Mapping An Organization's Temporal Signature from Order To Chaos

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Is there a map that traces the stages of organizational change as it moves from order to chaos? Are there characteristic organizational rtyhms that regulate this dissolution and reforming process at critical points on the map? This paper presents a theoretical argument that the Feigenbaum Diagram provides such a map and that the concept of temporal signature predicts organizational rythms at various mapped points. In support of these claims, the paper presents empirical evidence that organizations under extreme stress follow the path shown by the Feigenbaum Diagram. The paper defines the concept of temporal signature, shows how it has been used to study organizations, and makes specific and testable predictions about how it might change across the Feigenbaum map. We will draw on the organizational disaster response literature and present original research to illustrate and test our theory.

Workplace Rules and Fields Of Action

Generally, employees are applying policies, work processes, work behaviors and attitudes, or "workplace rules" within a "field of action" (Kiel, 1994). The field of action is defined as the interface (surface) between the physical workplace and external environment. Although it is usually experienced as relatively ordered and predictable from day-to-day, the field of action is multidimensional and highly complex. In the case of a disaster, the field of action is influenced by the initial conditions following an abrupt transformation of the environment. Kiel tells us that:

> It is the interaction of the [workplace] rules of motion with the field of action that determines the direction and result of motion in the workplace. The dynamic created by the interaction of the 'rules' and the 'field of action' lead to agency outputs and performance (Kiel, 1994).

The timing of the rules of motion is intimately connected with what happens in the field of action; the earlier is nested in the latter. From this perspective, agency outputs and performance is the result of the interactive *dynamic* (Kiel's "motion") of the organizational patterning process. This abruptly initiated process of transition from one type of organizational pattern—emergency medical day-to-day response or planning and practice for example--to a another organizational pattern--disaster response--is accompanied by a change in workplace rules within a unique, disaster created field of action according to the rules or "timing" of dynamic motion. Such rules would have a great deal to do with emergent organizational form (Thom, 1972). Put another way, process and structure are

complementary via the dynamic rules of motion. Organizational survival and the emergence of the response system is related to these time dependent, self-organized adaptive activities and to the rules of dynamic motion (Jansch, 1980). As we will show, an organization's temporal signature varies according to where it is on the Fiegenbaum Diagram. Together they trace the emergent results of the dynamic of motion.

Social Time, Temporal Signature, Workplace Rules and Fields of Action

Social time is an ordering principle that coordinates, orients, and regulates interactions between people and groups (Adam, 1990) As such, social time is embedded in the emergent organizational pattern of workplace rules in a field of action; social time expresses the dynamic rules of this "motion".

Group processes create expectations and ideas of conformity. By doing so these processes give give meaning to the various dimensions of time orientation in each area that the group is active in. These group temporal models are not "ideal" in the sense of being defined by an external universal standard such as a clock. Individuals create time models of how time is patterned and how it flows. For example, temporal patterns can be circular based on the round of the seasons or linear and extending indefinitely into the future. How quickly change occurs, its rhythm, and its constancy and uniformity are example of the social construction of time's flow. Concepts of causation, prediction, personal ability to influence the future, readiness to act as well as to whether a person feels that they can create their own future (fatalism vs. self-determinism) are related to this temporal constructing process.

An individual's or group's temporal signature is a product of the active pattern forming processes of social time. Just as the hand moves to form a unique signature, so too does the individual and group engage in a unique timing of motion according to a temporal signature. The various shapes resulting from this process trace out time characteristics that can be interpreted as open, closed, progressive, traditional and so forth. "Temporal signatures vary from individual to individual by education, social class, and other factors." (Macy, 1994). By studying the pattern of the temporal signature at moments in time, and the rules that govern this change process (we will call this morphogensis) we can determine the states of the components of the process that regulates the motion defining workforce rules in a field of action. Since these motions form the deep structure of pattern we must acknowledge that process and structure—workforce rules and field of action are examples of the latter—are complementary. Each offers a different and essential construction of the phenomenon, and each are necessary for its complete description.

Generally, the organization's temporal signature defines a sort of dance that people engage in as they collectively create organizational life. Managers and staff define the pattern and flow of time, and thus the rhythm of this dance (Macy, 1994). All schemes of periodization of organizational life are authoritatively defined in the sense that they reflect management's view, tempered by the employees, about what is "good" or "right" within a particular field of action for its organizational "dance" (Koehler and Haden, 1982). Studies of Western organizational culture note that most managers view time as "monochronic" or extending

like a line into the future that can be divided into equal segments. “Time is a valuable commodity that can be spent, wasted, or made good use of...”(Schein, 1985). In contrast, “polychronic” time is defined more by social relationships and what can be accomplished than by a clock. “Relationships may be more important than efficiency; therefore, rapid completion of a task or punctuality may not be valued as highly...”(Schein, 1985). The ability to plan for and control one’s future varies by organizational rank; those higher in rank have longer time horizons than those lower in rank. Different agencies vary in their capacity to mobilize their personnel, to organize their response, to rhythmically entrain with other organizations, to perform tasks, and to meet time deadlines (Macy, 1994). Different groups and individuals within the organization may be either future or past oriented making it difficult to coordinate to achieve common goals. From this perspective, temporal continuity, particularly future time perspective, appears to be important to the cohesion and internal functioning of the group, to the interaction between the multiple groups that make up a complex organization, and probably to inter-group relations. But, temporality may be even more complex than what we have laid out up to this point.

