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The Age of Uncertainty, Organization, and Chaos Theory

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Abstract

In Over the born of the XXI century, in front of a growing complex, changing, and uncertain world, favored by technological advances in information and telecommunications, chaos and paradoxes are present at any level on the human knowledge scale. They defy learned paradigms because no explanation seems to express the facts but generates new theoretical perspectives to express them as a better comprehension of reality. Chaos, complexity, and uncertainty may explain, in different ways, such a transforming organization.

Keywords: Uncertainty, chaos theory, complexity.

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Earthly identity and antipolitics can only be conceived with a thought capable of connecting fragmented notions and compartmentalized knowledge. The new knowledge that leads us to discover the Earth-Homeland... makes no sense while they remain separated.
– Edgar Morin, 1993

INTRODUCTION

At the threshold of the 21st century, facing an increasingly complex, changing, and uncertain world, favored by advances in information technology and telecommunications, chaos, and paradoxes are present at all levels of human knowledge, challenging learned paradigms, because apparently, they explain little of the facts, which has led to the emergence of new theoretical perspectives in the search for a better understanding of reality.

Indeed, with the manifestation of a set of crises in the social, economic, political, cultural, ecological, and of course, organizational fields, it is evident that it is not possible to understand, let alone address, the complexity and multiplication of unforeseeable situations with a linear, deterministic, or authoritarian control vision. All of this is frightening because it implies a departure from the predictable, the known, and the controllable.

However, amid the confusion, the emergence of metaphors, concepts, and methodologies is observed in the endeavor to understand this borderless world, this global village that encompasses everything, both material and spiritual. It is precisely in this vein that chaos theory can be of great utility for its contribution to the study of complex systems and particularly to the development of the complexity paradigm, which allows understanding the plurality, interconnection, instability, and uncertainty of phenomena as implicit aspects of the complex world. (Jantsch, 1980; Kauffman, 1991; Stacey, 1991; Vriend, 1994; Waldrop, 1992; Wheatley, 1992; Zohar, 1997).

This essay describes the main characteristics of chaos theory to observe its relevance in the study of organizations. To this end, the work is divided into three sections: the first describes two perspectives that have influenced organizational thought, the Newtonian deterministic vision, and the complexity vision; the second highlights some fundamental characteristics of chaos theory within the development of the complexity paradigm, and the third refers to the use of some of the principles of chaos theory in the characterization of the organization as a self-organized complex system, concluding by referring to its analytical importance in the study of organizational dynamics.

FROM THE PARADIGM OF SIMPLICITY TO THE PARADIGM OF COMPLEXITY: TWO WAYS OF UNDERSTANDING THE ORGANIZATIONAL WORLD

The paradigm of simplicity, known in the organizational realm as the Taylorist-Newtonian vision, for adopting deterministic schemes similar to those of Newton, understands organizations as machines or mechanisms artificially created to achieve objectives, and being mechanisms, they are considered to be externally regulated.

This paradigm[97] is based on the analytical method of isolating elements (organizational agents) to examine them separately and thereby reveal their operating laws. The organization results from the placement of these elements in a hierarchical order, with cause-and-effect relationships between them. In this order, randomness plays a secondary role, as it only causes temporary deviations from the predetermined order and does not intervene in explaining the modes of organization.

The integral premises of how this paradigm understands organizational reality are: a) linear causality in relationships between organizational elements; b) organizational objectives as an integrating element of individual behaviors; c) the external environment as determinants of organizational changes; d) tendencies toward order and balance of organizational activities; and e) reductionism as a method for analyzing participant behaviors. In summary, the essence of this theoretical perspective is revealed in the interest in achieving hierarchical control of organizational behavior; that is, programming the behaviors of organizational agents and their regulation are paramount to avoid variability and hence the uncertainty of behaviors outside the norm (Etkin and Schvarsten, 2000).

Indeed, for much of the past century, the administrative process, predominantly influenced by Taylor's thinking and Weber's bureaucracy theory, led organizations to operate within the parameters of a deterministic and mechanistic management that sought to reduce variability and avoid uncertainty in organizational processes to achieve maximized efficiency and profitability.

Thus, organizations were predetermined under a hierarchical order, where individuals at lower organizational levels were considered to have no free will or participation in decision-making, and were only suitable for executing the norms established by the higher hierarchy (Sérieyx, 1994).

