

Chaos and Complexity

An Overview of the ‘New Science’ in Organization and Management

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Abstract

This conceptual contribution presents an English-literature based overview of the chaos and complexity paradigm with a prime focus on organization and management. Some basic concepts, methods, and techniques for the diagnosis and design of so-called ‘chaordic enterprises’ are explored, in which emphasis is put on the analysis of wholes in terms of a synthesis of parts (i.e., holons), and in which the research goal is not to determine the largest common denominators, but rather to discover the weak signals as indicators of a new future. Also, it points to the analysis of (real time) dynamical instead of static phenomena, and it asks for the ability to trace emergent processes which substantiate on the basis of intensive interaction of the parts. Because the chaos-and-complexity field in organizations and management is still in its infancy, the goal is to systematically document the development of the new paradigm to date, to evaluate its status as a scientific approach, and to highlight some methodological issues.

Keywords: Chaos, complexity, nonlinear dynamics, chaord, chaordic enterprise, chaordic systems thinking, new science, emergence, coherence, connectivity, holon, holonic capacity, complex adaptive systems, self-organization, uncertainty, unpredictability, management

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Introduction

Chaos and complexity are indications for an emerged new paradigm in Management Science. Its key words principally refer to nonlinear models, discontinuous developments, uncertainty, and unpredictability. Self-organization, coherence and emergence are important themes. Chaos and complexity have firm roots in the ‘hard’ sciences – mathematics, physics and chemistry. The social sciences joined at a much later stage. The field of management was among the last to embrace the new paradigm, at the end of the eighties of the previous century.

Although chaos theory was the initial term, ‘complexity science’ is increasingly used as a label to identify the field. The ‘New Science’ – as both propagators and commentators frequently call the paradigm – will not replace older approaches, but rather transcend them, leave them as ‘special cases’ that cover relatively stable states, and doing that extremely well! Steve Maguire and William McKelvey (1999: p. 30) assert:

“CEOs need both old and New Science: (...) Not only do some parts of the organization need to be stabilized so that others can ‘design around’ them (indeed this is complexity – if whatever emerges then immediately dissipates itself on too fast a time scale, this appears as chaos to an observer), but these transient pockets of stability could be very likely behave in ways that are amenable to simple-rule explanations and managerial tools based on simple-rule understandings.”

Steve Maguire and William McKelvey (1999: p. 30)

This contribution will focus on the development of the ‘New Science’, sketching its historical lines, and explicitly zooming in on chaos and complexity in organizations and management. As far as validity is concerned, an important limitation of this study is that it almost completely was based on English-language literature, which might have distorted the chronology of events to some extent. Although completeness was not the intention, a serious attempt has been made to document its development by exploring the roots, describing the different threads, and building a database with detailed, double-checked literature references.

1 - Some Important Landmarks in the Development of Chaos Theory

Chaos is an important scientific discovery at the close of the Second Millennium. Huajie Liu confirms this field has literally exploded:

“In the past two decades, with the publication of more than 7200 papers and 260 books, the discovery of chaos in nonlinear dynamics has made an overwhelming impact on many disciplines, including mathematics, mechanics, computer science, biology, ecology, astronomy, engineering, economics, art, and of course philosophy.”

Huajie Liu (1999: p. 1)

According to Ralph Abraham (1996), chaos theory is a popular pseudonym for dynamical systems theory, a classical branch of mathematics. To give a full-blown overview of the development of chaos theory is beyond the scope of this paper. But some systematic inquiries into its roots might help the reader to better understand the scope and significance of the paradigm.

Already in the late eighteen- and early nineteen hundreds scientists started to discover anomalies in newtonian ‘normal science’ while initiating the field of nonlinear dynamics. Henri Poincaré (1892) was among the first to abduct deterministic chaos in a study of the movement of planets (Poincaré, 1892). Marston Morse (1921) and George Birkhoff (1922) elaborated the concept of discontinuous development. Balthazar van der Pol and Jan van der Mark (1927) pioneered in empirically observing bifurcation by accidentally hearing the ‘strange noises of chaos’ while testing an electronic tube circuit. Norman Levinson (1949) proved the possibility of an “attracting chaotic solution with continuous power” (quote by Liu, 1999). On the basis of this, Steven Smale developed the ‘horseshoe’ concept (Smale, 1967), and David Ruelle and Florus Takens finally articulated the ‘strange attractor’ (Ruelle & Takens, 1971) – a complex pattern that keeps recurring, but never repeats in exactly the same way – which serves as a key construct in chaos theory. James Yorke is said to have coined the term ‘chaos’ as being a mathematical concept in nonlinear dynamics to delineate systems that vary according to precise deterministic laws but appear to behave in a random fashion (Li & Yorke, 1975). However, Huajie Liu (1999) reports that Robert May used the term at an earlier point in time, in his 1974 article in *Science*, that Ilya Prigogine suggested the term ‘entropy chaos’ already in the beginning of the seventies (Glansdorff & Prigogine, 1971), and that Norbert Wiener (1938/1948) – who gave Cybernetics its name – preceded both authors by writing about different sorts of chaoses: ‘homogeneous chaos’, ‘one-dimensional chaos’, ‘multidimensional chaos’, ‘pure chaos’, ‘discrete chaos’, and ‘polynomial chaos’ (listing by Liu, 1999, p. 3).

