word game and a social construction without intrinsic truth-value, why should anyone take it seriously?

Second, over time it has become increasingly clear that postmodernism is, as much as anything, a specific form of politics. As philosopher Stephen Hicks points out, if postmodernism was purely an epistemological position one would expect to find postmodernists across the political spectrum from left to right. In fact, postmodernists are uniformly left wing, and for many postmodern rhetoric is first and foremost a political tool. Hicks, tracing skepticism from Rousseau to Foucault, makes a convincing case that postmodernism has become a sort of philosophical survival shelter for literate disappointed socialists. Modernism, by contrast, is politically orthogonal, and science can be embraced by both those on the left and the right [33].

Finally, postmodernism taken to its natural end, leads to a nihilism that is simply impossible to live out. It's one thing to be philosophically skeptical, but if one were to actually apply that skepticism to everyday decisions it's hard to know how one could ever leave the house. In a way related to the performative contradiction, postmodernism in practice inevitably leads to acts of philosophical bad faith and hypocrisy.

Artists who embrace Enlightenment values and science find themselves in the minority, and all too often the objects of dismissal as remnants of a long discarded modernism. This is a problem, but also an opportunity. Evolutionary artists, and other artists working with complex generative systems, are standing right where the foundation for a new bridge between the sciences and humanities must be built.

15.4 Complexism – A New Science-Friendly Paradigm for the Arts and Humanities

In this final section I would like to bring the speculative art manifesto aspect of this chapter to the fore. My proposal is that complexism is that which comes after postmodernism. Complexism is, in a sense, the projection of the world-view and attitude suggested by complexity science into the problem space of the arts and humanities. Complexism does this by providing a higher synthesis that subsumes both modern and postmodern concerns, attitudes, and activities.

15.4.1 Complexism and the Challenges of Uncertainty and Incompleteness

Complexism must provide an account that takes into consideration the changes that took place in science in the 20th century. In the move from classical to modern physics the Laplace clockwork universe was replaced with an uncertain statistical universe. No longer could one fantasize that given a full inventory of masses and velocities, one could deduce the state of the universe at any time. Quantum mechanics and Heisenberg uncertainty have forever removed that possibility. And at larger scales chaotic dynamics ensure that a deterministic universe will always, even in principle, remain unpredictable.

Complexism must also embrace the limits intrinsic to logic and mathematics as revealed by metamathematics. David Hilbert's program to deduce all mathematics using a formal grammar of provably consistent axioms was stopped dead in its tracks by Gödel's incompleteness theorem [43]. Gödel proved that in any axiomatic system there are going to be truths that cannot be proven. Resonating with independent work by Church [44], Turing demonstrated an algorithmic parallel in that there will always be programs whose end-state cannot be predicted without actually being run [45]. Chaitin extended this work to demonstrate that axiomatic systems can, in fact, contain an uncountable number of unprovable truths [46, 47].

Complexism must leapfrog the attempt by postmodern science studies to appropriate via misinterpretation these epistemologically loaded ideas. Yes, even simple physical systems are cloaked in uncertainty. And yes, there will always be mathematical truths that cannot be proven. And of course this shakes to its core the kind of early Enlightenment optimism maintained by a Laplace or a Hilbert. But none of these findings has brought science or mathematics to a halt. In fact understanding that knowledge is bracketed by uncertainty and incompleteness is in itself a major triumph of 20th century science and mathematics. And within those brackets the 20th century yielded unprecedented progress on virtually every scientific and mathematical front.

The problem is that 20th century science and mathematics have yet to be put in an appropriate cultural context. The accurate assimilation of these powerful ideas into the general culture will provide complexist artists with subject matter for many years to come.

15.4.2 Complexism and the Reconciliation of Modernism and Postmodernism

Without any specific commitment to literal Hegelian philosophy, the reconciliation of modernism and postmodernism by complexism can be best described with a thesis-antithesis-synthesis model. Remember that we are talking here about a paradigm for the arts and humanities. As such complexism is more about attitude than rigor, and more about metaphor than quantification.

Taking modernism as the thesis, and postmodernism as the antithesis, both can be described with a series of apparently irreconcilable polar opposites. For example, where modernism looks to the absolute, postmodernism emphasizes the relative, and where modernism posits progress, postmodernism denies progress. Under this scheme complexism can offer a point-by-point synthesis that in its totality suggests a new paradigm. A synthetic attempt like complexism should be expected to take many years to develop, but a first approximation is offered in Table 15.1 and in the discussion below.