In contrast to these postulates, the complexity paradigm asserts that organizational reality is fueled by processes that cannot be ordered or programmed from the outside. Here, the organizational entity supposes the presence of forces from multiple sources, and inherent plurality is not intended to be eliminated; on the contrary, the coexistence of complementary, simultaneous, and antagonistic relationships is acknowledged. Consequently, the organization lives and evolves in an internal environment of relative disorder, diversity, and uncertainty.

Regarding its basic premises, it highlights: a) the recognition of the organization as a complex system, that is, as an integrated and indivisible whole, b) the variability of the system is seen as an obvious result of the interconnection of its parts with each other and with other systems in its environment, c) the explanation of organizational change is understood within the inner framework of the system itself, as a process of self-regulation

[97] In management sciences, a paradigm is constituted by the set of values, concepts, reasoning, behaviors, etc., constructed and shared by the specific scientific community, which accommodates a vision of organizational reality and often leads to dominant administrative practices in the management of organizations. (See Kuhn, 1971)

or internal pattern of ordering that is not feasible to predict a priori (Etkin and Schvarsten, 2000; Morin, 1974).

This perspective began to be adopted in management sciences in the late 20th century as a result of the crisis of the Taylorist-Weberian model, which revealed that the ways in which organizations operated, separated from their environment and even without true internal articulation, were inadequate for their development. This led to the design of new organizational models with organic, flexible, or network structures that seek to be articulated under shared decision-making, recognizing the organization as a complex system capable of learning and self-renewal (Nonaka and Takeuchi, 1999).

Where change, fluctuations, and imbalances are no longer signs of destructive disorder, but rather, the primordial source of creativity. This situation has been described by scientists as a trajectory between order and disorder, such as order emerging from chaos, or order established through fluctuations resulting from the interaction of different elements of a system (Prigogine and Stengers, 1984; Bohm and Peat, 1988; Morin, 1974).

Thus, for authors like Edgar Morin (1974), society and individuality are not separate realities that adjust to each other— the same can be said of the individual in relation to the organization— but rather, there is an ambisystem, where both dimensions shape and mutually parasitize each other in a contradictory and complementary manner. In fact, ambiguities and "noises" from each of the elements in relation to the others appear in the ambisystem, but through movements that are too disorderly on one hand, and obligations that are too rigid on the other, the interferences that constitute the essence of both the individual and society are established. Complexity appears in all its splendor in this combination of individuals/society accompanied by disorder and uncertainty, and develops from the permanent ambiguity of their complementarity, their competitiveness, and ultimately, their antagonism.

Then, in contrast to the traditional view of management sciences, which perceives organizational dynamics through linear behavior, where prediction and hierarchical control are fundamental pieces of management to avoid disappearing into chaos, the perspective of complexity reveals to us that the non-linear dynamics of the interconnection of organizational agents, like the interconnection in any other living system, makes possible the generation of evolutionary changes through the collective construction of new realities in their historical development.

CHAOS THEORY AND ITS CONTRIBUTION TO THE PARADIGM OF COMPLEXITY

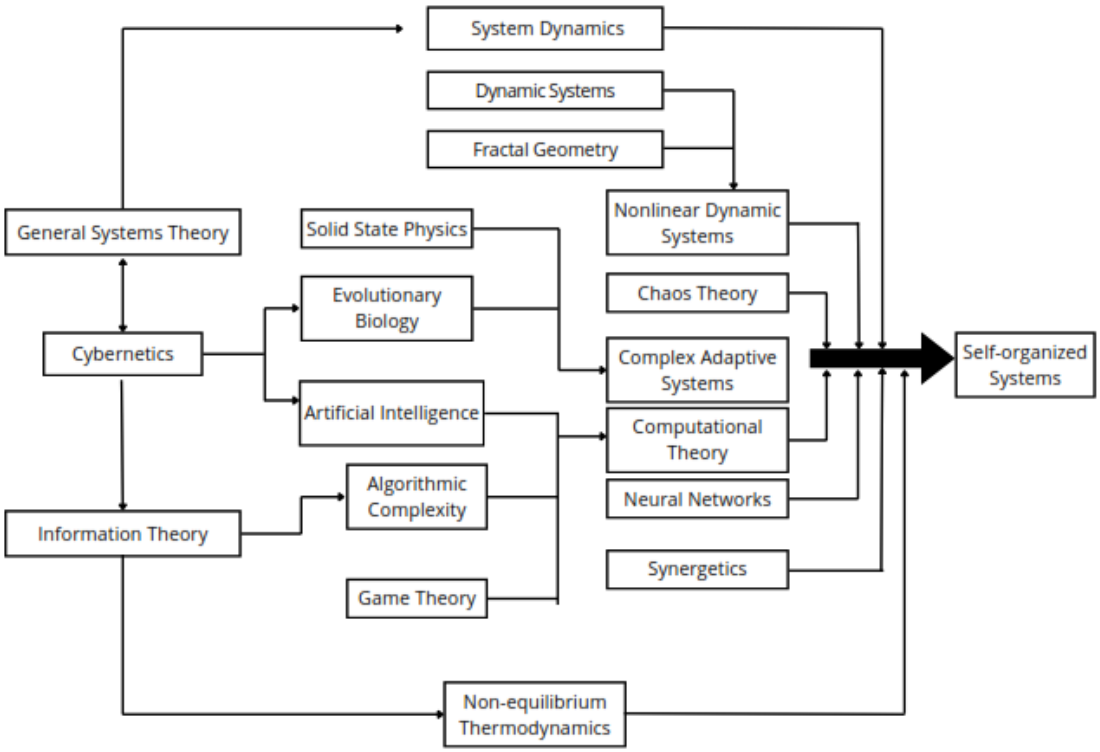
The study of organizations through the lens of chaos theory, as self-regulated[98] complex systems, emerges from the development of the complexity paradigm (Capra, 1982, 1996;

[98] The capacity of any complex system to self-organize, that is, the ability to reconfigure its interrelationships and activities, is a fundamental aspect. Every biological system, from the simplest bacterium to the most complicated organism, such as the human being, and organizations themselves, are self-regulated systems of energy on the edge of chaos. This is the secret of life—to creatively adapt to changing conditions. (Zohar, 1997, p. 77.)

Gleick, 1987; Morin, 1996; Jantsch, 1980; Stacey, 1995; Waldrop, 1992; Wheatley, 1992; Zohar, 1997), which in turn, stems from findings in the natural sciences such as physics, chemistry, and biology (Prigogine and Stengers, 1984; Bohm and Peat, 1988), as well as from systems theory, mathematics (Lorenz, 1987; Mandelbrot, 1982), and cybernetics (Wiener, 1961).

Thus, as schematized in the preceding figure, the theory of self-regulated complex systems and particularly the principle of self-organization of these systems, originate from discoveries across various sciences studying complexity in nonlinear dynamic systems; from biology, physics, chemistry, mathematics (chaos theory), and cybernetics, to computer science and informatics, where the peculiar characteristics of these systems were meticulously discovered and studied (Goldstein, 1998).

FIGURE 1. SCIENTIFIC ROOTS



Source: Taken from Jeffrey Goldstein, 1998. 'Emergence as a construct: history and characteristics'. Emergence, Vol. 1 No. 1, p. 55.

Highlighted for the purposes of this work are irreducibility, unpredictability, non-linearity, negentropy (associated with the thermodynamics of disequilibrium), and above all, the principle of self-organization of these systems (See Monroy, 1997).

- Irreducibility refers to the knowledge circumstance of these systems as all integrated, as the whole presents different characteristics from the sum of its parts, so understanding their logic is not possible by studying their constituent elements separately.

- Unpredictability alludes to the impossibility of determining a priori the trajectory and drift of these systems, given the sensitivity they exhibit to initial conditions.
- Non-linearity manifests the non-proportional relationship in the increase or decrease of the value of a variable concerning one or more other variables.
- Negentropy, contrary to the degree of entropy –thermal disorder– is a measure that determines the degree of order exhibited or produced by these systems about their environment.
- The principle of self-organization has to do with the process that self-regulated complex systems autonomously and randomly follow to minimize their entropy, in other words, to avoid disappearing into chaos.

Now, several scientific contributions stand out in the development of the complexity paradigm. For example, the synergetic school founded by German physicists is the first to describe the principle of self-organization as a parameter of order, by stating that the system must be seen as an integrated whole that tends to maintain a sense of identity over time and that this coherence or emergent order is reflected by expanding and integrating the lower level of its particular components into a higher-level unit, hence the precept that the whole is more than the sum of its parts (Haken, 1981).

The chemist Ilya Prigogine (1984), by studying the thermodynamics of disequilibrium, demonstrated the process of self-organization in the unique behavior of certain structures called dissipative structures[99]. Indeed, dissipative systems have the ability to import energy from their external environment and export or dissipate entropy—disorder—outside the system. In other words, they convert free energy into more elaborate forms of internal construction, transporting thermal disorder out of the system. Moreover, the result of this is what makes the continuous evolution of the system possible (Harvey & Reed, 1996).

