CHAOS AND THE NATURE OF ARCHIVAL SYSTEMS

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A new approach to scientific work and thought, termed chaos theory has recently drawn considerable attention among researchers. This so-called "new science of chaos" attempts to discover underlying structures in complex phenomena previously seen as highly disordered and beyond deterministic control. Classic areas for chaos research involve climate, fluid dynamics, and biological populations.[1] The 1970s' and 1980s' advances in ways to find order or system within what was previously seen as impenetrable chaos is an important moment in our ability to understand the universe.

To the non-scientist, these discoveries not only explain important natural processes and the limits of deterministic mechanical systems, but also suggest a framework for understanding human processes, such as documentation and archival practice. Just as the past discoveries of Newtonian mechanics or Darwinian evolution have prompted us to adopt

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[1]Throughout this paper, the term "chaos" will be used to refer to the new perspective on complex systems, and the traditional idea of chaos as disorder will be referred to as randomness, disorder, or "utter chaos". For convenience, chaos will be referred to as a science and as a theory, but it might be more proper to see chaos as a scientific vision of diverse components of the universe behave. Thus, while "chaos" is treated rather uniformly, in fact, the scientific research findings that have been the basis for the "new science of chaos" might be better seen as a phase of development in the respective disciplines rather than as part of a single overarching effort to understand chaos. Nevertheless, the fact that interest in chaos has spread so rapidly in the 1980s suggests that its ability to explain phenomena in diverse disciplines may lend it a transcendent value.

the language and conceptual frameworks of scientific ideas, so too might the concepts of chaos provide a rich means to understand and explain phenomena that hitherto have been difficult to understand.

This paper will focus on the application of chaos to archival theory and practice. As background it will describe basic elements in chaos theory and provide examples of chaos research. A key part of the paper will be an examination of writings in archival theory for evidence of ideas consistent with chaos theory.

THE SCIENCE OF CHAOS

In its simplest terms, the new view of chaos consists of discovering structure and system within complex and turbulent phenomena previously seen as either lacking any order or of such enormous complexity that controlling them or predicting outcomes would be impossible. Nature is filled with systems that are either complex from their initial state, such as the atmosphere, or are simple in their initial state but can go through a transition into a turbulent state where predictability and control are impossible, such as a stream of cigarette smoke that starts in an understandable stream but shifts into a swirling cloud.[2]

Scientists have long been aware of complex systems whose behavior is dependent on

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[2]The three best brief introductions to chaos are: the introduction to N. Katherine Hayles, Chaos Bound: Orderly Disorder in Contemporary Literature and Science (Ithaca, N.Y.: Cornell University Press, 1990); Gary Taubes, "The Mathematics of Chaos," Discover 5 (September 1984): 30-39; and James P. Crutchfield, J. Doyne Farmer, Norman H. Packard, and Robert S. Shaw, "Chaos," Scientific American 255 (December, 1986): 46-57. A more comprehensive and well-illustrated discussion is provided by James Gleick, Chaos: Making a New Science, (New York: Penguin Books, 1987), but Gleick overlooks important subjects such as Russian and Japanese mathematical research and the work of Ilya Prigogine. Heinz Pagels, The Dreams of Reason, (New York: Simon and Schuster, 1988) also provides a good description of chaos and places it in the context of the history of science since the late Renaissance.

large numbers of variables. The traditional approach has been to attempt to understand such problems by reducing them to their smallest parts in the belief that predictability could be achieved by collecting enough data on each small component before attempting to understand the whole. This has led to a tendency to ignore turbulent phenomena as being essentially unsolvable and irrelevant to scientific work.