While earlier approaches to the study of social time have reduced time perspectives to simple linear cause and effect relationships, on reflection we see that, when considering the entire temporal signature, the nature of the phenomenon is neither simple nor linear. The future in all it' s multiple forms and meanings, together with the present and the numerous constructions and reconstruction’s of the past, can be entertained in one mind with illogical and even conflictual simultaneity. Time flows quickly and slowly, toward a future which appears to be at once open and closed, bringing consistent but disjunctive change. In contrast, linear models of time look rather like "flatland" where elements and their values appear to exist in inexplicable and fragmented independence from each other. This snapshot of how things look or feel at a particular point in time--and which has been taken to reflect a unique and enduring perception--denies the complex processes and interpretations that lurk beneath the surface.

As an alternative Koehler-Jones proposes a model for the generation of group’s temporal signature where every element can potentially hold any range of values within a particular domain; it is the relationships between and among elements that gives shape and defines the temporal signature character of the workplace rules interaction with a field of action (Koehler-Jones, 1996a). The temporal signature tends to be stable but is not static particularly under extreme conditions as shown later in this paper. It is a multilayered process where the salience and dominance of various elements is continually shifting to augment, overshadow, or obscure others. The description that emerges is more like hypertext where various aspects move across layers of depth, in and out, interweaving in fluid, multiple, interlinking, yet parallel operating forms. Although the mathematical expression "non-linear" has been used as a single term for this complex of motions it has been suggested that a richer description would include humanistic connotations. J.T. Fraser has suggested: kaleidoscopic, unrestrained, multi-dimensional, volcanic, many-colored, unruly, elusive, rhapsodic, and, our favorite, unpredictably ordered (Koehler-Jones, 1996b).

For the purposes of this paper, we will speculate that disaster response organizations of whatever kind have characteristic temporal signatures and these signatures go through a particular change sequence—a "continuity" through time--illustrated by the Feigenbaum Diagram. Our "timeless" temporal signature model helps to understand the implications of these changes for workplace rules and organizational change. First we discuss the elements of the temporal signature, drawing from the disaster literature to provide examples. Next, we show that disaster response can be described by the Feigenbaum Diagram and that there are five distinctly different organizational timings as we move from order to chaos. We finish with an exploration of the termporal signature of each of the five different time zones and provide hypothesis for testing each.

The Elements of Temporal Signature

The temporal signature and its dynamic temporal perspective are created by temporal progression which forms the temporal pattern.

Temporal progression.

This is the dimension of process and motion describing the movement or flow of the present into the future or into the past (i.e., the "remembering of it"). The question is "how" is the present moved into the past or future. The components that describe the speed and nature of this "how" in motion are tempo and rhythm. It is the qualitative relationship between these elements, their existential quality, that is important for forming the temporal progression.

Tempo refers to the pace of activity. With respect to future events, tempo includes both the rate at which the future approaches and the speed of onset of specific events. (With respect to past events it is how fast they fade away.) This element has significance for situations like the one referred to by Green and associates where people living around Mt St. Helens believed they could outrun the rising river (tempo as on-set of the river's rising/personal running speed) if volcanic mudflows suddenly raise its level. [1]

Tempo is also conditioned by the relativism or independence of flow, i.e. the role of external forces, and/or other dimensions such as space, on the "flow of life." For example, the Einsteinium view argues that speed depends on position or motion relative to space shaped by gravity; the Newtonian view argues for uniform consistency unperturbed by context. The dimension of tempo then, covers "fastness" and whether that "fastness" is independent of other conditioning factors.

Rhythm refers to the regular recurrence of certain features of time. Does time move in "pulsating" or periodic cycles as described by Zerubavel.[2] Is its motion smooth, or irregular and unpredictable. If the latter, one must ask whether is it truly unpredictable or only apparently unpredictable being embedded in a chaotic attractor.

A distinction can be drawn between rhythm, and the character of change of features within it. It may be that, within a rhythmic system, change occurs gradually or in sharp disjunctive motions bringing unexpected novelty. Is the cadence within the rhythm smooth, choppy, disjunctive?

Overall, the character of the "how"--the structuration of the tempo and rhythm of the flow into the future--is an essential part of future and past perspectives even though it has not been previously recognized.

Pattern

Pattern reveals the shapes (cyclical, elliptical, linear, and so forth) of the temporal perspective (discussed below) and, more broadly, of the temporal signature. Pattern includes degree of demarcation of past, present and future as well as scope or "wholeness" of perspective. Pattern has two parts: shape and the structure within shape; and modal differentiation.

Shape. The structure of the existential flow is highly personal and idiosyncratic in small chunks of time like weeks.[1] Anthropologists and others have characterized the shape of cultural time as cyclical, elliptical, spiral, linear, and so forth.

Conventional views project these patterns in two dimensions but, as we have shown, their complexity suggests that designs with overlapping levels of temporal experience are more faithful expressions of the underlying progression. Cyclic (and other) biological processes combine with external rhythms--natural, manmade, social and so forth--to create tangled arrangements captured in multi-dimensional patterns, symbolizing the intricacy of the shapes created by these intermeshing, intermingling movements (Diagram 1 Phenomenological Complexity in Temporal Patterns).

(Diagram 1 about here)

Modal differentiation. The second aspect of pattern is the degree of differentiation assigned modalities of past, present and future. Assuming a continuum of time running from past to future, there is also a continuum of precision of demarcation of these directional elements running from clearly demarcated segments to a minimally demarcated state where everything exists at one time--in the present.[3]

Cottle's (1977) work points to two additional characteristics of modal differentiation; atomistic, and gestahltist.[4] This refers to the tendency to see time either in chunks (atomistic) or as an infinity of points (gestaltist) creating a unified whole within the broader model differentiation context (Diagram 2). We might refer to Cottle's variable as "scope," or

(Diagram 2 about here)

[1] It is not known whether the experience of pattern is ubiquitous, or at what age it begins to develop. Might some individuals express no discernible pattern at all?

extension of these directional demarcations. Differentiation and scope are aspects of the patterning dimension which have important implications for perception of causal relationships because they define the way the flow is segmented and the character of connections between things. In short, pattern is useful in investigating disaster response attitudes because, as cognative maps showing temporal experience and expectation, they portray the inevitability or uncertainty of future occurrences, where in time they lay, how they approach, and they portend how actions will be organized to respond.

Temporal perspective

Temporal perspective refers to temporal signature's phenomenological or existential view emerging from temporal progression and pattern. Generally, a person's sense of identity depends on "continuity in temporal perspective, especially future time perspective. ...[P]erspectives on the future are more permanent than other elements of time...If the continuity of the future perspective is disrupted one becomes estranged from one's self leaving an uneasy feeling of strangeness and unfamiliarity." [5] Most time related research deals with what we are calling concept of temporal perspective. Elements specifically identified in this literature and that will be briefly discussed below are: orientation or directedness with respect to the modalities (past, present and future); depth or expansion of past and future horizons; and reality. Reality is the orientation that emerges from the interaction between the density, richness and coherence (substance or concreteness of future or past images) of the temporal perspective.

Orientation refers to the relative importance of, or degree of involvement in the various modalities: past, present or future. Following Schneider, there are seven (simplified) possibilities for which modality or combination of modalities predominate as shown in Table 1.

(Table 1 about here)

Depth/Expansion: While orientation has to do with directedness, depth has to do with distance or reach. A subtle distinction exists between "extension," or the range of years between subject age and the most distant event named (as investigated by Wallace), and "expansion," or meaningful depth of the past and future (as explored by Fraise and Kastenbaum).[6] "Expansion" asks how far forward or backward in time the subject occupies himself within conceptualizing a particular type of event, either objective or mythical. Projective ability applies to both extension and expansion, but memory decay is only relevant to expansion. Expansion then is a broader, hence more useful, term.

Reality qualifies orientation and depth by specifying how well articulated spaces of time are. First introduced by Lewin, the concept is based on the idea that precision indicates how realistic future or past images are in the mind' s eye[7]. This aspect of temporal signature has to do with order and planning and consists of three parts: density, richness and coherence.

Density measures and explains orientation and depth by asking how many events, plans, goals, apprehensions or anticipation's are placed in what temporal spaces. By asking "..the number of events, roles and experiences an individual expects to populate his future," Kastenbaum asks how many relationships or connections are drawn from present activities to future states. Connections to past states, and relationships to present experiences are also highly relevant. In a comparative analysis one can ask, for example, about the number of future expectations relative to present and past experiences. Or the question may be posed to explore depth, as Nowotny suggests, by asking whether an overly dense proximal future has negative implications for thoughtful consideration of the distal future.[8] The relationship between density and extension is shown in Diagram 3.

(Diagram 3 about here)

Richness refers to the level of existential or phenomenological detail in present planning or past remembrances. It provides qualitative differentiation by assessing the unity, intelligibility, or logical integration of the event itself.

Coherence refers to the degree of consistency in the structuring and ordering of differentiated events. Wallace originally used the term to refer to consistency in sequential ranking tasks. Kastenbaum later used it for the broader purpose of arranging the occurrences of important past life events. Here coherence should be used in its broadest sense as a term for relating events--whether past or future--to each other.

Trommsdorff and Trommsdorff and Lamm observe that coherence is related to causality because the ordering of events in temporal sequence is primary to establishing causation.[9] We argue that the "order" suggested by these authors is linear and, to free ourselves from unnecessary methodological prejudice, coherence would be better conceptualized as an aspect of pattern. While coherence refers to concrete and finite arrangements of particular events or experiences, pattern refers to abstract structure with multiple dimensions and limitless possibilities (Digram 4).

(Diagram 4 about here)

Each element of the time signature can have various levels of concreteness, providing a wide range of possible ways of "seeing" time. Temporal distances and concrete expectations are manifest by future planning or past remembrances at both fuzzy and detailed levels.

Each of the elements of the time signature depend on subject/object relationships, (*what* one is talking about and *to whom* it is relevant). We normally plan only weeks or months into the future when we are thinking of such things as holidays, birthdays and the purchase of big-ticket items, but Svenson' s work shows that thoughts turn to longer time periods with environmental subjects such as climate change and hazardous waste. Desirable planning horizons increase as we move from self to other. Context is also critical for optimal density which depends upon the subject being discussed and for whom it is relevant. With respect to context and the relationship between coherence and reality, Schneider made this value judgment: "..we can assume that the future perspective is more favorable the more coherent and in touch with reality it is," but he neglected to explain what is meant by "favorable," and we are left to wonder whether it means being right about what actually comes to pass or

whether it means emotional satisfaction (both being meaningful relational realities). In our concern about how far into the future extreme disasters are perceived--and perceived in such as way that they are made of sufficient concern to change or impact the everyday world--we must be clear in our definition of subject and object.

Our brief discussion of the temporal signature shows just how complex the rules are that shape the timing of organizational workplace rules. Many factors are entertwined with concepts of future planning, current work organization practices, and how a response is "supposed to go" from the perspective of "normal" time. These factors are listed in outline form below. Disasters severely upset this comfortable timing out of group life.

Table 2 about here

Disaster Characteristics That Disorder Response Organizations

A public disaster response agency (ambulance and hospital services for example) trying to organize itself to respond is an example of an organization under extreem stress. A disaster occurs when the local emergency response system's means for managing and coordinating a response are overwhelmed and require outside intervention to succeed (Drabek, 1994; Dynes and Tierney, 1995; and Quarantelli, 1994) They simply don't have the resources to do the job.

The effort to organize a disaster response structure involving multiple public, private, and non-profit agencies can be disrupted in any one number of unpredictable ways (Drabek, 1994, 1986; Auf der Heide, 1989; and Waugh and Hy, 1990).