Modernism	**Postmodernism**	**Complexism**
Absolute	Relative	Distributed
Progress	Circulation	Emergence & Co-evolution
Fixed	Random	Chaotic
The Author	The Text	The Generative Process
Authority	Contention	Feedback
Truth	No Truth	Incomplete truth known to be not fully knowable
Pro Formalism	Anti Formalism	Form as public process not privilege
Hierarchy	Collapse	Connectionist networks

Table 15.1. Complexism as a higher synthesis of modernism and postmodernism

Modernism, whether in the sciences or in the hands of painters such as Rothko and Pollock, reflected Enlightenment values in reaching for the absolute and the fixed. The postmodern attitude rejects the absolute, and rather posits a multivalent view of relative positions that are, ultimately, as good as random. Complexism reconciles the absolute with the relative by viewing the world as a widely interconnected distributed process. Complexism posits a systems view where processes may be neither fixed nor random, but are instead chaotic. Complexism will nurture in the broader culture a visceral appreciation of how the world can be deterministic and yet unpredictable.

Where modernism posits progress, and postmodernism rejects progress for multiple contingencies in constant circulation, complexism looks towards the emergence of co-evolved possibilities. Co-evolved entities achieve real progress in the relative context of each other, and success remains a moving target rather than a fixed end-state. In human communications the modernist ideal posited the gifted author (scientist or artist) in a demonstrable position of authority. The postmodern retort is that the reader creates the meaning of the text (experiment or artwork), and such readings should be contentious via deconstruction. In complexism the flow of information is seen to require agents acting as both authors and readers, creating a generative process based on constant mutual feedback.

Where modernism posits hierarchies, postmodernism seeks to collapse them. Complexism doesn't erase relationships, but nor does it mandate hierarchies. Complexism emphasizes connectionist models and networks, creating systems of peer agents rather than leaders and followers. Where modernism aspired to absolute truth, and postmodernism denied any possibility of truth, complexism acknowledges known limits to human knowledge, but takes seriously the incomplete and statistical scientific truths that are achievable.

15.4.3 Complexism and the Importance of Evolutionary Art

Complexism has revolutionary implications for art. For example, modern art embraced formalism, i.e., the study of significant form. Whether by representation or abstraction, formalism was celebrated as the heroic pursuit of the specially gifted artist. Postmodernism rejected formalism as a fetishistic pursuit of meaningless beauty that makes false claims to authority and privilege along the way.

Complexism rehabilitates formalism, but not as a privileged view. Complexist formalism is a public process where form is an understandable property created by underlying generative processes. Static form is no longer meaningless but rather serves as an icon for the systems from which it emerges.

It was noted earlier that some generative art uses a system "in the studio" to create an object that is displayed to an audience at a later time, while other generative art displays systems in action to an audience in real time. As useful and interesting as the former is, it is the latter that best expresses what is revolutionary about complexism. Because in its purest form generative art using complex systems is about the dynamics of complex systems.

Complexism not only rehabilitates formalism, it perhaps more importantly reintroduces the artistic notion of dynamism. As originally introduced by the Futurists, dynamism celebrated the aesthetic of the locomotive and the race-car, and called for the exploration of motion and process rather than portraying objects as being frozen in time [48].

Dynamism in complex art is the visceral appreciation of the beauty of dynamics as more fully revealed in the context of complexity. In a sense, formalism is to nouns as dynamism is to verbs. With its focus on complex generative systems, complex art encourages artists to move from art objects to art processes, i.e., from nouns to verbs.

Through the 19th century generative artists primarily used simple highly ordered systems. The 20th century saw the rise of generative art using simple highly disordered systems. In the 21st century we are starting to see an explosion of generative art using complex systems in the realm between order and disorder. Evolutionary art, at the apex of the effective complexity curve, completes the full spectrum and history of generative art.

Presented in its purest form rather than as a means to some other end, evolutionary art takes complexism as both its content and working method. Evolutionary art demonstrates the reconciliation of the sciences and humanities by providing a visceral experience of the distribution, emergence, co-evolution, feedback, chaos and connectionism that are the hallmarks of the new paradigm of complexism.

Evolutionary art, especially when offered as an ongoing process rather than a static object, presents the dance of formalism and dynamism. It underscores how each arises from the other, and marks a radical shift of emphasis in art away from nouns and towards verbs.

In short, evolutionary art creates the dynamic icons by which complexism can become known and understood, and in doing so creates a new paradigmatic meeting place for the sciences and humanities.

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