In his “*Brief History of the Concept of Chaos*” Huajie Liu (1999: p. 5) emphasizes that two developments have been crucial for the development of chaos theory: “One is the KAM theorem of conservative systems [delineated by Andrei Kolmogorov in 1954 which was subsequently proved in the 1960s by Vladimir Arnold (1963) and Jürgen Moser (1962) – FVE], and the other is E. Lorenz’s weather model of dissipative systems”. KAM is a theorem in nonlinear dynamics that specifies the conditions under which chaos is confined in extent to form a kind of ‘doughnut-shaped’ surface in phase space. The second asset is the ‘Butterfly Effect’ – named after its attractor image – which is the nickname for a phenomenon that Edward Lorenz observed during his pioneering computer simulations of weather systems back in the sixties: Minuscule deviations in the data entry – slightly over .0001 – produced totally contrasting weather patterns over time (Lorenz, 1963a/b). Initially, his colleagues thought of an error of some kind; the infancy of the computer could be a reason for these anomalous results. However, in the middle of the eighties it became clear that any weather forecasts exceeding five days are principally impossible no matter how much additional computing power is spent. Long-term prediction of the behaviour of complex systems is unfeasible due to its ‘Sensitive Dependence on Initial Conditions’ (SDIC), as the ‘Butterfly Effect’ became officially named. According to Liu (1999) SDIC was already hypothesized and described by James Maxwell in 1873, Jacques Hadamard in 1898, and Henri Poincaré in 1908!

A number of conceptual developments could be seen as kind of ‘preludes to the chaos and complexity symphony’. For instance, the Belgian mathematician Pierre-

Francois Verhulst derived a model of restricted growth from the unrestricted growth function, a forerunner of the ‘logistic growth curve’ (Verhulst, 1841); the philosopher Stephen Pepper already wrote about ‘emergent change’ back in 1927 (Pepper, 1927). Jan Smuts from South Africa invented the word ‘holos’ – which stands for a total, a tendency of the universe to build units forming a whole, and of increasing complexity – or ‘Gestalt’ as Wolfgang Köhler (1929) called it. Smuts already wrote about ‘holism’ as early as in 1926 (Smuts, 1926). Forty years later Arthur Koestler articulated a ‘holon’ as an entity that is both a whole and part of a bigger whole, at the same time (Koestler, 1967). Wilber (1984/1995/1996a/1998/2000) has further elaborated this construct into the concept of ‘holarchy’, a hierarchy of increasing wholeness. Wholeness is a central concept in chaos theory and complexity science. In France, René Thom developed the ‘catastrophe theory’, a mathematical treatment of continuous actions producing abrupt changes (Thom, 1972). Such ‘leap-like changes’ are characteristic of the new paradigm. Von Neumann constructed ‘cellular automata’ – discrete nonlinear systems whose behaviours are completely specified in terms of local relations (Van Neumann, 1951), further developed by John Holland, and extensively documented by Stephen Wolfram (1994/2002). Although the ‘fractal’ already was delineated by Gaston Julia in his famous paper “*Mémoire sur l'Iteration des Fonctions Rationnelles*” back in 1918, it could only be elaborated using computer graphics by Benoît Mandelbrot – who coined the term by the way – not before the seventies (Mandelbrot, 1977). He actually showed that strange attractors have fractal proportions. According to Ermel Strepp a fractal is a rough or fragmented geometric shape that can be subdivided into parts, each of which is (at least approximately) a reduced-size copy of the whole. Fractals are generally self-similar and independent of scale (Stepp, 1995).

Most before-mentioned developments were rather isolated events; the real ‘orchestrated’ chaos-and-complexity symphony started not before the second half of the seventies. A group nicknamed the ‘Chaos Cabal’ – a bunch of young scientists at the University of California at Santa Cruz – made path-finding contributions to the ‘New Science’, from 1977 onwards. This multidisciplinary circle – called the ‘Dynamical Systems Collective’ – consisted of Ralph Abraham, William Burke, James Crutchfield, Doyne Farmer, John Guckenheimer, Michael Nauenberg, Norman Packard, and Robert Shaw. They published in both professional and popular journals about the ‘New Science’ (see for instance Crutchfield et al., 1980/1986; Guckenheimer & Holmes, 1983). Other developments also set the stage for the paradigm shift. In population biology chaos research was focused on the bifurcation diagram or ‘logistic difference equation’ (Li & Yorke, 1975; May, 1976). Mitchell Feigenbaum (1978/1979) discovered a constant that was present in these functions. Ilya Prigogine specialised in the study of the irreversible role of time in the physical sciences and in biology (Prigogine, 1947). He developed the theory of dissipative structures (Glansdorff & Prigogine, 1971; Nicolis & Prigogine, 1977), and consequently, he undisputable influenced the development of chaos in the before-mentioned fields (Prigogine & Stengers, 1984; Prigogine, 1997).

The Santa Fe Institute (SFI) in New Mexico performed an important role in the further development and consolidation of the paradigm. SFI, founded in 1984, was set up as: “a private, non-profit, multidisciplinary research and education center, (...) pursuing emerging science” (SFI, 2003). Well-known SFI members in the eighties and nineties were Philip Anderson, Chris Langton, John Holland, and Stuart Kauffman. Kauffman (1991) developed the concept of ‘antichaos’ in biology: The idea is that systems at the ‘edge of chaos’ can make qualitative leaps; that: “some

very disordered systems spontaneously ‘crystallize’ into a higher degree of order” (p. 79). Chris Langton (1997) developed the Complex Adaptive Systems (CAS) concept and the Swarm simulation model (Minar et al., 1996). John Holland continued his ‘artificial networks with metaphysical neurons’, which were called ‘genetic algorithms’ (Holland, 1992). Langton (1997) characterizes a CAS as a system which: “often consists of hundred or thousands of autonomous agents interacting with each other in the context of a dynamically changing environment. The Swarm Simulation System is a general purpose modeling package for the investigation of such concurrent, distributed systems” (Langton, 1997, p. 1). Paul Plsek (1997: p. 2) defines a Complex Adaptive System as “A system of individual agents, who have the freedom to act in ways that are not always totally predictable, and whose actions are interconnected such as that one agent’s action changes the context for other agents.” According to Kevin Dooley (1996, p. 1): “a CAS behaves according to three key principles: 1) Order is emergent as opposed to predetermined; 2) The system’s history is irreversible; and 3) The system’s future is often unpredictable.” Stuart Kauffman (1993) developed the NK ‘adaptive fitness landscape model’, a kind of playground for experimenting with genetic algorithms. It is a sort of ‘trampoline’ – N stands for the number of genes, K for the dependency or interaction between genes – a surface with elastic hills and valleys on which many different agents travel.