In the field of mathematics, the study of deterministic nonlinear dynamic systems gave rise to a very important theory, the theory of chaos. This theory is defined as the qualitative study of the unstable and aperiodic behavior of nonlinear, deterministic dynamic systems (Kellert, 1993). It is precisely this theory that more deeply explains the "chaotic"[100] behavior of such systems and emphasizes the phenomenon of the strange attractor that occurs within them, a point that exerts a radial attractive force in a nonlinear manner, producing aperiodic and irregular trajectories in objects within its influence horizon. Paradoxically, this phenomenon makes the emergent process of self-organization possible (Lorenz, 1987; Mandelbrot, 1982).

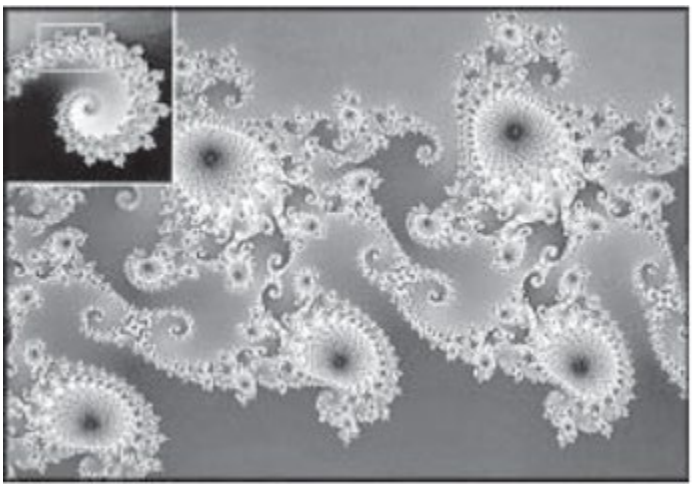
[99] The scientist Prigogine and his colleagues won the Nobel Prize for proving that under appropriate conditions, certain chemical systems called dissipative structures pass through randomness to evolve towards higher levels of self-organization. Here, the different levels and stages of evolution are irreducible to one another, as the transitions between them are characterized by symmetry breaks. This simply means that they are not equivalent to new arrangements of the same material, but rather represent a new creative twist. (Prigogine and Stengers, 1984).

[100] Chaos or chaotic behavior is defined as a type of order without periodicity, different from an absolute state of disorder (Monroy, 1999).

Thus, complex self-regulated systems are understood by this theory as systems capable of changing over time in a nonlinear manner and exhibiting a "chaotic" behavior that is impossible to predict. This behavior occurs in a space composed of two zones and a boundary between them: a stable zone where any disturbance causes the system to return to its initial state, and an unstable zone where a small disturbance takes the system far from its initial or equilibrium point, generating divergence.

However, the particularity of these systems leads them to operate at the boundary between both zones, on the edge of chaos. Here, the pattern of movement or family of trajectories is defined as the strange attractor that generates a new order, achieving self-organization. This pattern, incidentally, has the property of being a fractal[101], meaning it presents the same structure regardless of the scale of observation (Rosenhead, 1998). See Figure 2.

FIGURE 2. FRACTAL



Source: Taken from James Gleick's book, 1994. Chaos: Making a New Science. Editorial Seix Barral, Barcelona.

Then, this creative twist is something entirely new since it presents characteristics not observed at the level of the system's constituent elements. Although it is assumed to be neither predictable nor deducible from the particular level of its components, it exhibits internal coherence by appearing as an integrated whole.

Therefore, the principle of self-organization, implicit in chaotic behavior, is defined as the ability of living organisms to organize themselves, that is, as the aggregate ability to spontaneously form systems or create structures as a result of the interrelation of their members (Maturana & Varela, 1980; Tasaka, 1999).

Thus, the order of its structure and functions is not imposed by the environment, as this capability implies a degree of autonomy to establish its dimensions according to internal organizational principles that do not depend on environmental influences. This does not

[101] A fractal is a figure or process that exhibits a similar structure despite indefinitely changing the scale of observation. Self-similarity is present in a wide variety of phenomena.

mean that these systems are isolated from their surroundings, as they constantly interact with them, but rather that this interaction does not determine their internal organization (Jantsch, 1980). It should be noted here that there are two phenomena in the process of self-organization: self-renewal and self-transcendence.