By contrast in the past few decades, several scientists have discovered that not all turbulent or disordered phenomena are without structure. Instead, many behave in ways that are scientifically describable. To categorize such phenomena, the term "chaos" has been used in a new way to connote complex and unpredictable behavior which, while not following simple mechanical laws, follows complex patterns that are mathematically describable.[3]

There is not time today to do justice to the full story of "chaos." Rather, as a basis for archival use of the language and ideas of chaos, I will describe a few concepts and cite examples of chaos research. Probably, the most important concepts or attributes are: sensitive dependence on initial conditions, strange attractors, feedback loops, fractals, and recursiveness and self-similarity, and information richness.[4]

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[3]Some scientists doing research in these fields have shunned the word chaos and instead have preferred more respectable sounding names such as complex systems, non-linear dynamics, or nonequilibrium statistical physics. Certainly these alternative names offer a richer description than "chaos," and eventually the scientific terminology may evolve into more precise and differentiated terms. For the moment, however, "chaos" has been widely accepted in scientific and popular literature. In addition, use of the term "chaos" can emphasize the revolutionary nature of many of these new scientific developments which are explaining parts of the universe which were previously considered ununderstandable. Thus, "chaos" will be used throughout this paper to cover all these complex phenomena.

[4]Another key idea in chaos theory is that complex systems can create structure as they dissipate energy. This may provide a clue to why applications of the idea of entropy cannot

SENSITIVE DEPENDENCE ON INITIAL CONDITIONS

This key attribute of chaotic systems simply means that very small differences can have big consequences and is sometimes called the "butterfly effect." It is often explained by reference to Edward Lorenz's 1960s work on long-term weather forecasting. Using a computer model of the atmosphere, Lorenz repeated a series of 13 equations several times, using the output of one set as a source of data for the next run. The model worked reasonably well until Lorenz stopped and then restarted the calculations using a printout listing of the last value from the stopped run for the restarted run. However, the new model began to diverge radically. (slide) Upon investigation, he discovered that while the computer used numbers rounded to the sixth decimal place, the restarted run had used a number rounded to the third place. Despite this very minor difference, the system behaved quite differently. Based on such minor initial differences causing dramatically different conditions, he concluded that long-range weather forecasting would be unlikely because such a minor event as a butterfly flapping its wings over China could affect the weather on the Eastern coast of the United States.

STRANGE ATTRACTORS

If chaos theory is pursued no further than sensitive dependence, we are left with the conclusion that much of the universe is unstructured and unmanageable. The companion concept of strange attractors, however, provides the structure. Strange attractors are the

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explain increasing complexity in the universe, especially in evolution. According to entropy, lifeforms should be winding down into ever simpler forms. However, if chaos processes are part of evolution (e.g., populations dynamics), it may explain how the dissipation of energy can lead to complex structures. Ilya Prigogine and Isabelle Stengers, Order out of Chaos: Man's New Dialogue with Nature (New York: Bantam Books, 1984).

boundaries of behavior of chaotic processes--they are the tendency toward order within a system and they illustrate the range of conditions which normally occur within a complex system even though one cannot precisely predict its behavior.

Again, Lorenz's work provides a good explanation. After his initial discovery, he began calculating as many solutions to the equations as possible based on different starting points. Rather than finding randomness, Lorenz found that the numbers varied only within a certain range, and he plotted the data to reveal a visual image of an attractor which has subsequently been called the "Lorenz attractor." As the following slides shows, the attractor demonstrates a complex pattern with trajectories that never exactly repeat each other, but all of which occur within a limit space or set of possibilities. In practical terms, the attractor explains that July blizzards in Miami are outside of systems' boundaries.

FEEDBACK LOOPS

One of the reasons that small differences can have big consequences systems is the succession of events where the output of one event becomes input for the next. Consequently, minor differences at the outset, or those introduced by environmental conditions, have increasingly dramatic effects as the events repeat and multiply. This can be visualized as a taffy-pulling machine. Two points may be infinitely close on the taffy as it is placed on the machine. With each successive cycle of the machine, the taffy is stretched and kneaded, and the points move progressively farther away from each other. Thus, after only a modest number of cycles, the points can be literally miles apart, and it would be impossible to predict where they would be.[5]

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[5]The taffy-pulling machine is an example of the horseshoe shaped mathematical model developed by Stephen Smale. (slide)

FRACTALS, RECURSIVENESS, AND SELF-SIMILARITY

The borders and patterns in complex systems are highly irregular, but still systematic and possible to model through fractal geometry, a term and concept coined by Benoit Mandelbrot. Fractals explain the additional fractional dimension found in the surfaces of complex natural forms, such as coastlines or snowflakes, as well as strange attractors. This can be seen in his development of a Koch curve (use slide). Because of the recursive nature of the mathematics of complex systems, fractals illustrate the basic structure of a system such that whether one looks at it from a distance or up-close, its nature is the same. The following slides of Mandelbrot fractals illustrate this visually. If you have any doubts about the relevance of this geometry to complex natural phenomena, examine the ice-crystals that form on the inside of your windows on the next sub-zero day. (slide)

CHAOTIC SYSTEMS ARE INFORMATION RICH

Rather than seeing chaos as meaninglessness and an information "sink," the new approach argues that these systems are rich information sources, provided we have the equations or other descriptive tools to examine them. That is, the stretching and folding of a system moving into chaos creates new information as it replaces the information used to describe its initial state with that needed to describe each of its subsequent states. Thus, rather than seeing the chaotic system as an example of entropy where the system loses its information value as it winds down, Robert Shaw has noted that chaotic systems are be information rich.[6]

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[6]Robert S. Shaw, "Strange Attractors, Chaotic Behavior, and Information Flow," Zeitschrift für Naturforschung 36a (1981): 80-110. See also, Crutchfield, "Chaos," pp. 53-56.

PHYSICAL AND SOCIAL SCIENCE APPLICATIONS OF CHAOS

The development of these concepts has significantly altered how we perceive and describe complex natural phenomena in three ways: 1) orderly structures can be found within disorderly phenomena, 2) such structures will be understood best by examining whole systems rather than by reducing them into separate components, and 3) precise predictability is no longer a pre-eminent test of whether we understand complex systems. To understand the practical implications of chaos one need only look at some of the applications in the physical sciences. Chaotic period doubling has been found in muscle fiber contraction in the human heart just before the onset of an often fatal condition known as ventricular fibrillation, and thus provides a way to understand a medical problem that had previously appeared to be random and indescribable.[7] Chaos is not always associated with negative conditions. Brain cells may generate chaotic waves of electricity that thereby keep the brain in an active and receptive mode to be able to receive signals and interpret the world.[8] Chaos has found in a large network of connected computers which were designed to "bid" against each other for access to central processing time. The slightest disturbance in the system, such as delays in sending a string of data, could lead to highly unpredictable variations in the solutions that the computers were calculating.[9] Chaotic irregularities have been found in the patterns of a

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[7]Taubes, "Mathematics of Chaos," p. 34. See also Gleick, Chaos. pp. 283-85, 289-91; and Briggs and Peat, Turbulent Mirror, 64.

[8]Bruce Bower, "Chaotic Connections," Science News 133 (January 23, 1988): 58-59.

[9]John Markoff, "In Computer Behavior, Elements of Chaos," New York Times, September 11, 1988, p. ??

sound signal even when other measures, such as the pitch, do not show noticeable changes.[10]

As a bridge to understanding the role of chaos in archives, we can examine social sciences and business management literature which has been quick to examine chaos to see what relevance it can hold for these fields. A few examples illustrate the potential uses of chaos theory. After looking at Wells Fargo's unforseen 1986 acquisition of Crocker National Bank, Robert Waterman concluded management processes should be adaptive and comprehend unpredictability because traditional mechanical and linear models of business organizations do not fit their behavior so well as chaotic systems.[11]

Ikujiro Nonaka examined several Japanese corporations to assess how organizations can increase their intake of information.[12] Drawing on examples of the renewal of corporations like Honda and NEC, Nonaka argued that more information of greater benefit to the organization can develop when chaotic or turbulent conditions exist, and he recommended that managers therefore look for ways to accentuate turbulence to create such creativity.

Educational administration researchers recently have suggested that chaos can provide a framework to explain crises confronting school officials. Griffiths, Hart, and Blair examined a conflict in a southwestern school district and found "evidence" of sensitive

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[10]"Sign a Song of Chaos," Science News 133 (May 7, 1988): 300.

