Complexity: the Science, its Vocabulary, and its Relation to Organizations

Michael R. