The Emergence of Art Systems
Cycles of Change in Art Styles

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Abstract

Our objective was to develop a model of social change to explain changes in art styles as they are affected by changes in the surrounding society. We derived our model from complexity science and network theory to show how systems move from chaos into the complex region at the edge of chaos from which emerges order. Eventually, the cycle reverses back into complexity or even into chaos, before a new cycle begins.

In order to account for these cycles in art styles, we subsumed many social and economic factors under two general system variables: *differentiation* and *centrality*. *Differentiation* refers to the amount of variety within a system, for example, the range of services in an urban system such as the city of Florence during the Renaissance period. Differentiation also refers to how a variety of skills and techniques are organised, say, through political and economic links among art patrons. *Centrality* is the extent to which a system is connected to other systems, and, hence, exposed to incoming information. Thus, centrality varied over time for a city such as Florence during the Renaissance from the fourteenth to the seventeenth centuries, depending upon its links with other cities. We then showed how the ratio of differentiation to centrality accounts, at least in a general way, for cycles of art.

1. Introduction

The general idea of change seems to be the most obvious and yet the most elusive of concepts in both the physical and social sciences. On the one hand, nature seems to be in a constant state of flux, never the same from moment to moment, exploding in surprising new directions, sensitive to the slightest breeze, the merest touch of another object. Some modernist abstract art seems to capture this almost random, fluctuating kaleidoscope of appearance, interaction and change (Stella, 1986).

Yet, the primary goal of rational science is to detect orderly, fixed structures where change is predictable and controlled through universal laws. The physical sciences, in particular, from the ancient Greek mathematicians to Renaissance scholars to Enlightenment researchers and modern experimentalists, have uncovered a variety of such predictable processes which govern the state of almost everything, from the tiniest ‘string’ of sub-sub-atomic particle theory to the expansion of the universe itself into multiverses. These processes that scientists have discovered seem to be governed by laws which are themselves unchanging. Much Renaissance art was an attempt to replicate these laws of reality, from using mathematical formulae to reduce three dimensional perspective to two dimensions, to drawing the human form and its behaviour according to certain formulae (Stella, 1986).

Thus, there seem to be two regions within nature, modelled, in turn, by two extreme art styles—the region of constantly changing *chaos* sometimes found in post-modern art styles, and the region of relatively fixed order exemplified by the elegant beauty of art during the High Renaissance. In the chaotic region, change seems quite unpredictable, sensitive to the influence of every outside force. Within the region of order, on the other hand, change is more predictable and determined by laws that explain when and how change happens. It may be, however, that the appearance of both chaos and order is somewhat misleading, and more recent discoveries in complexity science have revealed underlying patterns even in chaos, and evidence that even the most ordered structures may be chaotic in the long term (Gleick, 1987; Murray & Homan, 1999).

The new science of complexity has discovered, also, that there exists in addition to chaos and order, a third region between the region of less predictable chaos and the region of more predictable order. This intermediate region was first called “the edge of chaos”, since it is within the orderly region but near the boundary with chaos (Kauffman, 1995: 86ff). More recently, this intermediate region has come to be identified with complex processes, and we will call it the region of *complexity* (Wolfram, 2002: 281ff). In this third, intermediate region, systems and their structures, and even the laws which govern change processes, appear to be emerging out of chaos into new patterns of order, a process known as *self-organisation* (Kauffman, 1994).

More recently, another group of system theories, which began with the computer modelling of Duncan Watts and Albert-László Barabási, have studied the structure and behaviour of a specific type of system, social networks, again within each of three regions. Much of the study of networks grew out of investigations of the small-world phenomenon—why even casual acquaintances often have other connections to us (Barabási, 2002; Buchanan, 2002; Watts, 2003). Watts and Barabási found, midway between decentralized *nodes*—close to random chaos—and dominant *hubs*—more ordered systems—a third region of small worlds made up of many smaller *clusters*. This intermediate region corresponds to what we are calling the complex region between chaos and order.

We will use the terms of chaos, complexity, and order for the three regions within which systems may exist. We will also demonstrate why we can assume that systems exist primarily within one of these three states. The overall movement from less order to more order we will call *social focusing*. That is, the less ordered chaotic systems are much less focused—they are very sensitive to outside disturbances. Even slight changes in the environment sends the system off into a new, unpredictable direction.

Ordered systems, on the other hand, are more focused, in the sense that their output, their visible behaviour, resists outside pressures to change. The output of ordered systems is concentrated around a narrow variety of actions—it is focused. In between, within the region of order but at the edge of chaos, is the region of complex behaviour. Complex systems reveal a core of orderly behaviour but they respond to outside forces by adapting and even generating new forms of order, while retaining their essential core structure. Hence, to move from chaos through complexity to order, is a process of becoming more focused, specifically, for social systems, to be more socially focused.

The focus of this paper is to explain how and why social focusing varies in the social systems which produce styles of art. Why do societies move from one state to the other? In particular, why do groups of artists and their styles change from a somewhat chaotic system of loosely connected artists working with their own styles, into a more complex system of several clusters of workshops each with a certain style, to a more ordered stage when all artists are expected to conform to a dominant style often dictated to them by powerful academies? Why, following this process of increased focusing, do art systems then return from order back into complexity and even into chaos?

We will begin with a review of some of the theories of change growing out of Wolfram's studies on the computer of simulated systems based on cellular automata, along with more recent simulations of networks. We will then offer our own explanation for change among the three regions, based on what we are calling the differentiation/centrality ratio. Elsewhere we use our model to explain specific changes in art styles during the Gothic period before the Renaissance, the Renaissance period itself, and the succeeding period of the Baroque (Flynn, Hay, & Lennon, 2006). Here we will focus on the model itself.

2. Theories of Change in Social Systems

2.1 Cellular Automata and the Four Classes

Although cellular automata were invented by John von Newman in the 1940s, it was Stephen Wolfram's exploration of cellular automata in the 1980s which defined the classes corresponding to chaos, complexity and order (Flake, 1999: 232, 236; Wolfram, 1984, 2002). The simplest form of a cellular automaton is a row of ones and zeros—or a row of black and white cells. Each successive iteration of the cellular automaton produces another row of cells. The appearance of the new rows is governed by a set of rules, such as, "If both cells adjoining a white cell are black then the white cell changes to black."

There are a finite number of such rules, all based upon Boolean logic, although the number of rules becomes very large very quickly as we make the system more complicated. Wolfram tested all such rules for simple cellular automata on a computer, over literally millions of iterations. From these results, he discovered that there were only four possible types of systems, which he called classes. Class 1 systems ended up in a homogenous arrangement which never changed. Class 2 systems cycled endlessly through a fixed number of states. Class 3 systems produced random-like results with no obvious pattern, and where the states were extremely sensitive to initial conditions. Class 4 systems were a mixture of local structures but on a random-like background, and can be thought of as intermediate between the first two classes and the third class (Flake, 1999: 237; Wolfram, 2002: 231ff). For this paper we have called class 3 systems *chaotic*, class 4 *complex*, and classes 1 and 2 *ordered* systems.

Wolfram then went on to study random samples of more complicated cellular automata—with several colours, in several dimensions, with more complicated rules such as rules for change based on the state of non- adjacent cells, 'mobile automata' where cells change individually rather than simultaneously, systems without a lattice, and 'substitution automata' where new groups of cells are substituted according to a meta-rule. Somewhat to his surprise, the same four classes appeared, albeit in different proportions. Complex patterns, for example, were much rarer for the more complicated cellular automata (Wolfram, 2002: 51-113).

In his magnum opus, *A New Kind of Science*, he described his experiments and also connected his results to a variety of other mathematical, physical, biological and social phenomena. His major discovery was that almost all phenomena seemed to be generated by simple rules, perhaps, he speculated, similar to the rules controlling cellular automata. At the very least, he discovered, all systems may be simulated by certain cellular automata, in particular by what mathematicians call "universal computers" (Flake, 1999: 467). He has shown that even a very simple, though complex, class 4 system is a universal computer.

So, what is a universal computer? The underlying arguments for universal computing are both subtle and profound (Flake, 1999: 430-433). It can be proven that all *computable* systems may be simulated exactly by a universal computer such as a digital computer—if it has enough memory. This raises a further question—what is a computable system? It is a system which can process a series of yes/no questions (Flake, 1999: 447). According to Flake, some systems seem not to be computable, although he admits that cannot be proved. Most non-computable systems involve some degree of randomness where, by definition, it is impossible to predict what will happen next, hence impossible to determine a yes/no answer to a question about the system. For Flake, this includes social systems made up of a variety of people each making decisions based on personal factors that cannot be completely analysed, so that there is always some inherent randomness and unpredictability in social behaviour. Hence, social systems may not be computable and it is not clear, therefore, to Flake that it is possible to simulate them on a universal computer such as a complex cellular automaton.

Wolfram, however, is not so sure that any system is truly random, arguing that even apparently random systems are probably repetitive if observed over a long enough time period—possibly much longer than the age of the universe—but they are not random. Certainly all cellular automata are repetitive—eventually—and are precisely determined by the rules which govern what happens next. His argument for more complicated systems such as societies is that they may be reduced to individuals, which in turn may be reduced to biological processes, which are based on the interactions of genes, which depend upon molecular processes, and so on, until at some level, social behaviour, in theory at least, is mathematically computable.

At the very least, Wolfram argues that all systems, even social ones, are approximately computable. There is another principle, "universal approximation", also from mathematics, which states that any process may be approximated by certain kinds of networks, such as the neural networks found in biological organisms (Flake, 1999: 407). This implies that cellular automata that are universal computers can simulate approximately what happens in social systems.

To make a long story short, for all practical purposes, the patterns of chaos, complexity and order found in cellular automata, are probably the only types of systems which can occur in social systems. Hence, we agree with Wolfram, that what happens in the real social world may be understood—approximately—through various kinds of computer modelling, especially through the study of cellular automata.

Wolfram's conclusions based on cellular automata, then, helped us classify the states of social systems—such as those governing art styles—according to differences among chaos, complexity and order. Furthermore, using Wolfram's logic for simulation, there exist cellular automata that are universal computers able to mimic social systems. Unfortunately, most such simulations are very complicated. This complication can be reduced by altering the structure of the cellular automaton but it still seems much more artificial than the way in which natural processes of change happen in real social systems. Furthermore, since each particular cellular automata is a discrete system governed by a certain set of rules, his results are not very helpful in understanding how more general systems change from one class to the other.

There are, fortunately, other kinds of computer models which seem more similar to social systems than the somewhat abstracted cellular automata. In the next section we will review recent research on the simulation of networks by computer models developed specifically to imitate social networks involved in the 'small world phenomena.' Although network models are very different from cellular automata, they appear to produce results which, again, fall into either chaos, complexity or ordered regions.

2.2 Network Theory

The small world phenomenon, although well known to anyone who has met a stranger who shares a common acquaintance, was first tested systematically by Stanley Milgram in the late sixties. By following the paths of letters sent from people in one part of the United States to strangers elsewhere, he was able to demonstrate that most people—in the United States at least—are connected to each other by a remarkably small number of links, perhaps as few as six (Watts, 2003: 37-39). In the nineties, Duncan Watts, a mathematician who later became a sociologist, developed computer models of networks which would simulate the small world phenomenon.

2.2.1 The Small World Problem

Watts started studying the small world problem by modelling three kinds of network systems—he called them three worlds—corresponding to what we have been calling chaos, complexity and order (2003: 74ff). By using relatively simple rules, he could produce a continuum of networks, for, as Wolfram had already discovered,

> Very simple rules, at the level of individual actions, can generate bewildering complexity when many such individuals interact over time, each making decisions that necessarily depend on the decision of the past (Watts, 2003: 77).

Watts called the first world *Solaria*, named after a planet in Isaac Asimov's *Robot* books. In Solaria, the chaotic world, people are widely scattered with few links among them, but even the addition of a few random links—approximately one per person—will connect everyone, as the mathematician Erdös had already discovered (Watts, 2003: 43ff). The network structure itself changed dramatically with the addition of a few links—it was sensitive to initial conditions, the key defining property of chaos in Wolfram class 3 systems.

At the other extreme, in the ordered world of Caves—also named after a planet in the Asimov *Robot* series—people lived in clusters tightly linked internally, with virtually no external links among the clusters, so that the overall network was static and unconnected. Furthermore, the internal network structure of the clusters also remained relatively fixed, even when more links were added, since most links were among people who were already closely connected. The Cave world, then, corresponded to Wolfram's class 1 ordered systems, where little structural change occurs no matter what happens. In a later model Watts was able to generate ordered networks which were periodic, corresponding to a class 2 system (2003: 84-85).

Between the chaotic world of Solaria and the ordered world of Caves, Watts manipulated his computer models to simulate small worlds, that is, a complex world where people still lived in relatively isolated cave-like clusters but where even a few 'shortcut' links between clusters soon connected everyone, forming a system with short path lengths among individuals. Watts concluded that this intermediate network with many clusters—neighbourhoods, families, workplaces—and a short path length between any two nodes, corresponded to a small world. As in Wolfram's complex class 4 systems, order remained within the clusters, but the overall structure gradually changed as a few shortcuts were added, and a new suprasystem emerged.

The shortcuts connecting clusters are what the sociologist Granovetter called *weak ties* among casual acquaintances (Csermely, 2006; Granovetter, 1973). Granovetter discovered that weak ties linking casual acquaintances were often more useful for finding employment than strong ties among neighbourhood friends. Residents already knew everyone in their neighbourhood—they needed the weak ties to link up with other job opportunities.

So, in the process of solving the small world problem, Watts had generated the regions of chaos, complexity and order, although he did not use those terms. He, and others working in this field, also found that the intermediate complex model of clusters connected by weak ties corresponded to many real world networks, from networks of academics, to movie actors, to electric power grids, to neural networks in worms. He also found that the transitions among the three regions in his computer simulations were quite abrupt, what he called phase transitions, corresponding to the transition among the physical states of gas, liquid and solids (2003: 80-81). Again, this resembled the very distinct regions of the Wolfram classes.

Now, while Watts could make his models move from one region to the other by changing parameters in the equations governing the output of the models, this was not too helpful in figuring out why real world systems move from chaos to complexity to order, because his model parameters seemed to have little correspondence with the real world (2003: 84, 87). Better understanding of change among the three regions came from studies of actual networks—such as the Internet—done by Barabási and others.

Barabási used two terms to describe different types of network structure (Barabási, 2002: 70ff). The early stage of widely scattered nodes he called *scale networks*, where scale refers to the average number of connections for each node, with a few nodes having a slightly larger and few with a slightly lower number of links. The result of plotting frequency of links against the number of nodes with that frequency is a 'normal' or Poisson distribution—a hill with steeply falling sides. The centre of the distribution, the average number of links, becomes the scale for the network. This is typical of more random-based networks, close to the region of chaos.

For later stages, a few nodes have a high number of links—they are hubs—with a declining number of links for the remaining nodes. This produces the so-called *power law* distribution, which resembles a ski slide falling from a high number of connections to a gradually decreasing number of links. In this case, it is not meaningful to speak of an average number of links to describe the distribution, and so Barabási named the distributions *scale-free*. Since Barabási's original research, scale-free distributions have been discovered in a myriad of networks, from neural systems to the distribution of users of downtown shelters (Gladwell, 2006). In each case, a few nodes have a disproportionate number of connections, typical of more ordered networks.

Between random-based networks and ordered hubs are intermediate, decentralized clusters—the small worlds of Watts' models—equivalent to complex systems (Barabási, 2002: 145).

Barabási's goal, then, was to simulate and discover parameters—what he called 'principles' in his computer models—governing the change of structure from chaotic systems with near random nodes, through clusters to ordered hubs. His 'principles' were ad hoc ideas such as the principle of "preferential attachment," which assumed that the more popular, connected nodes attracted more new links—the rich became richer. Varying the strength of the principles caused the model to move from chaos, through complexity to order.

Both Watts's and Barabási's models were able to simulate transitions among the regions but they did so by altering parameters within the mathematical equations governing their computer models. Watts' parameters were rather obscure exponentials in his earlier models or probabilities in his later ones. To explain how networks such as the Internet grew, Barabási added somewhat arbitrary assumptions about individual behaviour to his model.

We are suggesting in this paper that there are other, more social variables which lead to the process of change from chaos through complexity to order and back again. The interaction of these social forces produce, we believe, cycles of change. In the next section we discuss the social process involved in the interaction between two such fundamental variables, summarized by the differentiation/centrality ratio. We will also show how this ratio is related both to the models of cellular automata investigated by Wolfram and others, as well as the networks theories introduced by Watts and Barabási.

2.3 Cycles of Change and the Differentiation/Centrality Ratio

Before introducing the idea of the differentiation/centrality ratio, we will review two underlying fundamental—yet apparently contradictory—processes in nature. The first process is *self-organisation*, the tendency which moves systems out of chaos, through complexity, and into order. The second process is the production of *entropy*, the tendency of all systems to run down, to move from order back through complexity into chaos. The differentiation/centrality ratio, we argue, determines which process dominates. If the differentiation/centrality ratio is greater than one, self-organisation takes over; if the ratio is less than one, entropy dominates. If the ratio increases and then decreases, the result is a cycle from chaos to chaos, peaking with order, where complexity is at the shoulders of the cycle. Of course, the cycle may not go all the way back to chaos before rising again to order, hence the cycles are really *near*-cycles. First, a brief summary of the two processes leading to either self-organisation or entropy.

2.3.1 Self-Organisation

The new science of complexity really began with attempts to explain self-organisation, how systems, especially living biological and social ones, are able to move, seemingly spontaneously, from disorder to order. From Prigogine (Prigogine & Stengers, 1984) to Kauffman (1994) complexity theorists have been fascinated with the emergence of order out of chaos. Prigogine demonstrated that the self-organisation in chemical reactions required extra energy from the environment but it was not always clear why it happened (Prigogine & Stengers, 1984: 142-143). Kauffman's computer simulations seemed to show that self-organisation was most likely to occur within the more complex region between chaos and order. Again, he was not sure why this happened but speculated that biological evolution has moved living systems—including social ones—into complexity because that is where systems are most likely to survive. if they are in a state of complexity then self-organisation can help them adapt to changing environments. The important point is that order seems to emerge during the intermediate stage of complexity.

We will use the term increasing *social focusing* to describe self-organisation, the process of moving from chaos into order, of order emerging from disorder.

2.3.2 Entropy

The concept of increasing entropy is a much older idea. Ever since the nineteenth century studies of heat transfer and the development of the Second Law of Thermodynamics, it has become accepted that it is normal for entropy—an increase in unpredictable randomness—to increase in any transfer of energy or information. In simple terms, this means that some energy or information is lost at each transfer so that all processes are essentially irreversible. It seems that entropy has increased in the universe since the original Big Bang and this may explain why the arrow of time runs one way—downhill, according to the Second Law (Greene, 2004: 143ff; Prigogine & Stengers, 1984: 257ff). You cannot put Humpty Dumpty, the smashed egg, back together again. In our terms, there is a tendency for all systems to move out of order into complexity and, eventually, all the way back to the extreme chaos of randomness. Overall, a sense of focus is lost, and the system becomes unfocused.

During the intermediate stage of complexity, however, it is possible for self-organization to overcome entropy, at least temporarily, that is, for systems to re-emerge into new order and to generate more social focusing. An example from the social world occurs when an organization begins to collapse but then emerges with a new form of order, a new sense of focus.

Self-organization—negentropy as it is sometimes called—comes at a cost, however, because outside energy is needed to replace the energy lost during the ongoing process of entropy. What this means, then, is that the two processes, while going in opposite directions, can go on at the same time. In order to temporarily reverse entropy, however, the system needs to bring in energy from outside to increase its social focusing. For the larger suprasystem supplying the energy, of course, the borrowing of energy speeds up the process of entropy in the external suprasystem. In the long run, then, entropy wins—we and all social and biological life are temporary blips in a universe inexorably running down.

These two meta-laws of self-organisation and entropy production, then, tend to move systems in cycles back and forth among the three regions, where systems, especially social ones, move out of chaos into order, and back toward chaos. Between the two extremes of chaos and order there are periods spent in the intermediate region of complexity. The question remains, however: why does one tendency or the other dominate at any given time? Why do systems sometimes experience self-organisation while at other times the production of entropy takes over? Why does the degree of social focusing vary? Our explanation is based on the differentiation/centrality ratio.

2.3.3 The Differentiation/Centrality Ratio and Social Change

The concept of the differentiation/centrality ratio has several sources. One source is Frank Young's explanation for why solidarity varies, from which we have borrowed the sociological terms of differentiation and centrality (Young & Young, 1973). Another source is Ross Ashby's suggestions for designing cybernetic systems (1966 (1956): 206ff). Ashby used the general systems terms of variety—variety of input, thruput and output—combined into what he called the 'Law' of Requisite Variety: $Vo = Vi/Vt$. We have combined the ideas of Young and Ashby with more recent findings in complexity science, to develop our own explanation for social change, and, specifically, the effects upon art styles.

We begin with a brief description of the two variables of differentiation and centrality. Differentiation refers to the amount of *internal* variety within a system, for example, the variety of occupations in a city such as Renaissance Florence. For a group of artists, differentiation would refer to the different kinds of techniques available as they set out to do their painting. It is important that the variety of occupations and techniques are available to the system or to individual artists, so the concept of differentiation also includes the internal structure that connects and coordinates the variety.

As we have learned from network theory, that differentiated structure differs among the three regions of chaos, complexity and order. In the chaotic region, the structure is almost random, a haphazard arrangement of connections. In the region of complexity, the structure uniting the differentiated parts consists of several clusters, each of which is loosely connected to other clusters. Finally, in the ordered region, the structure is a giant hub which controls and coordinates almost all of the other specialized nodes through a hierarchy of sub-hubs.

Centrality, the second variable, refers to the variety of threats and demands coming into the system through links to other systems (Wasserman & Faust, 1994: 171ff). So, centrality increased when the city of Florence became more connected to other cities during the fifteenth century. For groups of artists, centrality refers to their connections to other artists, and especially to patrons with their requests for works of art. Centrality may be measured indirectly by the number of links connecting the system to other systems. A more direct measure of centrality is the variety of messages entering the system, say, the amount of mail coming into Florence, or, for groups of artists, the variety of commissions received.

Changes in the differentiation/centrality ratio, we argue, explain why self-organisation or entropy dominates, and, hence, whether the system is closer to chaos or nearer order. For example, in the Late Gothic and Early Renaissance periods, as a result of several conditions both natural and human, European society was subject to an influx of information—especially from the New World and from the Mid-East. At the same time there were major losses of life from the devastations of the Black Death. The new information represented an increase in centrality; the deaths from the Black Death lowered differentiation. The combination of higher centrality and lower differentiation dropped the differentiation/centrality ratio. This led to a more chaotic society as the forces of entropy took over, out of which, we argue, arose the experimentation of the Early Renaissance in the fifteenth century.

In an analogous fashion, the same effect happens when a group of artists are asked to meet the demands of patrons who suddenly have a lot of money, in effect, when the artists are faced with increased centrality that exceeds their differentiation abilities. As a result, the differentiation/centrality ratio falls, and the artists become unfocused. The lowered social focusing results in innovative styles as the group of artists moves close to chaos. If the differentiation/centrality ratio drops even lower, however—that is, centrality is much greater than differentiation—then the artists may produce very shoddy and degraded work that no longer conforms to any accepted style, because the artists as a group lack the differentiation to handle the higher demands. Their differentiation/centrality ratio is so low they have moved from order all the way back into chaos.

Conversely, when the differentiation/centrality ratio is greater than one, that is, differentiation is larger than centrality, the system becomes more focused, more ordered and organized. This happened in Florence during the early sixteenth century when the city contained a wide range of skills, coordinated by a strong central government under the Medici—that is, differentiation was high. At the same time, centrality became lower—the city protected itself against outside threats. The effect upon art styles was the ordered focusing we know as the High Renaissance.

In between, when differentiation and centrality are approximately matched, we are in the region of complexity where new systems gradually emerge. This happens for cities when they gradually increase their skill repertoire, while outside contacts increase at approximately the same rate. Similarly, a group of artists who have a variety of skills equal to or slightly greater than the variety of demands for their works will behave in complex ways, as different schools arise for awhile then decline in importance.

Eventually, however, if differentiation—the techniques available to artists—continues to increase and becomes coordinated, along with a constant demand—centrality—we would expect again, one dominant style to emerge, as the differentiation/centrality ratio becomes greater than one and moves the system into a new type of order. The system is more focused and self-organisation and order dominates.

Eventually, the process is reversed as centrality increases and/or differentiation falls, both changes bringing the differentiation/centrality ratio back closer to one. Thus, during the late sixteenth century, when there were threatened and actual invasions, the centrality of Italian cities such as Rome and Florence increased. Furthermore, artists began to rebel against the rigid rules of the High Renaissance, and overall differentiation fell as new artists in cities such as Bologna refused to follow the old order (Lennon & Flynn, in preparation). In the end, centrality matched or even exceeded differentiation, the differentiation/centrality ratio was approximately one, and the cities and their art scenes were less focused—more complex—during the Late Renaissance and the Early Baroque than they had been during the High Renaissance. In terms of artistic styles, this period was marked by more experimentation, including the sometimes bizarre Mannerist art of the Late Renaissance.

Those changes seemed to occur in cycles and, hence, may be an explanation for historical change in general, discussed in the next section.

2.3.4 Cycles in History and the Differentiation/Centrality Ratio

In most social systems, the variables of differentiation and centrality change rather slowly. As well, social systems eventually adjust to differentiation/centrality ratios which are very high or very low, and the result is a succession of cycles as the system moves out of chaos, through complexity into order, then falls back, at least into complexity, before a new type of order emerges.

The resulting cycles are really *near*-cycles, since, over the long term, there is an accumulation of differentiated skills which enable later social systems to adapt more easily to new influxes of information. Only rarely does an entire society fall back into chaos. As well, briefer cycles are superimposed upon longer term mega-cycles so that the individual mini-cycles never quite return to their earlier state. To use a term from complexity science, this cyclical phenomenon over time is *fractal*, where the same shape is visible over any time period, so that mini-cycles rise and fall on mega-cycles. For convenience, however, we will usually use the term cycles, realizing that they are actually near-cycles.

Figure 1, below, shows an abstract example of any system passing through a long cycle of change, as it moves from Stage 1, a chaotic phase, up to the highest point of order at Stage 6, before eventually moving back to chaos at Stage 11.

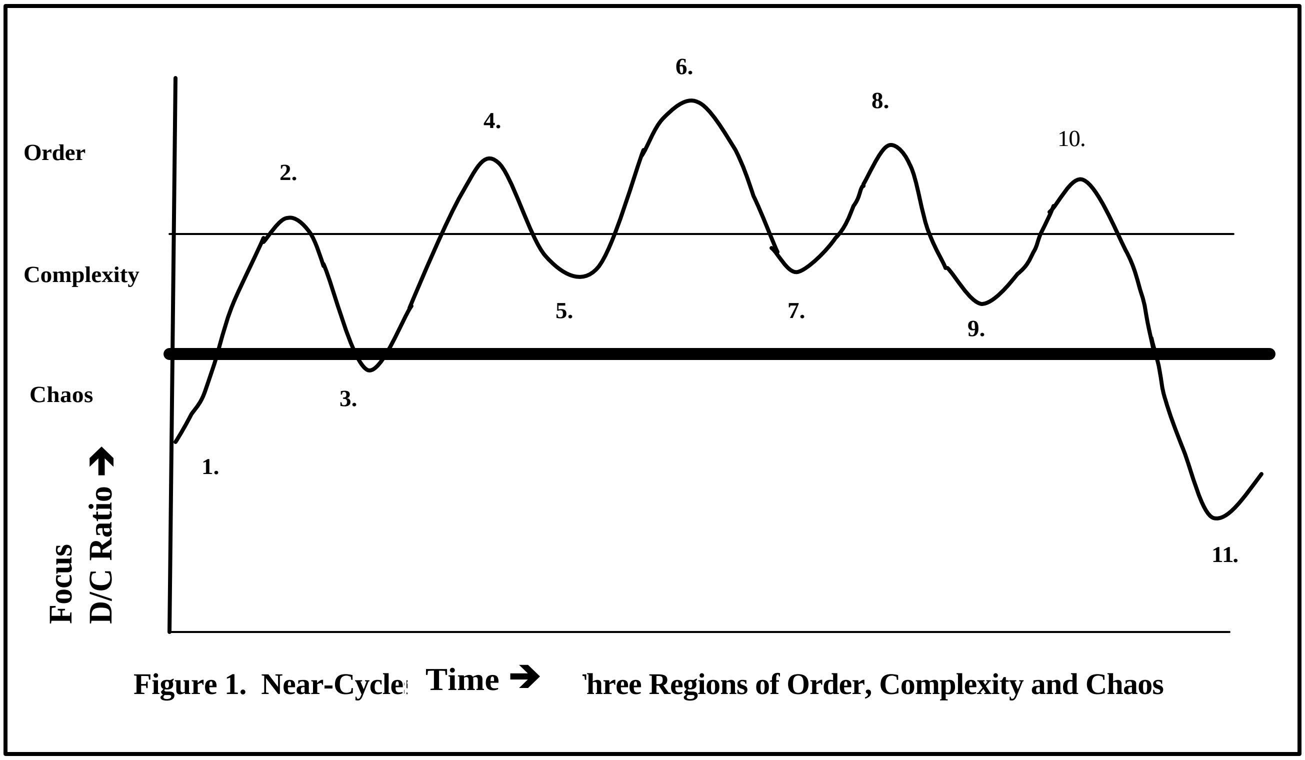

Figure 1. Near-Cycles Among the Three Regions of Order, Complexity and Chaos

According to our theory of social focusing, systems move among the three regions depending upon the degree of focusing, which, in turn, is defined by the differentiation/centrality ratio, shown as the vertical axis in Figure 1. That is, for very low values of the ratio, when centrality is much higher than differentiation, the system will be in the chaotic region. For very high values of the ratio, when centrality is much lower than the level of differentiation, the system exists in the ordered region. Between the extremes of chaos and order, is the region of complexity, where centrality and differentiation tend to match each other.

As we discussed earlier, various factors affect both centrality and differentiation. Thus, the opening of borders raises centrality, and the discovery of new technologies increases differentiation. Over time, as well, systems tend to adjust in such a way that the levels of centrality and differentiation converge. So, following an attack which raises centrality, a threatened society usually builds up a repertoire of coping mechanisms so that differentiation increases to match centrality, enabling the society to defend itself from future attacks. The reverse tends to be true for systems which become isolated with very low centrality. Without the stimulation of higher centrality, relatively isolated systems begin to lose their internal differentiation. Hence, there is a tendency over time for both very ordered and very chaotic systems to move toward complexity.

This combination of historical events, with an inherent tendency to converge on equal differentiation and centrality, explains, we are arguing, the appearance of the long cycle shown in Figure 1.

2.3.5 Cycles in Styles of Art and the Differentiation/Centrality Ratio

We now return to similar cycles among styles of art during different periods. Figure 2, below, is a copy of Figure 1 which combines the terms from complexity science with the appropriate names from art history. Both the dates and the values of differentiation/centrality, which define the cycles, are approximate and suggestive only, discussed in more detail below (See also Flynn & Hay, in preparation).

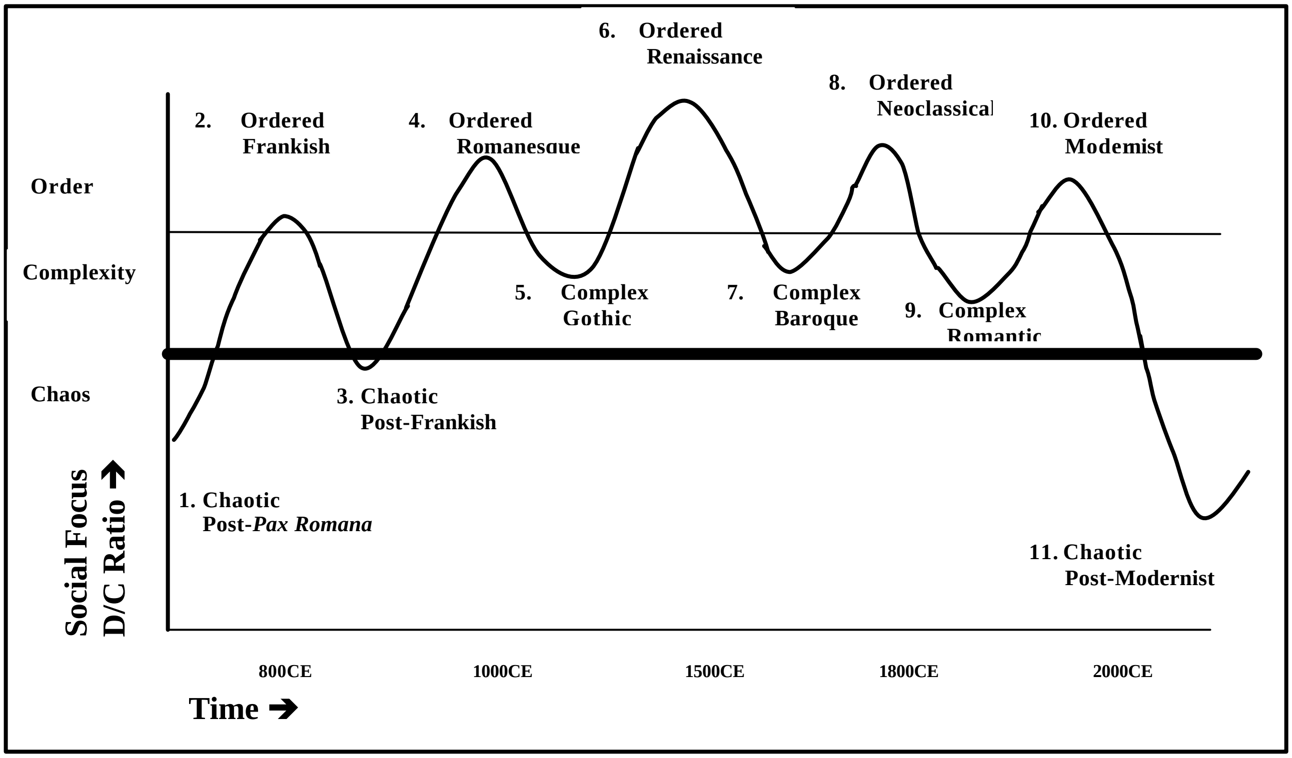

Figure 2. Art Cycles and the Three Regions of Order, Complexity and Chaos

Art historians, of course, do not use the terms chaos, order and complexity to describe different periods. Instead, *chaotic* periods correspond to what is sometimes termed *eclecticism* in art, ordered periods are called classical or High, and a variety of specific names are used for the complex periods between.

Chaotic eclecticism is most likely during the interim period between two long cycles, that is, during Stages 1 and 11, in Figure 2. These periods of chaos between cycles were once called 'dark ages,' and historians of ancient Greek art still refer to a Dark Age in Greek art history from c. 1100-700 B.C.E. when art—and culture in general—disintegrated into a "bewildering… collection of regional differences" (Pedley, 1998 (1993): 104-106).

The less pejorative term of 'eclectic' is more often used by modern historians of art to refer to the variety of styles during these turbulent times when there is no obvious single overall pattern, and patterns change constantly in response to new influences. Another such period occurred after the collapse of the Roman Empire following the *pax Romana* of High Roman art.

An example is shown in Figure 3 below, a fresco painting from an early Christian meeting place. The work is a mixture of Greco-Roman motifs along with an emerging--and simpler—folk art. The stance is a not very good Greek classic *contrapposto* one where the weight shifted to one side is counter balanced by the body twisting to the other side. At the same time, the use of various symbols such as the animals and the container of water are becoming more prominent as they did in later medieval art. But overall the painting and the decorative designs around it are more cluttered and less focused than was found in ancient classical art.

Fig. 3 **T*he Good Shepherd*** c350 CE
Catacomb of Callixtus, Rome

The current postmodern period of eclecticism may be another example of chaotic, eclectic art styles. In Figure 4 below Ofili's very controversial, contemporary collage, consisting of a variety of styles and materials—primarily elephant dung. The symbolism is chaotic, ranging from the Virgin Mary herself, to various pornographic images.

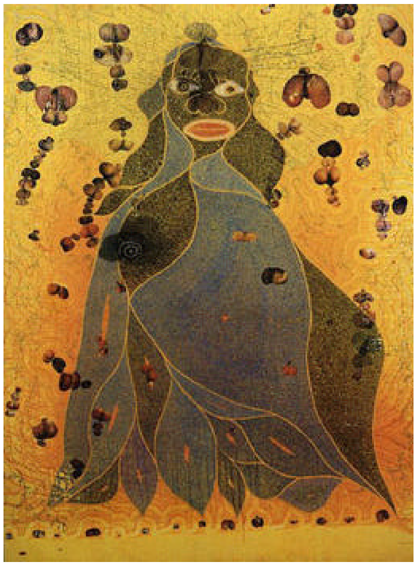

Fig. 4 **Ofili**
***Black Madonna*, 1996**
Paper collage, oil paint, glitter, polyester resin and elephant dung on linen
Saatchi, London
(destroyed by fire, 2004)

Ordered periods, where one style dominates, are known to art historians as *classical*—in the general sense—or *High*, when referring to the dominance of a style at the peak of a single period. An early example of ordered, more predictable styles is that of the Classical period of ancient Greek art in the fifth century B.C.E. Figure 5 below, the *Warrior from Riace*, shows a typical sculpture from that period. [MP1] It too, like Ofili's Black Madonna, uses a variety of material but they are blended in an almost perfect, harmonious whole. All the experimentation of earlier Greek art came together during this ordered period. Furthermore, most art from that period—or later Roman imitations—are easily recognized because all the artists followed fairly rigid rules having to do with proportion and ideal body types.