- The type of disaster that could occur at any time is unpredictable.
- Where a disaster will occur is often unpredictable.
- How a disaster will unfold in geographic space over time is often unknown.
- The type and distribution of injuries in space and time is often unknown.
- Which elements of the response system or of supporting organizations (law enforcement for example) will be damaged, how they are damaged, and the resulting delay in their response is unpredictable.
- Self-organizing efforts by citizens, responders in the field, and other emergency organizations at the state, federal level, non-profit and private sector level will create unexpected communications paths and response structures.
- Information about the entire emergent disaster response structure or even parts of response (including how it extends across the community, city, operational area, the status and organization of the regional response, state response, and federal response) is incomplete. A disaster response structure is "emergent" because it did not exist at a time prior to the disaster. It involves the birth of new units or the restructuring of old ones at the work group, organizational, inter-organizational, community, or regional level that are more or less adaptive to a particular circumstance within the disaster (Drabek, 1989). It is difficult to not only identify what and where the new structures are or how

old ones have changed, but also to identify the form of inter-group and interagency connections.

- Existing strains between organizations may be exacerbated. Existing strains between organizations due to competition with other organizations, organizational placement (fire service or police for example), under funding and under staffing and other factors may come forward or be revealed making inter-organization coordination more difficult (Drabek, 1989)
- Because of initial starting conditions, and varying resource demands, critical activity rates of the response within and between organizations drive each other and the overall response in unpredictable and complex ways. For example, the EMS disaster response depends on tight and effective coordination between many different public and private organizations including, for example between citizen self-organizing rescue efforts, ambulance companies, law enforcement, hospitals, pharmaceutical supply houses, surface and air transport, military forces, and federal, state, and local government agencies. The rate of victim rescue affects how quickly transport vehicles must be identified and dispatched which in turn affects how many injured people are waiting for care in a hospital emergency department, emergency department staffing, etc. These factors are driven by the availability of communications, of health care personnel and supplies, and by whether transport can move necessary resources to where they are needed.

Barbara Adam in her analysis of the Chernobyl reactor accident, provides an excellent example of how such problems can lead to a catastrophic response:

> The difficulty of appreciating and handling complexity, I want to suggest, is tied to the tendency to think in terms of one-dimensional, linear event chains associated with aims, thus neglecting to take account of feedback and amplification, of side-effects and exponentially accumulating processes. To achieve the urgently required cooling down and thus renewed stability of the reactor, the operators activated all eight pumps instead of the allowed maximum of six. Whilst the operators acted in accordance with *their* one-dimensional safety goal, the reactor went into a series of predetermined interconnected safety measures which proceeded along a very different rationale and lay outside the operator's control: *operators and system functioned according to different underlying theories, assumptions, principles, time scales, implicit rules and mechanisms.* They were on a collision course that ended in catastrophe (Adam, 1995).

Chaos Theory And The Rules Of Organizational Morphogenesis

Bateson tells us that: "The *pattern which connects is a metapattern*. It is a pattern of patterns. It is that pattern which defines the vast generalization that, indeed, *it is patterns which connect*"(Batson, 1979). By this Bateson meant that there is a nested relationship between the unique individual pattern and the overall metapattern that guides its formation. For example, a spiral is a pattern that the growing shape of various species of snails, conches and other similar creatures exhibit in their shells; it is a precise relationship that

defines how one segment is added after another that informs each growth process. Paraphrasing Bateson:

- All symmetry and segmentation is somehow a result of growth;
- *Growth* makes its *formal* demands for patterning; and
- One of these formal demands is satisfied (in a mathematical, an ideal sense) by spiral form (Bateson, 1979).

Or in the terms we are using here:

- All organizational change is a result of growth ordered by the temporal signature;
- Growth makes its formal demands for patterning; and
- One of these formal demands is traced by the Feigenbaum Diagram.

Thus an uneque pattern is an expression of a general guiding metapattern that connects particular elements into a dance of interacting parts as they grow or change. Workplace rules are a particular interpretation of a metapattern characteristic of the interface formed by these particular rules and the environment. It is our view that the Feigenbaum Diagram provides a guiding metapattern for uneque changes in organizational structures as they respond to extreme conditions. How do we go about understanding the relationship between these two domains; the metapattern and the unique pattern of a particular response organization under extreme conditons?

According to Kellert: "chaos theory is the *qualitative* study of unstable aperiodic behavior in deterministic nonlinear dynamical systems. ...As a qualitative study, chaos theory investigates a system by asking about the general character of its long-term behavior, rather than seeking to arrive at numerical predictions about its exact future state"(Kellert, 1993). Rather than answering the "why questions" such as explaining why a particular event occurs, it answers the "how questions". It does this by pointing to a computer graphic that has been created by a long series of iterations and asking how this complex pattern occurs. The answer to this "how" question often involves a complex *geometric* historical process such as stretching and folding and period doubling that bring these holistic, historical pattern forth (Peitgen, et.al.,1992). The unique organzational patterning at the interface is one point or interpretation of this larger, bounded metapattern.

These geometric mechanisms are not law-full or casual mechanisms. The geometric process reveals patterns; it does not need to show the workings of an actual causal mechanism in a specific system.

> "...[I]t is 'transcendentally' impossible to trace the actual causal influences that lead from one state to a later one. Not even an 'ideal explanation text' could contain the full causal account....

> Two physically identical chaotic systems with identical boundary conditions and laws and with their one particle in the same physical state t_0 can be different states at $t > t_0$. That is, determinism as uniqueness of evolution fails to hold" (Kellert, 1993).

What is being shown are the qualitative geometrical features traced out by continuous interactions of a particular set of non-linear conditions. It is a "dynamic pattern that connects." The term "morphogenesis" will be used to refer to this deeper dynamic qualitative set of organizing, response system dissolution/reforming rules across an extended time period.