To conclude, the chaos and complexity paradigm is well on its way in the second half of the eighties. James Gleick, a science journalist, contributed much to the diffusion of the emerged paradigm towards the general public by putting out his 1987 book, entitled: “*Chaos: Making a New Science*”. In this popular publication Gleick tells the well-known ‘success stories’ in a clear and playful way: The ‘Butterfly effect’; models of wild-life populations (predator/prey ecologies); and all kinds of fractals as images of chaos: i.e., The Mandelbrot and Julia sets, Jupiter’s Great Red Spot, ferns and snowflakes, a hurricane, and the mysterious ‘chemical clocks’ (Beluzov-Zhabotinsky reaction). His conclusion is both straightforward and inevitable:

“Now that science is looking, chaos seems to be everywhere. A rising column of cigarette smoke breaks into wild swirls. A flag snaps back and forth in the wind. A dripping faucet goes from a steady pattern to a random one. Chaos appears in the behaviour of the weather, the behaviour of an airplane in flight, the behaviour of cars clustering on an expressway, the behaviour of oil flowing in underground pipes. No matter what the medium, the behaviour obeys the same newly discovered laws.”

James Gleick (1987: p. 5)

However, in 1987 nothing was said about chaos in organizations. Indeed, we had to wait a few more years before the new paradigm diffused into the business and management domains as well.

2 – Chaos and Complexity: Some Definitions

As already said in the introduction, chaos theory is a popular pseudonym for dynamical systems theory, a classical branch of mathematics. Ralph Abraham clarifies: “As there are two flavors of dynamical systems – continuous and discrete –

there are also two chaos theories” (Abraham, 1996: p. 1). Stephen Kellert (1993) defines chaos as the qualitative study of unstable a-periodic behaviour in deterministic nonlinear dynamical systems. Huajie Liu (1999) describes classical chaos as: “recurrent, random-like, and a-periodic behaviour generated from deterministic nonlinear equations with sensitive dependence on initial conditions of the system” (p. 9). According to Liu, this definition contains the following basic characteristics: 1) Determinism; 2) Nonlinearity; 3) Sensitive Dependence on Initial Conditions; and 4) A-periodicity. He argues that these properties are necessary, but not sufficient for the occurrence of chaos. Therefore, he added a fifth feature: 5) “Some stability with some tension and boundness”. Devaney (1986) defines a function as chaotic if it has sensitive dependence on initial conditions, it is topologically transitive, and periodic points are dense. In other words, it is unpredictable, indecomposable, and yet contains regularity (Stepp, 1995).

As the definition of complexity is concerned, Steve Maguire and William McKelvey state that there are many kinds of complexity, and that deterministic chaos is only one of them. They distinguish five sorts: Random complexity, probabilistic complexity, deterministic chaos, emergent complexity and newtonian dissipative structures (Maguire & McKelvey, 1999: p. 55). Waldrop (1992) describes complexity mainly contextually as the name given to the emerging field of research that explores systems in which a great many independent agents are interacting with each other in a great many ways. Murray Gell-Mann (1994/1995) is more elaborate in his definition of what he calls ‘effective complexity’. He distinguishes between computational complexity, algorithmic information content, a set of entity’s regularities, the amount of mutual algorithmic information, and time measures like logical depth. Unfortunately, despite great efforts, any consensus about the complexity definition was not achieved thus far. Even following Bruce Edmonds’ extensive bibliography of measures of complexity (Edmonds, 1996), a generally accepted complexity definition still is lacking. Heylighen complains:

“Complexity has turned out to be very difficult to define. The dozens of definitions that have been offered all fall short in one respect or another, classifying something as complex that we intuitively would see as simple, or denying an obviously complex phenomenon the label of complexity. Moreover, these definitions are either only applicable to a very restricted domain, such as computer algorithms or genomes, or so vague as to be almost meaningless.”

Francis Heylighen (1996: p. 3)

However, Heylighen (1996) suggests there is some communality in the different concepts of complexity: Both ‘distinction’ (variety, heterogeneity; leading to chaos) and ‘connection’ (redundancy, dependency; leading to order) go hand in hand. So, he is positioning complexity: “in between order and disorder, or, using a recently fashionable expression, ‘on the edge of chaos’ ” (Heylighen, 1996: p. 1-2).

3 – Initiating Chaos and Complexity in Organizations

As said before, chaos and complexity entered the management literature not before the end of the eighties. Ikujiro Nonaka pioneered in applying chaos to explain self-renewal in Japanese firms (Nonaka, 1988; Nonaka & Yamanouchi, 1989). Tom

Peters (1986) presented his handbook for a management revolution, Dudley Lynch and Paul Kordis (1988) metaphorically applied the attractor concept to the world of work, and Peter Senge (1990) published a book about nonlinear systems and the learning organization. Margaret Wheatley (1992) wrote an essay about *“Leadership and the New Science”*. In France, Raymond-Alain Thiétart and Bernard Forgues served as liaison persons in introducing the new paradigm to management science (Thiétart & Forgues, 1993/1995/1997).

Certainly, Dee Hock is the ultimate entrepreneurial pioneer of the chaos and complexity paradigm in management. Already in 1970, he founded VISA International – the credit card company – that became the first ‘chaordic’ (the term is an amalgamation of chaos and order) enterprise in the world (Hock, 1996a/b/1999). Hock defines a ‘chaord’ as follows:

“By Chaord, I mean any self-organizing, adaptive, nonlinear, complex organism, organization or community, whether physical, biological or social, the behaviour of which harmoniously blends characteristics of both order and chaos. Briefly stated, a chaord is any chaotically-ordered complex. Loosely translated to social organizations, it would mean the harmoniously blending of intellectual and experiential learning.”

Dee Hock (1996b: p. 3)

Hock describes the birth of VISA International: “In 1968, the VISA community was no more than a set of beliefs and a vague concept. In 1970 it was born. Today, twenty-nine years later, its products are created by 22,000 owner-member financial institutions and accepted at 15 million merchant locations in more than 200 countries and territories. Three-quarters of a billion people use VISA products to make 14 billion transactions producing annual volume of \$ 1.25 trillion – the single largest block of consumer purchasing power in the global economy. VISA has grown a minimum of 20 percent and as much as 50 percent compounded annually for three decades, through the best and the worst of times, with no end in sight” (Hock, 1999, p. 189). Hock also founded a non-for-profit organization to stimulate the new thinking (cf., The Chaordic Alliance, 1998; The Chaordic Commons, 2003).

In Europe, Ralph Stacey was among the first who systematically elaborated a conceptual chaos and complexity approach for the management field (Stacey, 1991/1992/1993/1995/1996). He founded the Complexity and Management Centre (CMC) at the Business School of the University of Hertfordshire, United Kingdom, in 1995, and pioneered in adapting the Complex Adaptive Systems approach to organizations. On this basis he developed the so-called ‘legitimate and shadow systems’, two parallel networks that can be identified in organizations, both of which are driven by nonlinear feedback to evolve adaptive behaviours. Managers control the legitimate system – the formal organization. However, the shadow system – the informal organization – cannot be controlled by anyone. The shadow system typically shows stronger interconnections between agents than the legitimate system does; it forms a basis for organizational creativity. By hypothesizing this dual structure Stacey influenced significantly the development of complexity in management in the early nineties.

Also in Europe, professional networks increasingly connect interested stakeholders. For instance, the UK based ‘Manufacturing Complexity’ network (Manufacturing Complexity Network, 2004) – operating since 1998 – is explicitly

aimed at the application of complexity to manufacturing organizations (McCarthy et al., 2000). The European Chaos and Complexity in Organizations Network brings together organization and management researchers, since 2000 (ECCON, 2004).

In the USA, Michael Lissack, a former investment banker and manager, pioneered with initiating the COMPLEX-M discussion group, a web forum about complexity and management, in 1995 (COMPLEX-M, 2004). He chaired the Organization Science Related Programs Unit at the New England Complex Systems Institute in Cambridge, Massachusetts, in 1997, and continued this initiative from the Boston based Institute for the Study of Coherence and Emergence (ISCE), since 1999. Also, he started the Journal *Emergence*. Lissack organized many conferences on the subject, and produced an avalanche of books and articles about complexity and management (Lissack, 1996/1997a/b; Lissack & Gunz, 1999; Lissack & Roos, 1999/2001).

Central in Lissack's approach to complexity is the concept of 'coherence'. According to Lissack & Roos (1999: p. 2) coherence is "an alignment of context, viewpoint, purpose and action that enables further purposive action." Coherence plays a central role in leadership:

"Finding coherence, enabling coherence, and communicating coherence are the critical tasks of management in the era of the next common sense. We call this mastering complexity through coherence. (...) we have to have an understanding at a level separate from the actions. Such an understanding will encompass both purpose and identity. (...) By purpose we mean the reason for being or doing: Why am I doing what I am doing? By identity we mean an evolving, moving intersection of the inner and outer forces that make each of us who we are (...)."

Lissack & Roos, (1999: p. 5-6)

Another important construct of Lissack's complexity in management school is 'emergence', even so much that he chose it as a name for the journal. Goldstein (2000: p. 7) states: "Emergent patterns, structures, and properties are characterized by a radical novelty in comparison to properties and patterns of the components out of which emergence arises." Emergence results from self-organization, and is unpredictable (Goldstein, 1999; Bergmann Lichtenstein, 2000). Terry Jones joked: "Emergence is what happens when lots of fish get together" (Jones, 1995).

At the turn of the 20th century, complexity is a 'hot' topic at management conferences, for instance, 'Managing the Complex' in Toronto, 1998 (Lissack & Gunz, 1999), and in Boston, 1999 (Lissack, 1999); the panel discussion at the Academy of Management Meeting in Toronto, 2000 (Lissack et al., 2000); and the 17th EGOS Colloquium in Lyon, Sub-Theme on Complexity, 2001 (McKelvey & Thiétart, 2001).

4 – The Current Situation

As was already the case in other academic disciplines, the 'New Science' is also booming in the field of organization and management, at the moment. Chaos and complexity have captured a significant share of the management literature market in less than a decade. According to Michael Lissack (1999: p. 3): "Books on the topic of

complexity and management have become numerous enough to fill several bookshelves in even a non-specialist bookstore.” At least three Special Issues were published in academic journals, in the last four years:

- 1) – The Journal *Emergence* published a special issue entitled: “*Complexity and Management: Where are We?*”, with Steve Maguire and William McKelvey as guest editors, in 1999,
- 2) – The *Journal of Organizational Change Management (JOCM)* put out a guest issue with the title: “*Chaos: Applications in Organizational Change*”, with Laurie Fitzgerald and Frans van Eijnatten as guest editors, in 2001,
- 3) – The Journal *The Learning Organization (TLO)* published a special issue entitled: “*Implications of Complexity and Chaos Theories for Organizations that Learn*”, with Peter Smith as guest editor, in 2003.

Also, Stacey’s Complexity and Management Centre put out a series of six complexity books in less than two years:

- 4) – “*Complexity and Management: Fad or Radical Challenge to Systems Thinking?*”, Ralph Stacey, Douglas Griffin, and Patricia Shaw,
- “*Complex Responsive Processes in Organizations: Learning and Knowledge Creation*”, Ralph Stacey,
- “*The Paradox of Control in Organizations*”, Philip Streatfield,
- “*Complexity and Innovation in Organizations*”, José Fronseca,
- “*The Emergence of Leadership: Linking Self-Organization and Ethics*”, Douglas Griffin,
- “*Changing Conversations in Organizations: A Complexity Approach to Change*”, Patricia Shaw.

All these titles suggest, that significant progress was made in applying the ‘New Science’ to organizations and management in the last decade.

Ad 1. In the 1999 *Emergence Special Edition* 50 reviewers commented on some 32 books on the topic of complexity and management. Four editors subsequently reviewed these commentaries. The results show a shaded picture of the development of the field to date. According to Steve Maguire and William McKelvey (1999) a commonality in all those publications is the criticism of both newtonian deterministic science, and the dominant command-and-control structures in management. However, in the suggested alternative approaches concepts stemming from dynamical systems theory are rather loosely interpreted most of the time; chaos and complexity are merely used as metaphors. At the same time they observe, that – despite the many new endeavours – there is a basic lack of empirical research, running the risk that the chaos and complexity paradigm will crash as a fad, as a next hype in management:

“Intellectual fads ride the tide of exuberant application of new ideas, mostly by consultants, and soon sink into oblivion, absent quality research. Consulting applications based on nothing but the hottest, most recent intellectual novelties suffer quick fates once a new

marketing tool appears on the horizon – unless research findings corroborate the lasting efficacy of the older idea. From what the reviews indicate, as well as our own reading of the trade books, New Science is well on its way toward short-lived faddism unless serious research shows there is more than metaphor to chaos theory and complexity science applications, and that CEOs using New Science produce more competitively advantaged firms than CEOs who do not.”

Steve Maguire and William McKelvey (1999: p. 54-55)

Ad 2. In the 2001 *JOCM Special*, Chaos is defined as a lens or worldview – a metapraxis or metaview of reality, a position that was already articulated in some earlier papers (Fitzgerald, 1994/1996/1997a; Fitzgerald & Van Eijnatten, 1998; Van Eijnatten, 2001/2003/2004). Following Hock (1998), a ‘chaordic system’ is defined as:

“A complex and dynamical arrangement of connections between elements forming a unified whole the behavior of which is both unpredictable (chaotic) and patterned (orderly)...simultaneously.”

(Laurie Fitzgerald, 1997a: p. 1)

“Therefore, it seems (...) apropos to refer to Chaos as the science of chaord (obviously, a combination of chao-s and ord-er) or of chaordic (...). Although every organization (...) is by definition a chaord, we suggest that the term ‘Chaordic Enterprise’ be reserved for (...) enterprises in which the two (...) properties (...) are maintained in dynamical balance by virtue of an intentional process of management.”

Laurie Fitzgerald & Frans van Eijnatten (1998: p. 264)

“Chaos is neither a model nor a theory. Rather, it is essentially a metapraxis – a fundamental way of seeing, thinking, knowing and being in the world. (...) Chaos is prior to the development of theory and models.”

Laurie Fitzgerald & Frans van Eijnatten (2001a: p. 403)

Five chaordic properties are distinguished (Fitzgerald, 1997a/b/2001): Consciousness, Connectivity, Indeterminacy, Dissipation, and Emergence. These five properties are assumed to have explicit implications for designing a chaordic enterprise: 1) Consciousness: When you want to change the organization, you have to change its ‘organizational mind’; 2) Connectivity: Think globally, act locally; 3) Indeterminacy: The answer to the ‘how’ of change must be made up as you go; 4) Dissipation: Change before it is time to do so; and 5) Emergence: Managers have to let go of command and control (Fitzgerald, 1996/2001).

Based on Wilber (1995/1996a/b), a central concept is ‘holonic capacity’ which is defined as the ability of a holon – in this case an individual or group who is both autonomous and dependent at the same time – to operate with greater mindfulness, expanded awareness, control- and response-ability (Fitzgerald & Van Eijnatten, 1998). This greater level of depth is believed to develop following the use of dialogue

(Bohm, 1980/1987; Gerard & Teurfs, 1995; Ellinor & Gerard, 1998; Gerard & Ellinor, 1999; Isaacs, 1999), and multilogue (Hoogerwerf & Poorthuis, 2001; Van Eijnatten & Hoogerwerf, 1999/2000; Zaitsev, 1998; Zaitsev & Artemova, 1998). An empirical study about the implementation of dialogue and multilogue as the main modes of communication in a Dutch manufacturing firm shows some support for this claim (Van Eijnatten & Van Galen, 2001/2002). Another important concept is 'emergent leadership', which is seen as a discretionary role open for every employee, rather than a fixed privilege of a particular hierarchical position in the organization.

In JOCM's special issue Lisa Irvin presents an ethical approach to Chaos (Irvin, 2001), in which the 'ethic of self-preservation' is replaced by the 'ethic of connectivity', which primarily focus on relationships: "recognizing no boundary between self and other" (Irvin, 2001: p. 375).

In a reflective article the guest editors articulate the primacy of Chaos over complexity:

" (...) the term complexity has been used herein in the more general sense of an attribute of a phenomenon, specifically that of the chaordic system. We recognize that this position deviates significantly from that of a number of organizational theorists who argue that complexity should be accorded the status of a science in its own right. For instance, Lissack & Roos (1999: p. 10) define complexity as " (...) the collection of scientific disciplines (...) concerned with finding patterns among collections of behaviours or phenomena (...) across a multitude of scales in an effort to detect their 'laws' of pattern generation or 'rules' that explain the patterns observed." Well as that may be, no evidence has been offered to support the tacit contention that complexity has emerged from its original status as a characteristic of system behaviour into a metapraxis comparable to Chaos."

Laurie Fitzgerald & Frans van Eijnatten (2001a: p. 407)

'Chaordic Systems Thinking' (CST) is proposed as the way forward (Fitzgerald & Van Eijnatten, 2001a). CST is a way of thinking and subsequently, an approach to designing a complex organizational system that recognizes the enterprise not as a fixed structure, but as 'flow' (Van Eijnatten & Fitzgerald, 1998; Van Eijnatten & Hoogerwerf, 2000; Van Eijnatten, 2001). The JOCM special also hosts a detailed glossary of chaordic terms and phrases (Fitzgerald & Van Eijnatten, 2001b).

Organizations seen as 'chaordic systems' may go through different phases, ranging from more orderly to more chaotic. In those phases different patterns or 'attractors' can be distinguished. The 'status-quo' situation might represent instances of the dominant attractor ('old doing, old thinking'), while the desirable dreamed-of situation might represent any 'weak signals' of a new attractor ('new doing, new thinking'). A typical successful transformative change or 'qualitative leap' is defined as a transition from the old attractor into a new attractor, which change might result rather instantaneously instead of gradually (Van Eijnatten, 2003). In CST planning is primarily used for better priority setting in the present by means of 'holographic decision-making' (Van Eijnatten & Keizer, 2002; Keizer & Van Eijnatten, 2003).

Ad 3. The 2003 *TLO Special Issue* brings together diverse papers from different chaos and complexity frameworks, all of them focusing on the theme of learning.

Ralph Stacey sets the stage by affirming that learning is an activity of interdependent people (Stacey, 2003). Following the social behaviourist George Mead (1934) he argues that gesture and response are inextricable actions in the process of sense making. He sees organizations as “self-organizing patterns of communicative interacting and power relating between human bodies in the living present” (p. 330). Consequently, he defines learning as:

“ the emerging shifts in the patterning of human communicative interaction and power relating. Learning is emerging shifts in the thematic patterning of human action. Another way of saying this is to say that learning is the emerging transformation of inseparable individual and collective identities.”

Ralph Stacey (2003: p. 330-331)

Marie-Joëlle Browaeys and Walter Baets discuss the theme of cultural complexity (Browaeys & Baets, 2003). By quoting French authors – like Edgar Morin, Jean-Louis Le Moigne, Dominique Genelot, and Jean-Michel Larrasquet – they introduce an alternative constructivist approach to complexity thinking based on the dialogic principle, the principle of recursivity, and the hologrammic principle (Le Moigne, 1990; Morin, 1990; Genelot, 1998; Larrasquet, 1999). Browaeys and Baets see those principles predominantly as preconditions for organizational learning. As far as company culture is concerned, each individual employee is both worked by it, and is carrying it. The focus of this constructivist approach is on ‘representations’, i.e., mental models or personal constructions of the organization.

Saskia Harkema describes the innovation process at Sara Lee/Douwe Egberts as a CAS, a complex adaptive system consisting of interacting agents with cognitive schemes. For her: “organizational learning refers to the fact that individual knowledge becomes collective and shared. (...) The primary forces in this process are emergence and self-organization” (p. 344). To explore this hypothesis, she runs a simulation using a multi-agent model RePast, which is based on Swarm (RePast, 2000), where the agents were modeled in a hierarchy. Especially one of her results is worth noting in this respect: “A run of the model wherein senior managers were left out of the hierarchy showed that learning took place faster than in prior cases (...)” (p. 345).

Birute Regine and Roger Lewin focus on the topic of complexity and leadership (Regine & Lewin, 2000). In the TLO Special they report about a study on complexity and leadership (Regine & Lewin, 2003), wherein they interviewed 50 women leaders in the US, Canada, Australia and the UK, and discovered a ‘third possibility’: Those women showed leadership behaviour that may be best characterized by wholistic thinking, relational intelligence or knowing how and when to form networks, community building, and engaging in paradoxical ways of behaviour. To clarify this last ‘both...and’ trait the authors wrote:

“ ‘Paradoxical’ ways reflects the ability to contain both masculine and feminine qualities: to be both tough and empathic, flexible and orderly, patient and timely, diplomatic and candid, competitive and collaborative. Softer and stronger.”

Birute Regine and Roger Lewin (2003: p. 349)

Charlotte Shelton and John Darling suggest seven ‘quantum skills’ for continuous learning (Shelton & Darling 2003). They elaborate the abilities to see intentionally, to think paradoxically, to feel vitally alive, to know intuitively, to act responsibly, to trust life’s process, and to be in relationship. They claim that those skills: “enable leaders to surface and test their mental models and thus improve their capacity to learn” (p. 354), see also Shelton (1999) and Shelton & Darling (2001).

The last contribution in TLO’s Special is from Frans van Eijnatten, Maarten van Galen and Laurie Fitzgerald, and is about the same Dutch manufacturing firm as the one that was performing in JOCM’s special issue. The authors, who worked as a team in the project, also see learning as an activity of interdependent people, who are using ‘dialogue practice fields’. They conclude:

“By focusing on changing their system from the inside (orgmind-as-target) out, they have discovered and tapped into DMT’s previously unrecognized reservoir of holonic capacity.”

*Frans van Eijnatten, Maarten van Galen, and Laurie Fitzgerald
(2003: p. 366)*

Ad 4. The last significant development that is reported in this overview, is Stacey’s 2000/2002 CMC book series published by Routledge. These publications breathe a new life, and comprise a clear break with the past. Ralph Stacey made a remarkable conceptual leap in 1999, after which he and his associates completely re-furnished their complexity views. He himself reports about this remarkable transformation:

“I (...) wrote a book about complexity, that was published in 1996, in which I said we could think of organizations as complex adaptive systems. I no longer think that’s possible (...). I now think that the theory of complex adaptive systems is useful only as a source domain for analogies with human action. One can turn to the ideas of complex adaptive systems and then look at them as an analogy (...) an analogy means taking abstract relationships from one domain, without any attributes, and using them in another domain in which we have to supply the attributes. (...) That means we have to bring to it some theory about human psychology and human sociology. That is what colleagues and I have been doing (...). We have been trying to find ways to understanding ourselves – our actions and interactions – in terms of emergence and self-organization by taking these ideas as analogies to be understood in terms of particular theories of sociology and psychology.”

Ralph Stacey (2002: p. 29-30)

The result was an impressive book series about ‘complex responsive processes’ (Stacey et al., 2000; Stacey, 2001; Streatfield, 2001; Fronseca, 2002; Griffin, 2002; Shaw, 2002). The first book is probably the most crucial in the series. In it the focal point of disputation is causality. Like Alicia Juarrero (1999/2000) did, Ralph Stacey, Douglas Griffin, and Patricia Shaw (2000) explore different forms of causality. Central in their approach is change and human choice. They distinguish between Natural Law, Formative, Rationalist, Adaptionist, and Transformative Teleologies. These so-called ‘theories of causality’ enable diverse arenas for change and human

freedom of choice. For Natural Law Teleology change is basically a repetition of the past, while human choice is basically obeying natural laws: an optimizing mechanism. In Formative Teleology change is the unfolding of a macro pattern, which is known in advance, and in which there is no intrinsic human freedom. Rationalist Teleology recognizes human reasoning as the basic initiator of change, where human freedom is based on ethical universals: design and apply. Transformative Teleology sees micro interactions – forming and being formed by themselves – as potential ‘causes’ of change, and human freedom of choice arises in spontaneity. Adaptionist Teleology defines change as random variations in individual entities, filtered out for survival by natural selection, while human freedom of choice occurs only by chance. Based on this typology Stacey *et al.* (2000) claim, that conventional Open Systems Thinking contains a methodological error in the application of theories of causality with respect to human functioning in organizations. This flaw is characterized as a ‘Kantian split’ between Rationalist and Formative frameworks:

“The way both of these teleologies are applied [in conventional Open Systems Thinking - FVE] is as follows. Rationalist Teleology applies to the choosing manager (theorist, researcher, decision-maker), from whom the organization is split off as a ‘thing’ to be understood. The organization, that which is to be explained and operated on, is then regarded as an objective phenomenon outside the choosing manager (theorist, researcher, decision-maker), equivalent to a natural phenomenon, to which Natural Law or Formative Teleology can be applied.”

Ralph Stacey, Douglas Griffin, & Patricia Shaw (2000: p. 58)

So, in rationalist and formative frameworks the organization is seen as an exterior object that can be controlled like a machine, while the manager/designer sees her/himself as an intentional individual, actually making the choices which are to be imposed on the system. This criticism of conventional Open Systems Thinking is best summarized by the assertion that freedom is solely located in the manager, whereas workers are supposed to follow. According to Stacey *et al.* thinking in terms of mechanisms or systems (efficient cause as a feedback process) cannot be successful in explaining human freedom and participation. They state that complexity theorists combine Transformative Teleology with either Adaptionist or Rationalist Teleology. Stacey *et al.* suggest to avoid any split between causal frameworks in explaining human organization:

“(...) we will be arguing that any combination of the five causal frameworks immediately implies the kind of split upon which the dominant management discourse is built (...). This move increases the risk that notions from the complexity sciences will simply represent the current discourse in a new vocabulary. We will be arguing for the development of a perspective from Transformative Teleology on its own. We see it as encompassing other types of causality, not subordinated to, or in combination with, any other in a ‘both / and’ resolution of paradox. This means a clear move away from the way Systems Thinking is currently being used to understand human organization.”

As a second point Stacey et al. (2000) claim that conventional Systems Thinking basically is unable to create novelty, because – in line with Formative Teleology – the system's ultimate goal already is known in advance. This is another fundamental criticism of the dominant control paradigm.

The other five books are filling the gaps in the new picture very well. Book 2 (Stacey, 2001) is about learning and knowledge creation; book 3 (Streatfield, 2002) discusses the paradox of control; book 4 (Fronseca, 2002) treats complexity and innovation; book 5 (Griffin, 2002) elaborates leadership and ethics; and book 6 (Shaw, 2002) is about a dialogical approach to change. For Stacey and associates an organization is re-defined as a set of complex responsive processes of relating.

5 – Some Methodological Issues

A number of authors have emphasized the methodological consequences of a paradigmatic shift to chaos and complexity in organization and management (for instance Stacey, 1996/2001; Lissack, 1999; Gharajedaghi, 1999). Central to the chaos/complexity view is the emphasis on the system as an undivisible whole and part, at the same time (i.e., 'holon'), consisting of both exterior, interior, individual and collective holarchical dimensions (Wilber, 1995/1996a/1997/1998). Other important issues are the ability to trace emergent processes that substantiate on the basis of intensive interaction of the human parts; the analysis of (real time) dynamical instead of static phenomena; and the identification of weak signals instead of large common denominators. Jamshid Gharajedaghi presents a method for holonic, dynamical systems diagnosis (Gharajedaghi, 1999). This is a research technique for both analyzing and synthesizing, based on the work of Ackoff (1978), which essentially consists of the following three steps (p. 119/120):

- *Systems Analysis*: To develop a snapshot of the current system and its environment that describes their structural, functional, and behavioural aspects without making a value judgement,
- *Obstruction Analysis*: To identify the malfunctioning in the power, knowledge, wealth, beauty, and value dimensions of the social system,
- *Systems Dynamics*: To understand the interactions of critical variables in the context of the following: Time, the totality and the interactive nature of the change within the system, and the system's environment.