[11]Robert H. Waterman, "Strategy in a More Volatile World," Fortune 116 (December 21, 1987): 181-82.

[12]Ikujiro Nonaka, "Creating Organizational Order out of Chaos: Self-Renewal in Japanese Firms," California Management Review 30 (Spring 1988): 57-74.

dependence, dissipative structures, strange attractors, and feedback mechanisms.[13]

INFORMATION SCIENCE AND HUMANITIES APPLICATIONS OF CHAOS

More directly relevant to archival interest are a few attempts to apply chaos to information science, history, and literature.

> Albert N. Tabah's examination of nonlinear dynamics of literature growth is relevant to archivists because it involves the dissemination of information. Suggesting a similarity between studies of fluctuations in animal populations and of fluctuations in literature citation, Tabah quantitatively analyzed the literature of superconductivity from 1966 through 1990. He found that periods of sudden bursts in activity could be understood better through chaotic models, such as attractors, rather than traditional exponential and linear models. Although more investigation is needed, Tabah's study is instructive to archivists considering issues such as the relationship between volume of records and value and volume and use.[14]

The application of chaos ideas to the humanities is beginning to be considered by a small group of scholars. At present, I am not aware of any experimental or quantitative humanities applications of chaos, but some of the proposals are interesting because of their connections to history and texts.

Historians George A. Reisch and Donald McCloskey have emphasized that history

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[13]Daniel E. Griffiths, Ann Weaver Hart, Billie Goode Blair, "Still Another Approach to Administration: Chaos Theory," Educational Administration Quarterly 27 (1991) 430-51.) Ultimately, however, the argument is not very convincing because the elements of chaos are described in only the vaguest of terms and areas where quantification might be employed (e.g., population changes) are overlooked.

[14]Albert N. Tabah, "Nonlinear Dynamics and the Growth of Literature," Information Processing & Management 28 (1992) 61-73.

may be chaotic in the extreme dependence on initial conditions found in historical events. used chaos as a new way to discredit the idea of universal historical laws by arguing that history basically follows nonlinear dynamics with a high degree of sensitive dependence and extensive feedback loops. Neither Reisch nor McCloskey offered anything resembling scientific proof and neither pursue the relationship between orderly events. Nevertheless they present an effective argument for refuting covering-laws history and the importance of narrative as the main vehicle of historical knowledge since only description can take into account the many minor matters upon which big events depend.[15]

Perhaps the most thorough and well-reasoned applications of chaos to the humanities is Katherine Hayles' book-length explanation of the relation of chaos to recent developments in literature and literary criticism, especially post-structuralism and deconstruction. She argues that both chaos and the literary trends involve attempts to understand the variability of meaning in systems or texts. Of archival relevance, she explains the relationship between information theory and chaos, emphasizing that the information richness of chaotic systems.[16]

ARCHIVES AND CHAOS

The these applications illustrate how broadly the interesting ideas of chaos can be applied. But, in themselves, neither the ideas and nor applications justify a linkage with archival theory and practice. Some of you may share Maynard Brichford's initial and continuing skepticism of the relevance of chaos to archives based on a very pragmatic view

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[15]George A. Reisch, "Chaos, History, and Narrative," History and Theory 30 (1991), 1-20. Donald N. McCloskey, "History, Differential Equations, and the Problem of Narration," History and Theory 30 (1991): 21-36. [15]

[16]N. Katherine Hayles, Chaos Bound: Orderly Disorder in Contemporary Literature and Science (Ithaca, N.Y.: Cornell University Press, 1990).

of the nature and circumstances of documentation. Others may share my first intuitive reaction to the ideas of chaos--that they explain much about archives. Because neither the enthusiast nor the skeptic should be content with leaving the chaos image at merely the intuitive, we must consider the problem of proving or testing the linkage.

At first, I thought that one might demonstrate the connection though mathematical analysis of key archival statistics, e.g., growth in documentation, level of use, or relationship of use to external factors. However, we lack standardized statistics, and the meaning of even the best numbers currently available is so variable that it is unlikely quantification would be usable. As a result, I despaired of demonstrating that archival systems and the historical record behave as chaotic systems, and for a while abandoned the issue. However, I could not escape the fact that the more I applied archival principles to everyday problems in arrangement, appraisal, and response to user inquiries, and the more I re-read archival theory, the more the chaos model seemed to explain why some things worked and why others did not. Therefore, I have adopted an alternate approach to investigating whether the principles of chaos are useful to archives. I believe it is possible to explore the relevance of chaos ideas by looking at how they can explain core developments in archival theory and practice. More research is needed, but a review of a few archival writings and a few more recent contributions illustrates how chaos may be a very useful language for understanding the nature of documentation and archival processes.

One of the most important works summarizing the development of archival theory in the 19th and early 20th century is Muller, Feith, and Fruin's <u>Manual for the Arrangement and</u>

Description of Archives.[17] Written in Dutch in 1898, revised in 1920 and widely translated, the Manual did not appear in English until 1940. It laid out 100 rules for the practical handling of archives and manuscripts, and in so doing explained key archival principles, especially for arrangement and descriptive work. Permeating many of the rules is the basic concept that archives are organic entities. At many occasions, especially in the first 14 rules relating to arrangement, the idea of organic wholes, we might say systems, is the wedge use used to separate archival practice from the approach of historians and librarians. For example:

> ". . . an archival collection is an organic whole, a living organism, . . . Every archival collection has, therefore, as it were, its own personality, its individuality, which the archivist must become acquainted with before he can proceed to its arrangement." (MFF, p. 20).

The use of "organic" language is no accident or side-effect of translation, but the imagery recurs throughout the text and becomes the basis for further explanatory metaphors, such as that of the "skeleton."[18] The reference to the skeleton is then used to support the idea that minor flaws in the organization of files need not undermine the overall concept of the material's arrangement. As in complex systems where each detail need not be precisely defined for the system to maintain its overall character, archival arrangement can stand

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[17] S. Muller, J. A. Feith, and R. Fruin, Manual for the Arrangement and Description of Archives, translated from second edition by Arthur H. Leavitt, (New York: H. W. Wilson Company, 1940).

[18] Rule 20 includes the statement: "The comparison with the animal skeleton, more in harmony with the definition that the archival collection is an organic whole, naturally emphasizes the unchangableness of those lines; . . ." (Ibid. p. 69).

despite specific imperfections. "If however, he [the paleontologist] wishes to form for himself a picture of the animal whose bones he has joined together again, he follows very closely the general structure of the body and the shape of the bones, but he takes no account of the accidental circumstances, e.g., that one of the animal's paws had grown bent because of a fracture or that one of the ribs is missing."[19]

When they come to explain the importance of respect des fonds, the Dutch employ a naturalistic language that is consistent with the suggestion that what archives document are complex systems that follow many of the principles of chaos. For example, Rules 10 and 11 stress the idea of dismemberment and relate the need to keep deposits together to the idea of maintaining wholeness and completeness of the historical record. (MFF, pp. 36-40).

As in many archival texts, Muller, Feith, and Fruin do not provide much theory for description. Rule 38, however, has relevance to the notion that archival documentation constitutes chaotic systems. It states that before description can focus on details, the archivist must form a clear concept of the "dominant idea that presided over the formation of the documentation."[20] Despite the difficulty of capturing the "dominant idea" of a record series, the Manual's emphasis on the series summary description as the primary descriptive tool also make sense from the standpoint of chaotic and complex systems. In such systems, it is most important to describe the boundaries and general nature of the system's flow, and it is unproductive to describe the system in an incremental or reductionist fashion. Thus, item level inventories might be useful for specialized access or control, but archival

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[19] Ibid. p. 71.

[20] Ibid. pp. 101-102, see also Rule 41.

documentation is too highly fractal to enable such descriptions to explain what the series really is.[21]

Before turning to American writings, it is useful to consider a statement by the influential English writer, Sir Hilary Jenkinson, to illustrates how consistent ideas of chaos are with classical articulations of archival theory. Jenkinson saw the structure and complexity of records as emerging from a natural growth process.

> "They [archives] came together, and reached their final arrangement, by a natural process: are a growth; almost as you might say, as much an organism as a tree or an animal. They have consequently a structure, an articulation and a natural relationship between parts, which are essential to their significance: . . . Archive quality only survives unimpaired so long as this natural form and relationship are maintained." [22]

In itself, the idea that archives are organic does not mean they fit the mold of chaos, but the way this language has been used shows great consistency with chaos principles of complexity, recursiveness, and non-reductionism. The central theme of archives as organic is particularly evident in the work of Theodore Schellenberg.[23]

As in chaotic systems where one cannot predict precise relationships in advance, Schellenberg noted that classification of archives could only be done a posteriori not from an a priori scheme. "The classes should be established as experience attests . . . not . . .

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[21]Ibid., p. 109.

[22]Hilary Jenkinson, The English Archivist: A New Profession, inaugural lecture at University College, London, October 14, 1947: London, 1948, as quoted in Schellenberg, Modern Archives, p. 19.

[23]T. R. Schellenberg, Modern Archives Principles and Techniques, (Chicago: University of Chicago Press, 1956).

arbitrarily . . . on the basis of speculation . . . " in advance. (p. 63) Repeatedly, he rejected all efforts to arrange and categorize records by predetermined, abstract, or universal systems. Rather the records themselves, like a strange attractor would set the order. (pp. 22, 114, and 188)

Schellenberg and others have long since told of the practical and theoretical reasons for the failure of the original arrangement system at the Archives Nationale (p. 169). The ideas of chaos, which run counter to Newtonian mechanics offer a further explanation. The Archives' "methodical" scheme was built from a classification mentality consistent with the Enlightenment's reductionist approach to science. However, we have subsequently learned that as in some of the physical sciences, reducing information systems into ever smaller parts cannot advance our understanding of the whole or of the relationships of the parts. Complexity in the small parts is so great that one cannot reverse the process and reconstruct the whole from the parts because of the variability of the parts.

The principles that ultimately emerged as workable, respect des fonds and the two Prussian contributions of provenance and respect for original order, emphasize relationships and wholes, rather than parts. Admittedly, some archivists have not been comfortable with the archival emphasis on deriving order and system from holdings rather than from some logical constructs. However, rather than be embarrassed by such fuzzy and seemingly unscientific principles, we can look to chaos to explain why the archival a posteriori approach may indeed be scientific.

Schellenberg is a leading exponent of modern archival appraisal. His explanation of its principles remains both practically and theoretically sound even if subsequent archivists have added important refinements. The soundness of his approach to appraisal can also be understood if one considers the historical record as chaotic. As with a chaotic system, Schellenberg rejected a reductionist or item-level approach to appraisal and instead emphasized the consideration of relationships and the whole body of documentation.[24]

In addition, Schellenberg recognized the complexity and fuzziness of appraisal more than recent writers credit him. As with complex natural systems where linear formulae fail to explain the systems' behavior, he noted "Techniques cannot be devised that will reduce the work of deciding upon values to a mechanical operation." (p. 94) He seemed to understand that present and future generations might desire standards to regularize appraisal, but he cautioned against too much precision, and emphasized that the organic nature of records made general principles far more useful than precise standards. Decisions on retention were linked to the circumstances of the records creation, the nature of the information or evidence they contained, and the likely interest of users in the evidence or information. Each of these elements in turn was so multifaceted, that charting a uniform course for decision-making was unproductive. As in chaotic systems, charting decisions with precision is impossible given the highly fractal, unpredictable, and fundamentally chaotic nature of documentation. (pp. 133-60)

A final observation from Schellenberg is relevant. As in natural systems, complex behavior can be introduced by changing only one variable--increasing the volume of documents. Just as the pattern of dripping water moves into chaos when the flow is increased, so too Schellenberg emphasized that the nature and arrangement of records became much more complex as their volume and the number of agencies generating records

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[24] Ibid., p. 21.

increased, for example in the U.S. federal government.[25] In all such technologically-driven changes, the added complexity has important implications for the nature of archival practice.

CHAOS AND THE REVISION OF ARCHIVAL THEORY

So far my re-explication of archival theory from the perspective of chaos has followed a very traditionalist course. Critics might suggest that I have been overly attentive to traditional archival writers, many of whose ideas have been called into question by more recent developments, and that I have not paid sufficient attention to the emergence of new ideas in the past decade. In this light, it is useful to look at a few recent theoretical developments to identify how principles of chaos may explain not only the soundness of traditional ideas but also the kernel of changing ideas.

For example, the record group concept and the related idea that classification systems should reflect administrative hierarchy have long been fundamental to American archival practice. Since these principles were derived from European ideas of provenance, one might think that Max Evans' 1986 well-stated argument for replacing the record group concept with authority control would undermine my use of the principle of provenance as justification for the relevance of chaos to archives.[26] However, when you examine Evans's argument closely, there is great consistency between his rationale for abandoning record groups in favor of authority control and the suggestion that archives are chaotic systems. In fact, the great strength of Evans' argument is that he is attempting to address the fundamental chaos or

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[25] Ibid., pp. 36, 183. He also cites the example of the introduction of paper in the later 14th century which led to expansion of offices and records systems, including registry offices, p 66.

[26] Max J. Evans "Authority Control: An Alternative to the Record Group Concept," American Archivist 49 (1986): 249-61.

complexity of archival information. He states, "The disadvantages of the record group concept can be overcome by shifting the center of the archival world view from one that is flat and mono-hierarchical to one in which records and the record creating agencies exist in a multi-dimensional conceptual space." (p. 255) He wrote "Archivists must cast off the model that holds that records have only a single referent and create a system that recognizes instead that they are created and maintained as part of complex bureaucratic networks." (p. 261)

Evans' emphasis on the importance of context is consistent with how one should focus on boundaries and relationships in understanding a complex system rather than on structures extrapolated from individual elements. Evans thereby develops an approach which is more consistent with both the core of the principles of respect des fonds and provenance and with the fundamental non-linear dynamical nature of archival documentation.[27]

BOLES-YOUNG

Given that Julia Young could not attend this meeting, it is with reluctance that I now move to an examination of the work that she and Frank Boles have done on the "black box" of appraisal. At the outset, I should acknowledge their great contribution of exploring and describing the detailed aspects of appraisal. In particular, their categorization of three areas of decision making--value of information, costs of retention, and political and procedural implications--elucidates much of what happens when we appraise.[28] At the same time, I

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[27]A nearly contemporaneous article by David Bearman and Richard Lytle came to a similar conclusion for using authority control as an alternative to the record group concept. David A. Bearman and Richard H. Lytle, "The Power of the Principle of Provenance," Archivaria 21 (Winter 1985-86): 14-27.

[28]Frank Boles and Julia Marks Young, "Exploring the Black Box: The Appraisal of University Administrative Records," American Archivist 48 (1985), 121-40.

think that their unsuccessful attempt to understand appraisal by breaking the decision down into more than 58 small parts provides further confirmation of the relevance of chaos theory to archives.

Boles and Young were aware of the difficulties their model might face because of the dynamic of the appraisal process. (p. 124). They are to be commended for their persistence and thoroughness in following through with an exploration of the black box. With NHPRC funds they conducted an experimental project to test the three-part model by asking archivists from 14 institutions to assign weights to each of 43 elements as an appraisal decision was reached.[29] Underneath the project was the assumption that before "macro-level" solutions to the problems with appraisal methodology could be solved, "micro-level" tools and analysis would have to be developed. Through quantification they hoped to unlock the appraisal decision process. However, archivists found that "the system did not work as a practical selection tool Neither the final ratio nor the module scores accurately predicted absolute or relative record value." (p. 79)

Their response was the traditional reductionist approach--further refinement and greater archival familiarity with quantification would permit a refined model and even an "expert system" to reach appraisal decisions.(pp. 81-82) As they confronted these problems, Boles and Young saw the limits of what they were attempting in ways that I suggest are consistent with the fact that chaos explains many aspects of archival work. For example, they acknowledged how the dynamic nature of appraisal undermined their work: "The methodology used here made the assumption that the relationships between the various