It turns out that in mathematical theory the change for dynamic systems from order and predictability into unpredictability or chaos is governed by a single law, and that the 'route' between the two conditions is a universal one. According to Pietgen and his colleges: "Route means that there are abrupt qualitative changes--called bifurcation's--which mark the transition from order into chaos like a schedule, and 'universal' means that these bifurcation's can be found in many natural systems both qualitatively and quantitatively" (Peitgen, et.al.,1992).

The Disaster Response Is At The Edge Of Chaos

By applying the logistic equation to the appropriate disaster response data it appears to be possible to determine if a disaster organization or response system traces the universal route to chaos (Priesmeyer and Cole,1995). The logistic equation is particularly useful for showing the relationship between various competing but interdependent forces, such as that between an animal population's growth and some limiting factor in the environment (chickens, foxes, and chicken feed for example). Priesmeyer provides a detailed discussion of how the formula is applied to a large number of businesses and other phenomena to produce what is called a logistic map. (The logistic map is a special case of the Feigenbaum Diagram.) The level of activity or use of resources characteristic of a particular set of organizational work force rules is displayed on the X or vertical axis, and the stability of the environment on the k (horizontal axis) ranging from stable and calm (1.0) to highly disturbed (4.0). Each point on the Logistic map represents an organizational or system state or attractor at a particular moment in time (Diagram 5).

(Diagram 5 about here)

Priesmeyer's and Cole's Chaos paper, "Nonlinear Analysis of Disaster Response Data," applies the logistic equation to time series data set representing 146 valid responses from interviews with 257 key participants (EMS, fire, police, and other personnel) in 106 organized disaster responses.[2] The time series was derived by determining the number of hours from initial impact before the individual became involved in the response and the time they terminated their response. According to Priesmeyer:

> The resulting data set was ..."sliced" in one hour intervals to create a frequency distribution of the activity levels. Specifically, the data set was searched to count the

[2] The data were provided by Kreps and Bosworth. They extracted data from 1,062 tape recorded and transcribed interviews of individuals involved in disaster response: 250 from one earthquake, 198 from two hurricanes, 330 from six tornadoes, and 284 interviews from six floods (Bosworth, and G. Kreps,1986).

> number of individuals involved within the first hour after impact, then searched again to identify the number of individuals involved after one hour but before two hours after impact. Twenty four of these searches provided a time series indicating the number of individuals involved in disaster response during each hour for each of the first 24 hours (Priesmeyer and Cole, 1995).
>
> In this particular case, the variable X can be taken as the level of activity of all respondents at the initial condition and during each subsequent hour. The constant k is a parameter defining the level of disorder in the environment. The value of k can be computed from the data to indicate the level of stability or chaos in the system.

Digram 5 shows the statistically significant results of this analysis. The data indicate that the level of disorder among responders occurring during the first twenty-four hours following this group of disasters traces out the Feigenbaum Diagram and is at the edge of chaos. Returning to Priesmeyer's and Cole's data, we find that disaster systems exist at the edge of chaos:

> When the equation is fitted to the first 24 hours of disaster response activity for this wide range of events it reveals a value of k of 3.66 with an initial value of X of .10. It also provides an F value of 6.75 which is significant at the 95 percent confidence level.
>
> The logistic map shows that the *opportunity for true system change is built into the [disaster response] system*, but is only possible when the system is operating in or near the chaotic region (when k exceeds 3.7). One will note that the derived value for k of 3.66 is very near but does not exceed the edge of the chaos domain of 3.7. [Italics in the original.] (Priesmeyer and Cole, 1995).

An important caveat is that the data are for a heterogeneous collection of disasters with varying levels of activity. Aggregating them together might create a chaotic time series. This approach of aggregating cases across disasters and disciplines has been used to arrive at generalized findings about disaster management (Draybek, 1989, 1990). Additional efforts need to be made to collect similar time series data for individual disasters to see if the logistic equation fits as well.

The Feigenbaum Diagram As A Universal Map Of Organizational Morphogensis

Diagram 5 ummarizes the relationship between work place rules and their environment, and the rules of morphogenesis driven by the interaction of resource depletion and environmental disorder as mapped by the Feigenbaum Diagram. The Feigenbaum Diagram

(Diagram 5 about here)

demonstrates a consistent mathematical geometry no matter how the mapping is generated; the length of each twig of the bifurcation tree is changed by a scaling universal constant of 4.669, and the rate at which the branches open at is expressed by a universal ratio of 2.502 (Ian Stewart,1989). These scaling ratios don't depend on the mapping equation be it logistic or trigonometric. The Feigenbaum Diagram is a graphic of a qualitative universal attractor. Interestingly, the Feigenbaum Diagram "...makes it relatively easy to test a

particular class of chaotic models by experiment; but it doesn't distinguish between the different models in that class." For example, to describe what the behavior of a particular organization is at a point on the diagram is not dependent on any particular model; "*any theory in the same universality class will do just as well*." (Ian Stewart,1989). (Italics in original.)

The Feigenbaum diagram is a qualitative pattern or mapping of patterns. While not predicting the course of any one organization it graphically shows the attractor upon which disaster response organizations reside as a class as key variables are changed (resources and environmental disorder). We are proposing that for each point on the map there is a characteristic qualitative organizational temporal signature that, like the mathematics of the spiral, guides a general bounded class of behaviors (Diagram 5 divides the diagram into five possible temporal signatures). Exactly how these behaviors form their *particular* pattern can not be predicted. But it is this *general mapping of the process of change*, this qualitative history of the states that shows how organizational morphogensis proceeds under extreme conditions and upon which this uneque pattern generating process rides that is important. Thus if we can understand the topology, stability, and timings of the Feigenbaum Diagram we can understand the geometric progression of classes of individual organizational patterns without knowing the exact, organizational causes of a particular pattern.

Clock Defined Intervals of the Feignebaum Map are not Isomorphic with an Organization's Temporal Signature Intervals

Evenly divided clock intervals are used to measure the interactive increments necessary to generate the Feigenbaum Diagram. The qualitative concept of social time is different from clock time. Yet the concept of "time" itself in both cases is undefined (Levich,1995).

Generally, the natural sciences depend on the concept of time formulated in physics. "In physics time is identified with the set of real numbers. ...Evidently the mathematical properties of a straight line should conform to the real properties of the physical time. ...[However, there is]...an absence of an explicit non-mathematical concept of time in physics" (Levich,1995). In physics time varies in the way it is conceptualized from subfield to subfield; the definition of time for statistical thermodynamics is quite incomparable with that for Hamiltonian formalism.

Not only does physics lack an explicit theory of time, but the question as to whether the time of physics is the time of all natural science and of the social sciences is unresolved. (Remember we are using clock time to trace a map of organizational change.) Again, a straight line divided into precise segments of a specific duration is substituted for an answer to this important question. In fact in the biological sciences, it has been necessary to uncouple from clock time and tie the biological clock closer to the biological phenomena under examination to discover important processes.

> In embryology the development of different organisms is effectively described using the biological time unit equal to the interval between the same fission phase.... the

> above unit ("a detlaf") depends on the temperature and the species, therefore the laws of development revealed using the description in detlafs, remain undiscovered when the astronomical time is used (Levich,1995).

A second example is the timing of phases associated with a trees growth from seed to tree or in its daily, monthly and seasonal cycles. Palentology and geology have also created units of time that are not of equal duration but that are much more relevant to tracing long term changes (Armand,1995).

The iteration of the logistical equation is a history or system "age" driven process. A "true age" of an organization as it responds to a disaster can be measured only by using the *system's proper time scale*, not by imposing the even segments of clock time. Levich (1995) cautions us that: "Dynamic models include time as an essential variable.... However, for studying them a neat investigation of the very notion of time, along with everything hidden under the notion, is necessary."

Our discussion of an temporal signature suggests that a proper scale for the history of disaster response organizations might be quite different from clock time. Rather than descrete intervals, such a scale may involve qualitatively different periods based on how the elements of the temporal signature contained in the workplace rules are reorganized as they move across the metapattern of the Feigenbaum map (Sharov,1995). Such qualitatively different periods are not absolute and need not have the same duration. Using this perspective, the Fiegenbaum Diagram becomes quite plastic, surrealistic almost as we move across it. This approach shifts the focus to the morphogenic process that ties these varying qualitative intervals together.[3]

Interpreting the Fiegenbuam Diagram as a Map of the Construction of Time

The Feigenbaum Diagram maps various timings from left to right that shape the temporal signature. There at least five distinct regions (Digram 5). Each zone is qualitative in the sense that the exact organizational time signature cannot be known but the characteristic qualitative metapattern driving it can be. The duration of each segment is highly elastic and is more like that of palentological or biological time than it is like clock time. The five distinct zones are:

1. The relatively *stable states* traced by the single line;
2. The *bifurcation point(s*);
3. *Period-doubling bifurcation's*;
4. The *edge of chaos*; and
5. *Chaos.*

[3]The temporal signature might have important implications for analytical and data collection methods, and for the form that explanatory statements take in Chaos theory and Complexity theory generally. Exploring these implications go far beyond the scope of this paper and the authors' expertise.

The following three tables tentatively suggest the characteristics of the organizational temporal signature for each zone. The following section combines these suggestions with descriptions of how a disaster organization might behave in each zone.

(Tables 3, 4, and 5 about here)

Stable State

Examining the Feigenbaum map, we see that a single line curves from the origin up to a point where it divides or bifurcates into two lines. Regardless of the initial conditions of the system (x) the result will always fall on this line so long as the stability of the environment (k) is between 1 and 3. This means that so long as the level of disturbance in the environment remains below 3, the organization or system in the environment will be more or less stable. (Some values along this line are more attractive than others. It will take an organization more time to settle down into a single configuration at the less attractive points (Peitgen, et.al., 1992)). Still, exactly what we mean by "stable" is not fully understood since stability from the perspective of chaos theory is just one among many dynamic states. The points on this line seem to "attract" the organization or system into a particular, stable, orderly state. Management is able to absorb the disturbances that are disrupting the field of action within the existing rules of work because (Kiel,1995).:

- The workforce rules' temporal signature rhythm is smoothly pulsating activity (weekdays are "short" but weekends are "long") according to an established pace. Change occurs in a known and regular way. The speed of future onset, event onset, and event fade away are known and relatively controllable. The context does not drive the temporal signatures formation, tradition does.

- The relationships between work rules, the field of action and the environment are generally predictable;

- Organizational responses to changes in the environment are proportional; big problems require big solutions, little problems little ones.

- Organizational processes may be rhythmic and pulsating as they extend into and contract out of the environment. For example, calls for emergency services care are typically cyclical but the rhythms are predictable, relatively well understood and are incorporated into workplace rules.

- Disaster responders and victims may not be changed much by the event. "Restoration of flexibility" is when the victim resolves the immediate problems and attempts to restore their lives to "normal". In this case, due to the elasticity of their temporal signature, a citizen may not move out of a flood plain after a major flood or responders may not change the way a response went even if it went poorly. This behavior is analogues to organizational inertia and policy drift

> characteristic of an organization that continues to do what it has always done rather than adapting to changes in its environment (Kress, 1981).

The Bifurcation Point

Organizations can no longer occupy one point on the line; *only* two (or more) distinct organizational states are available. (The exact point where the single line bifurcates is called a repeller; it cannot be occupied as a final state, only one of two attractor states are possible (Peitgen, et.al., 1992).)Which state or if both points will be occupied cannot be predicted. During this process at the bifurcation point the organization seems to "choose" one of two paths; each containing a mixture of elements that might be adaptive to one set of environmental conditions but not to another within the same environment (Kiel, 1994) This "choice" is an "instantaneous" one; it is sudden, "abrupt", a "discontinuous jump", "explosion" (Thompson and Stewart,1986; Abraham and C. Shaw, 1988). A close examination reveals that unlike the previous section which is characterized by an attractor, the bifurcation point is defined by a repellor; ie. a state which can not be occupied in time. Second, this "timeless point" creates a barrier for time; it is no longer reversible to a previous point even though it may return to a single attractor (Thompson and Stewart, 1986). Movement through such a bifurcation point is irreversible for biological organisms and probably for organizations as well. "The bifurcation barrier can be compared with a wall in which there is a hole provided with the valve opening only to one side. The return into the initial state if it is possible then only along hysteresis loop, i.e., through other valve or past the wall (sic)" (Mikhailovsky, 1996).

In summary, this is a relatively "timeless region". The workforce rule's temporal signature's rhythm and motion is unpredictable and exhibits a discontinuous pace. Change is sudden with a future appearing in a discontinuous way. Events vary in the speed of onset, but fade away quickly. The temporal signature is context driven by the onset of excessive disorder in the environment.

Region of Period Doubling

Moving further up the diagram, we see that the line divides. The disorder in the environment has increased, as has the commitment of resources.

> "Out of the major stem we see two branches bifurcating, and out of these branches we see two branches bifurcating again, and then two branches bifurcating out of each of these again, and so on. This is the *period-doubling regime* of the scenario.
>
> Let us explain very crudely what period-doubling means. Where we see just one branch the long-term behavior of the system tends toward a fixed final state... This final state will be reached no matter where...we start. When we see two branches this just means that the long term behavior of the system is now alternating between two different states, a lower one and an upper one. This is called *periodic* behavior. Since there are two states now, we say that the *period* is two. Now, when we see

> four branches all that has happened is that the period of the final state behavior has increased from two to four.... Beyond this period-doubling cascade at the right end of the figure we see a structure with a lot of detailed and remarkable designs. Chaos has set in, and eventually...chaos governs the whole interval... (Peitgen, et.al., 1992).

The most insignicant event (sensitivity to initial conditions) can cause an organization to get "locked" into one of the two possible states and be unable to shift to the alternate state. The organization might also create a complex pattern of oscillations defined by a particular type of attractor between the two or more points. If the environment becomes even more disordered requiring the commitment of even more resources or their exhaustion, the organization is forced to occupy any one of four structural states, then eight, until the edge of chaos is passed and chaos sets in. Again, it appears that we have multiple barriers to time reversibility leading to a variety of complex structures either at a point, oscillating between points, or characterized by a complex attractor of some kind as they move between two or more points.

Prediction of the next organizational structure becomes progressively more difficult. Rephrasing this in inter-organizational interactions terms, a series of ever increasing self-reinforcing "errors" are made by participants, deviating from established workforce rules and their relationship to the disaster's field of action (Koehler, 1995). These continuously repeated errors become amplified and redefine the functions of the organization which in turn redefines its structure. The errors increase the organization's sensitivity to small changes in the environment (sensitivity to initial conditions) which in turn cause large changes in the organizations structure. Thus "...process and structure become complementary aspects of the same over-all order of process, or *evolution*. As interacting processes define temporary structures...so structures define new processes, which in turn give rise to new temporary structures" (Jantsch and Waddington,1976).

To summarize what happens to organizations at and following a bifurcation point:

- The workforce rule's temporal signature is irregular as it periodically and sharply varies by switching from Feigenbaum branch to branch according to the geometric rules governing this qualitatively predictable branching process. Speed of future onset, of event onset, and of event fade away are highly complex and variable depending on the rhythm and tempo of switching between or across Figenbaum branches or by crossing new bifurcation points (see zone 2 above for time signature characteristics of a bifurcation point).

- The relationships between work rules, the field of action and the environment become progressively more complex and unpredictable but not chaotic.

- Problems of varying magnitude and the efforts to address them ("errors') may generate additional bifurcation's creating more structural changes in the organization.

- The organization's functions and structures may lock onto one of two or more states or may oscillate between them following a complex attractor.

- The rate of progression from one period doubling to another appears to increase as one moves to the right across this zone.

The Edge of Chaos

At or near the boundary of chaos it appears that the ordered structure of the disaster response agency loosens, potentially making new behavior possible. The response structures are no longer oscillating between two or more states or occupying an attractor that ties them together. It is at the edge of chaos that sufficient fluidity is achieved by continuous "error" making for new work rules and a redefined field of action to emerge and be absorbed into a new but not necessarily more adaptive organizational structure (Kaufman, 1993). Interestingly, such changes often can lead to structures with an increased level of organization, that are more complex, and are capable of doing more work, than the previous state. Kiel suggests that "this is due to its increased capacity to attract, utilize, and organize available energy for its creation and maintenance" (Kiel,1989). Recent work in evolutionary theory and simulation studies supports the view that organisms at the edge of chaos tend to be highly adaptive (Kaufman, 1993; and Goerner, 1994). As with a bifurcation point, it may be that the edge of chaos does not permit reversibility to an earlier bifurcation organizational state.

Research by Kreps seems to support our finding that a multitude of different and often complex organizational forms can emerge. According to Kreps, 423 different short-lived organizational systems can emerge during the response phase. Less than half exhibit a rational structure in how they go about doing things (Kreps,1989; and Kreps and Bosworth, 1994).