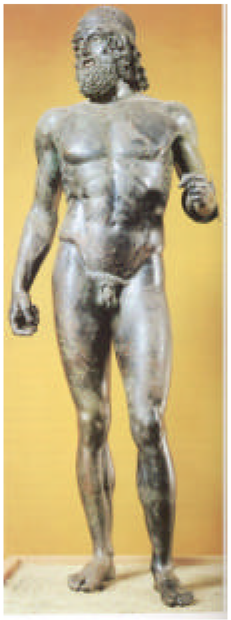

Fig. 5 ***Warrior from Riace* 460-450 BCE**
Museo Nazionale, Reggio Calabria
Bronze, inlaid bone, glass paste, silver and copper

The High Renaissance phase of the early sixteenth century represents a similar ordered style. For example, Raphael and his staff of assistants were able to turn out well over a dozen Madonnas, not identical but similarly ordered. The *Madonna of the Meadow* (Fig. 6 below) is typical. The triangular arrangement, the colouring, the backgrounds, the way in which eyes and arms draw the viewer first to Mary, then to St. John on the left, then to Jesus with a kind of twisting focusing, are predictable enough that his assistants could do much of painting by following his design.

Fig. 6 **Raphael**
***Madonna of the Meadow*, 1505**
Oil on wood
Kunsthistorisches Museum, Vienna

The intermediate *complex* periods between chaos and order, where there is an identifiable core of stability along with some experimentation, are identified by a variety of art terms—*Gothic, Baroque, and Romantic* are the ones used in more recent times.

The stained glass window from Chartres Cathedral in Figure 7 below is beautiful but has lost much of the harmony of the ancient High Roman and Greek figures. Nor does it compare, in harmony and serenity, with the art of the High Renaissance which emerged from this period. Even at Chartres itself a variety of styles are represented over the more than a century of construction. The symbolism varies—but there is a core of Christian iconography which a believer over a millennium would recognize. It is this core of permanence in the midst of experimentation which marks the complex.

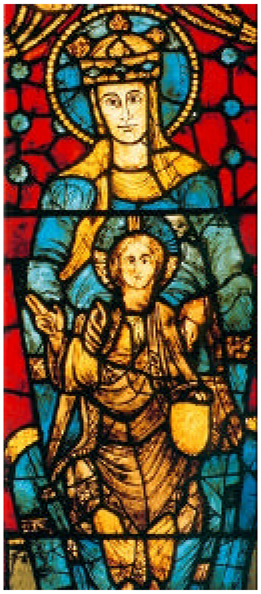

Fig. 7 ***Madonna and Child*, 1132-1240**
Stained Glass
Chartres Cathedral, France

The Early and Late phases of a period are often complex, and even given a different name such as the Mannerist phase of the Late Renaissance. These complex styles tend to be more varied, incorporating emotion and surprise into the elegance of the High phases. They both echo the earlier classical period and foreshadow the next more complex period.

Fig. 8 below, the Mannerist painting, Parmigianino's *Madonna with the Long Neck*, is meant to be an exaggeration of a High Renaissance sacred painting. Instead of serene saintliness, the Madonna seems to be looking with amusement at Jesus falls off her knee. Parmigianino is playing with earlier ordered classical art—from the ancient Greek column to Michelangelo's *Pieta*. Out of Mannerism emerged the entire complex period of the Baroque, where emotion and movement dominated.

Fig. 8 **Parmigianino**
***Madonna with the Long Neck*, 1534**
Oil on wood
Galleria degli Uffizi, Florence

If art cycles are fractal over system levels, as well as time, then we would expect that if any one period is examined more closely, the same shape will repeat. Thus, each period is usually broken down into Early, High and Late phases, and if magnified, we should see a shape similar to the overall cycle shown in Figure 2. This fractal effect would be expected to appear in an analysis of particular cities, art schools and all the way down to the careers of single artists, whose personal style should imitate the shape of the entire cycle. During the Renaissance, for example, the personal style of artists such as Michelangelo, who lived over the entire Renaissance period, varied from eclecticism at the beginning of his career during the Early Renaissance, to the emergence of a dominant, characteristic style during the High Renaissance, before he began to experiment and push the limits during the Late Renaissance.

This paper is only an introduction to art cycles and the differentiation/centrality ratio. Elsewhere we examine in more detail changes in art styles during the Gothic, Renaissance and Baroque periods over their Early, High and Late phases. We then relate these cycles to the social context of each period, looking for indicators of the level of societal differentiation and centrality to demonstrate how cycles of art styles are influenced by the differentiation/centrality ratio (Flynn et al., 2006).

3. Discussion and Conclusion

Perhaps it is inevitable that art styles rise and fall—from experimentation to consensus to experimentation—but we also see some underlying forces in society which help determine whether art styles are less or more focused. We have suggested an explanation for those cycles based upon the differentiation/centrality ratio. In the early phases of any system cycle, individual parts of that system are not yet unified, not focused. To put it another way, during the early part of a cycle, the internal structure of the system is not developed enough to resist outside information and ideas, and as a result, the system's structure is more sensitive to external contacts. The internal structure—what we are calling differentiation—is too 'low' to resist the high external impact—what we term centrality—hence the ratio of the two is also low, resulting in lower social focusing. The system is more subject to increasing entropy and chaos.

At the high point of development, the internal structure is able to convert any outside intervention into its own pattern. Furthermore, the system builds up boundaries to prevent unwanted influences from even entering. At its peak, the internal differentiation is much higher than outside centrality, making the differentiation/centrality ratio high and the social focusing intense, as the system moves far into self-organization and order.

In the last phase of an art period, for a variety of reasons—new ideas and rebellion from within, as well as a breakdown of outside boundaries through invasion and demands and threats from new, stronger outside systems—the differentiation/centrality ratio falls again, and the result is a variety of styles, and a loss of social focusing.

Our paper, we believe, has opened up several areas for more research. What about the ideas of autopoiesis, defined as the ability of living systems—biological and social—to exercise control over their own internal development and maintain boundaries (Goldspink, 2003; Luhmann, 1995 (1984))? We would redefine autopoiesis as the ability of a system to control differentiation—internal development—and centrality—boundaries—which, in turn, helps these systems maintain their identity, what we are calling social focusing. This definition suggests that social movements may focus themselves by deliberately increasing differentiation and tightening boundaries to move from a more chaotic stage, to the emergence of more ordered organisations during the complex phase.