[29]Frank Boles in association with Julia Marks Young, Archival Appraisal (New York: Neal-Schuman, 1991).

elements in selection could be expressed through simple additive procedures, augmented where necessary by multiplication." However, the complex nature of the relationships required a model that recognized how the decision process changed as each element in the relationship changed. (pp. 82-83)

From the perspective of chaos, it becomes crystal clear that the effort could not succeed because of the fundamentally non-linear dynamical nature of both documentation and decision-making. Given the number of feedback loops involved in each, I think the mathematics will remain against it, and we should not spend further time using quantification to understand appraisal. (cf. Boles 1991, p. 89) As physicist James Crutchfield has said, "The consequence of measuring with only finite precision is that the measurements are just not good enough--chaos takes them and blows them up in your face."[30]

As with complex natural phenomena, reducing a system into ever-smaller parts does not provide a reliable way to predict the behavior of the overall system. Such exercise will be problematic not just from the standpoint of knowing what numerical values to assign to each element, but because even with highly precise measures, the systems of documentation and decision-making exhibit key chaos characteristics (sensitive dependence and recursiveness) that make prediction impossible. We need to understand something of the components of the appraisal decision, but looking at the larger picture will be more productive. The comments of chemist/physicist Yoishi Oono are relevant here: ". . . even if you don't know the chemical details, you can know something. The chemical details are interesting but you don't need them. It's like taking the computer down to quarks, but do you

[30]Quoted in Gary Taubes, "The Mathematics of Chaos," Discover 5 (September 1984): 32).

need to know that? There are structures independent of these details."

CONCLUSION

I am not so foolish to claim that chaos provides a universal theory of archives, although so much of what we document as well as the information service we provide is fundamentally chaotic. For now, I wish only to note that the concepts of non-linear dynamical systems provide an additional significant explanation as to why some archival ideas have worked and others have not. At the very least, as we refine and advance archival theory, we must reckon with the principles of chaos or we are likely to develop overly complex tools that ultimately will collapse of their own weight as they become ever more artificially structured, ever less functional, and ever farther from the dynamical and chaotic nature of human activity, documentation, and information needs.

Some may react to my suggestion of the relevance of chaos to archives with a "So what! The phenomena you note are nothing new and have always been known." In response, I suggest these phenomena may have been experienced and recognized, but before the development of the ideas of chaos, we have lacked a language and a structure in which to place them. Rather than merely dismissing the seemingly random or irregular behavior of documentation, organizations, or user inquiries as unscientific or anomalous, we now have a way to understand that these phenomena fit a pattern that has scientific parallels and may corresponds to scientific laws. In the end, maybe I am advancing a theory of archives, at least in the sense that theory may be seen as the product of nearly "self-evident" truths.

Finally, I started thinking about chaos with the intuition that it made sense-it seemed to explain much that worked and did not work in archives. Subsequently, I have worried about how to prove that archives are chaotic systems. For a while I set aside the idea as little more than an passing metaphor. I still believe it highly unlikely we can ever quantify the world of archives to permit mathematical tests of the chaos model. Nevertheless, I am now persuaded that the intuition should not be ignored. Chaos explains much about the ordered disorder that archives attempt to control, and it helps us better understand the order parts of the universe we confront. 1

I find myself taking heart from Fred Stielow's thoughts on the nature and usefulness of theory when he quoted Lionel Robbins: "'We do not need controlled experiments to establish their validity: They arise so much the stuff of our everyday experience that they have only to be stated to be recognized as obvious. Indeed, the danger is that they may be thought to be so obvious that nothing significant can be derived from their future examination. Yet in fact it is on the postulates of this sort that the complicated theorems of advanced analysis ultimately depend."[31]

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[31]Lionel Robbins, An Essay on the Nature and Significance of Economic Science (London: MacMilan, 1935), 79 as quoted in Frederick J. Stielow, "Archival Theory Redux and Redeemed: Definition and Context Toward a General Theory," American Archivist 54 (1991): 17.