According to Gharajedaghi the three inquiries evolve iteratively, adding more and more details in each cycle. He suggests the use of pictorial representations. The results are synthesized into a number of categories and themes. This is called 'mapping the mess' (Gharajedaghi, 1999: p. 124). All kinds of interdependencies are distinguished: Multiple causes, time lags, circularity, and effects that stay after the cause has gone. Gharajedaghi's system's analysis is basically a heuristic process:

“Mapping the mess is the heuristic process of defining essential characteristics and the emergent property of the mess. It involves finding the ‘second-order machine’ residing within the system. This unanticipated consequence of the existing order produces paralyzing type II properties that create inertia, prevent change, and frustrate attempts to make significant improvements. To achieve an order-of-magnitude improvement in any system's performance, the second-order machine has to be recognized and dismantled. Exaggeration of the winning formula, combined with a possible change of game, more often than not will point to a set of seemingly innocent, simple, but deep-rooted assumptions that are the core of the second-order machine.”

Jamshid Gharajedaghi (1999: p. 125/126)

Often, the second-order machine is part of the organizational culture, deeply rooted in the organization's collective memory. It may appear that only a few simple assumptions are obstructing real progress in organizational transformation. Active engagement in both dialogue and multilogue may bring these beliefs to the fore (Bohm, 1980/1987; Gerard & Teurfs, 1995; Ellinor & Gerard, 1998; Zaitsev, 1998; Zaitsev & Artemova, 1998; Gerard & Ellinor, 1999; Isaacs, 1999; Van Eijnatten & Hoogerwerf, 1999/2000; Hoogerwerf & Poorthuis, 2001; Darsø, 2001). According to Linda Ellinor and Glenna Gerard, dialogue is:

“A way of conversation in which shared meaning is created among many. Learning is accomplished through inquiry into assumptions. Dialogue stresses the whole among the parts and focuses on the connections between them.”

Linda Ellinor & Glenna Gerard (1998: p. 21)

Opinions are expressed by talking – as too are views, conceptions and taken-for-granted assumptions concerning the task, work and organization. In dialogue, people have the opportunity to mirror their individual understanding and perceptions against those of others. Both parties speak at the same time as they think, and both hear immediately what is said. In this way, people obtain continuous, co-ordinated, mutual access to two subjectivities (‘mine’ and ‘yours’), resulting in inter-subjective proximity. This may develop into a mechanism for the aggregation of organizational members, resulting in the development of an organizational mind, and acting as a meta-agent. Then, there is an organization capable of action in a unified way, using its holonic potential (Fitzgerald & Van Eijnatten, 1998). Another appropriate tool for the qualitative analysis of, and writing about whole systems is the narrative method (Boje, 1995/2000a/b; Juarrero 1999/2000). Different voices may opening up multiple realities (Weil, 1996). An example of a management technique which explicitly take into account the wholeness characteristic of complex systems is called ‘holographic decision-making’ (Van Eijnatten & Keizer, 2002; Keizer & Van Eijnatten, 2003):

In holographic decision-making, the human process of decision-making takes a multidisciplinary instead of a monodisciplinary stand, including more aspects, at the same time; (...) follows an iterative instead of an instantaneous approach, in which degrees of freedom are

left open as long as possible (...); [and] (...) becomes a temporary instead of a definite endeavour. It becomes a successive approximation in which there is room for increased understanding, spontaneous reflections, and personal intuitions.

Jimme A. Keizer & Frans M. van Eijnatten (2003: p. 15)

A useful management technique for mastering the ‘emergent leadership’ role is the so-called ‘dolphin training’ (Lynch & Kordis, 1988; Fitzgerald, 2001). Ken Wilber (Wilber, 1995/1996a) provides a theoretical framework for holonic analysis, design, and development. These are just a few instances – among many – of methods and techniques for chaordic analysis, synthesis, and design, which are available, today.

6 – Conclusion

The chaos-and-complexity paradigm is well on its way in the field of organization and management. Different groups of researchers work systematically on its further advancement. Probably, Ralph Stacey and his CMC group have contributed most to the development of an authentic Chaos and Complexity in Organizations approach. According to the ‘new’ Stacey we should look at organizations not as homogeneous, but as *heterogeneous* complex adaptive systems. Actually, he wants to get rid of the term ‘systems’ altogether, because it puts managers/ researchers/ designers outside the unit of influence or study, of which they are an inseparable part. Therefore, he suggests to concentrate on complex responsive processes, only. A last quote from him concludes this overview:

“Peter Allen, from Cranfield University, shows convincingly that novelty can emerge only in a simulation in which there are differences in agents. It is only then that anything like human interaction emerges. (...) In fact these heterogeneous complex adaptive systems are pointing to a different kind of causality (...) that we call ‘transformative causality’ (...). In transformative causality, the iterations of interaction produce emergent patterns of behaviour that display continuity and transformation at the same time (...). Complexity sciences provide us with a demonstration of possibility, and with insights into the nature of nonlinear interaction among large numbers of entities. To me these insights (...) have to do with the dynamics of patterns of behaviour that are paradoxical (...). The questions then become: How would we think about organizations when we embrace paradox (...), instead of trying to eliminate it? How would we understand organizations and ourselves (...), if we took the insight about self-organization in which pattern and coherence emerge in local interactions? (...) Once we have seen how vital diversity is to the emergence of the novel and creative – to evolution – how would that affect how we think about organizations?”

Ralph Stacey (2002: p. 31/38)

It is exactly those questions that will guide proponents of the chaos-and-complexity paradigm to further adapt it for organizations and management in the years to come.

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