Self-renewal refers to the ability of complex systems to continuously renew and recover their components while maintaining the integrity of their overall structure. Self-transcendence is the ability to creatively surpass physical and mental limits through processes of learning, development, and evolution (Capra, 1982).

Therefore, self-organization is a complex capacity that includes multiple elements that can be integrated (Etkin and Schvarsten 2000):

a) Operating under different conditions from those of origin without losing continuity or cohesion among the parts;

b) Autonomy, in the sense that the system has its own governing units;

c) Maintaining identity traits in the face of disturbances from the surrounding environment;

d) Self-production, as the social system internally selects and carries out the activities it needs to continue operating, including the selection of its goals;

e) Presence of internal control processes by which the system's operations are regulated and the organization's boundaries are delineated;

f) The system's ability to perform its structural renewal when crises and catastrophes occur.

While the construction and development of this paradigm, to this day, focuses on the similarities observed in nonlinear dynamic systems, such as open systems that do not follow the predictable entropy path or the disappearance of closed systems, they move in patterns on the edge of chaos, generating higher-level systems as a result of the self-organization process.

THE ORGANIZATION AS A SELF-ORGANIZED COMPLEX SYSTEM

Firstly, when adopting the complexity paradigm as an analytical framework in the study of organizations, the vision of the organizational world is as an integrated and indivisible whole, specifically as a self-regulating complex system.

Secondly, organizations are understood as nonlinear dynamic systems where people do not behave according to the economic man or rational optimizer model, but rather change their behavior by collectively learning from their experiences (Brown & Eisenhardt, 1997; Kelly & Allison, 1999). The third peculiar aspect is that these systems, as open systems, do not follow the predictable entropy path or the disappearance of closed systems but move in patterns on the edge of chaos, generating higher-level systems as a result of the self-organization process.

Fourthly, organizations are nonlinear dynamic systems that do not reach equilibrium points. They are composed of independent agents whose behaviors vary according to their social, psychological, or physical rules. Therefore, the needs and desires of the agents are not homogeneous, so their objectives and behaviors may conflict and, push them to adapt their behaviors to each other. Fifthly, equilibrium is neither the end nor the destination of organizations. Simply put, as open systems, they are associated with the environment and use disequilibrium to avoid deterioration (Wheatley, 1992; Brown & Eisenhardt, 1997).

In summary, organizations as self-regulating complex systems are defined as integrated wholes whose properties cannot be reduced to those of the smaller units. They are nonlinear dynamic systems with the capacity for learning and self-transcendence, and thus the forms they adopt are not rigid structures but flexible manifestations of underlying processes (Capra, 1982).

It is worth noting that the complexity paradigm applied to the study of organizations is still in its early stages. In fact, the use of its characteristics, and specifically the principle of self-organization as an autonomous process of order creation, is recent. Research in this area essentially began in the 1990s.

Although a significant number of studies have been generated, they range from those that use this paradigm merely as a metaphor (Fuller, 1999; Harvey & Reed, 1996; Stacey, 1995; Waldrop, 1992; Wheatley, 1992; Tsoukas, 1998) to those attempting to operationalize its dimensions (Brown & Eisenhardt, 1997; Kelly & Allison, 1999; Tasaka, 1999). Recently, Guastello (1998) has used some characteristics of self-regulating complex systems as an analogy to understand leadership, particularly the behavior of emergent leaders in groups.

Similarly, there has been a start in studying the network as a self-organized organizational structure (Goldstein, 1999). Additionally, there have been several attempts to revisit the phenomenon of negentropy or operation at the edge of chaos in the study of organizational strategy, aiming to generate evolutionary patterns (Brown & Eisenhardt, 1997). However, there is still much ground to cover.

CONCLUSIONS

The complexity paradigm will allow us to develop organizational concepts that are closer to reality by viewing organizations as patterns of relationships sustained through human interaction processes, with the capacity for self-renewal and self-transcendence. The advancements in the construct of self-regulating complex systems have opened the black box that obscured the understanding of the self-organization process and provide a theoretical and methodological framework in construction for its study within the organizational realm.

In summary, the theory of self-regulating complex systems, in general, and the principle of self-organization, in particular, offer academics and managers a new way to understand organizational phenomena, because conflict, ambiguity, and disorder are the same as those present in the dynamics of any organization, but they are managed differently. Instead of

imposing a predetermined order from the outside, the richness of divergent forces is experienced from within as part of a complex process of meaning generation that results in a new, self-generated order.

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