Nonaka suggests that: "Chaos widens the spectrum of options and forces the organization to seek new points of view. For an organization to renew itself, it must keep itself in a non-equilibrium state at all times" (Nonaka, 1988). Here, the response organization is seeking to recreate itself to respond to a particular type of disaster with its own timing.

It may be that a new or adaptive response structure emerges from a "phase transition" at the edge of chaos. There are two types of phase transitions: first order and second-order.[10] A first-order phase transition involves a sharp change from one state to another. An example is the rapid transformation of water to ice. The change is very abrupt and well defined. A second-order phase transition takes more time to accomplish and is less precise. Once a second order phase transition starts, no clear cut structure remains or immediately emerges but there are lots of little structures coming into and going out of existence. Efforts to establish a "better" order or to "select" a particular organizational structure among many possible ones is management's task. This structure is reinforced by what is called a path-dependent process; that is, once the structure begins to aggregate, there is a tendency to direct resources towards that aggregation rather than to other alternative ones.[11] Both of

these concepts--phase transition and path dependent processes--are important to understand how large, geographically extended structures may emerge.[12]

Drawing together what has been said about the edge of chaos:

- At least during the first 24 hours after an event, disaster organizations may exist at the edge of chaos, a position that allows maximum adaptability.

- The workforce rules' temporal signature has for all practical purposes collapsed. An authoritative, creative act is necessary to select and establish a new temporal signature (second order phase transition) out of the vast range of possibilities.

- Very small changes or "errors" can have large organizational consequences.

- The accumulation of errors could lead to a second-order phase transition characterized by a period of disconnected organizational fragments that eventually come together to form the new organization or system.

- More complex, and adaptive structures may emerge from a phase transition but they are not necessarily more efficient.

- Path-dependent processes may play an important roll in reinforcing an emergent organizational structure.

- An individual's temporal perception and orientation at the edge of chaos is case specific and depends on whether or not they are optimistic about the future and actively involved in unfolding events. If they are, their capacity to plan further into the future is enhanced.[13] Having said this, Koehler-Jones points out that no one knows "...under what conditions future orientation might function as an independent, dependent or intervening variable."[14]

Chaos

If the environment continues to disorganize, eventually bifurcation's and accompanying oscillations become so complex that they become chaotic. Looking at the Feigenbaum map, we are now in the area with a large number of dots, sweeping arcs across the dots, and open bands.[15]

> When chaos occurs a...system does not retrace prior identifiable sequences of behavior and does not evidence obvious patterns in its behavior. Chaotic behavior thus appears extremely disorderly since patterns over time, a symbol of orderliness, do not appear to exist. Chaotic behavior simply skips from one identifiable point to the next, yet never extends outside clear and distinct boundaries.[16]

All potential workforce rule rhythms, tempos, speed of future onset, speed of event onset and fade away, etc., are possible within this highly context drive zone. From an existential viewpoint, the organization may come to occupy a state called "presentism". "Presentism" refers to a condition where the need to deal with the necessities of life is so overwhelming that no wider perspective is possible. Tarkowsaka notes that: "The effects of extreme presentism -- immediacy and provisionally, making up typical elements of the existing socio-political system -- intertwine with the effects of a collapse of social hopes and of the protracted crisis bearing a specifically intensive 'culture of the present' limited in its future visions, permeated with provisionally and temporal discontinuity."[17] Alternatively, loss of a consistent temporal signature might result in the loss of identity and an inability to function at all.

Some general observations emerge from this tentative analysis of the relationship between the temporal signature and the Feigenbaum Map:

- The Feigenbaum Mapping appears to show that the metapattern of organizational time signature morphogensis is complex, resulting in different temporal signatures from zone to zone.
- The qualities of rhythm, tempo, pace of activity, speed of future onset, speed of event onset, and temporal orientation, depth/extension, expansion and reality appear to vary in characteristic ways from zone to zone.
- Some temporal signatures may be driven by past workplace rules (zone 1); some by geometric progressions characteristic of the Feigenbaum Mapping process (zone 3); and some by the creativity and actions of individuals in either bounded (zone 2) or unbounded ways (zones 4 and 5).
- Clock time is useful as an analytic tool but insufficient to understand organizational morphogensis as traced by the Feigenbaum Diagram. It measures but does not provide understanding.

Specific existential conditions characterize each zone. The sudden occurrence of a disaster severely qualifies prior concepts of the present and the future; the future no longer unfolds in an orderly, predictable way that can be influenced. The sudden onset of a disaster "brings one crashing to the present" and depending on the zone, creates a characteristic temporal signature.

Discussion

We have reported preliminary data showing that disaster response organizations follow the Feigenbaum Mapping—a metapattern—as they respond to a very disruptive event. Using this data, we theorize that different temporal signatures are generated by each of the map's five temporal zones. These zones are qualitatively different and varying in duration. The clock time used to generate the Fiegenbaum Map is clearly different from the timing of the organizational temporal signature. Hopefully, sufficient details of this complex process have been provided to permit computer or other modeling, and eventual direct observation of this complex phenomena. Also, as noted above, the temporal signature might have important

implications for how experimental or other data is collected and analyzed useing the methods of chaos and complexity theory.

It may be that the Feigenbaum Map and its relationship to an organization's temporal signature has important implications for long term planning. Clearly, very significant and unpredictable changes begin to occur when the first bifurcation occurs. These changes are exacerbated by what may be very significant changes in what is participants "see" as "long term" given a the predicted temporal signature changes. Exact predictions of future organizational structures or relationships to the environment appear to be highly problematic if not impossible just when they are needed most, following a significant disruption brought on by environmental disorder relative to resources. Sensitivity to initial conditions makes this task even more difficult. All of this suggests that a new, process oriented approach may be necessary to address emergent contingencies under extreme conditions. This literature is beginning to emerge.

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