Looking at the connection between art cycles and societal change, why is it that differentiation and centrality seem to change just at the right time to create cycles? They do not, of course, but it is very difficult to maintain high internal differentiation and resist outside change in order to keep social focusing high. Inevitably, there is both an internal breakdown of differentiation and new threats from other social systems for which the once dominant system has no resistance. It is the same problem faced by a nation over its military defences or in its institution of health care. When everything seems to be working well, someone out there is already experimenting with a new weapon or somewhere a new version of an old disease has mutated.

Putting these two ideas together—autopoiesis and ongoing historical cycles of societal change—raises the problem of agent directed human behaviour versus historical determinism. Perhaps the entire process of social change should be seen as a constant struggle between the two forces of human choice and natural forces.

Our model has opened up, as well, more general questions for complexity science. Does the idea of fractals apply to all three regions? The term fractal was invented by Mandelbrot (1983 (1977): 14-15) to describe the many geometric structures in nature which differ from the Euclidian geometry of regular shapes such as lines, circles or cones. A working definition given by Feder is that "A fractal is a shape made up of parts similar to the whole in some way." (1988: 11). The relationship of fractals, chaos and power laws is discussed at length by Schroeder (1991). Now, while fractals and chaotic systems are clearly related—chaotic systems generally have a fractal structure—it is not clear whether or not complex and ordered systems may also be fractal.

Social change over the long term is more than the inevitable increase in entropy predicted by the Second Law of Thermodynamics which seems to explain why eventually all civilizations return to the noise and dust from which they arose. There is much contrary evidence for a rising mega-cycle which spans millennia if not the entire development of biological and social life. That is, while life began with a variety of single celled organisms only randomly connected, with not much overall system focusing, it appears that, in spite of many sub-cycles of rise and fall, there is an overall upward trend in focus. Differentiation for human society is much more varied and coordinated than it was a thousand years ago, a million years ago. We are better able to cope, physically as well as intellectually, with outside threats—centrality—from the environment. Will human society eventually reach a late phase and begin to disintegrate? Probably, but whatever replaces us will build upon our differentiated skills, and our ability to resist and cope with outside threats.

In the meantime, artistic styles will continue to develop, using new and interesting techniques and evoking more startling ideas. There will continue to be cycles in art history as one and then another style dominates, only to descend into eclecticism for a time until a new style takes over. Perhaps today we are in such an intermediate phase between dominant styles, as we see artists move from the somewhat static, cold ordered images of early twentieth century 'modernism' to whatever post-post-modern style takes over in this century.

References

Ashby, W. R. (1966 (1956)). *An introduction to cybernetics*. New York: John Wiley.
Barabási, A.-L. (2002). *Linked: The new science of networks*. Cambridge, Massachusetts: Perseus Publishing.

Buchanan, M. (2002). *Nexus*. New York: W. W. Norton & Company.

Csermely, P. (2006). *Weak links: Stabilizers of complex systems from proteins to social networks*: Springer.

Feder, J. (1988). *Fractals: Physics of solids and liquids*. London, U.K.: Plenum Publishers.

Flake, G. W. (1999). *The computational beauty of nature: Computer explorations of fractals, chaos, complex systems, and adaptation*. Cambridge, Massachusetts: MIT Press.

Flynn, J. D., & Hay, J. (in preparation). Near-cycles of chaotic, complex and ordered focusing: Understanding and controlling change in social systems.

Flynn, J. D., Hay, J., & Lennon, M. (2006, July 23-29). *Cycles of change in art styles before and after the Renaissance*. Paper presented at the 16th World Congress of Sociology, Durbin, South Africa.

Gladwell, M. (2006, Feb. 13). Million dollar Murray: Why problems of homelessness may be easier to solve than to manage. *The New Yorker*.

Gleick, J. (1987). *Chaos: Making a New Science*. New York: Penguin.

Goldspink, C. (2003). Review of Sociocybernetics: Complexity, Autopoiesis, and Observation of Social Systems by Felix Geyer and Johannes van der Zouwen. *Journal of Artificial Societies and Social Simulation, 6*(1).

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology, 78*, 1360-1380.

Greene, B. (2004). *The fabric of the cosmos: Space, time, and the texture of reality*. New York: Vintage Books.

Kauffman, S. A. (1994). Whispers from Carnot: The origins of order and principles of adaptation in complex nonequilibrium systems. In G. Cowan, D. Pines & D. Meltzer (Eds.), *Complexity: Metaphors, models and reality*: Addison-Wesley.

Kauffman, S. A. (1995). *At home in the universe: The search for the laws of self-organization and complexity*. Oxford: Oxford University Press.

Lennon, M., & Flynn, J. D. (in preparation). *Fat City: Siting Bologna in the Region of Complexity and the Beginning of Baroque*.

Luhmann, N. (1995 (1984)). *Social Systems*. Stanford: Stanford University Press.

Mandelbrot, B. B. (1983 (1977)). *The fractal geometry of nature*. New York: Freeman.

Murray, N., & Homan, M. (1999). The origin of chaos in the outer solar system. *Science*, 1877.

Pedley, J. G. (1998 (1993)). *Greek art and archaelogy* (Second ed.). Upper Saddle River, NJ: Prentice Hall.

Prigogine, I., & Stengers, I. (1984). *Order out of chaos: Man's new dialogue with nature*. London: New Science Library.

Schroeder, M. (1991). *Fractals, chaos, power laws*. New York: W. H. Freeman and Company.

Stella, F. (1986). *Working Space*. Cambridge, Mass.: Harvard University Press.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications*. Cambridge, UK: Cambridge University Press.

Watts, D. J. (2003). *Six Degrees: The science of a connected age*. New York: W. W. Norton & Company.

Wolfram, S. (1984). Universality and complexity in cellular automata. *Physica D, 10*(January), 1-35.

Wolfram, S. (2002). *A New Kind of Science*: Wolfram Media.

Young, F. W., & Young, R. C. (1973). *Comparative Studies of Community Growth*. Morgantown, W.Va: West Virginia University.

[MP1]Dit beeld wordt elders wel genoemd als voorbeeld uit een transitieperiode van Archaisch naar Vroeg klassiek (strenge stijl) en niet Hoog zoals in deze tekst wordt gesteld.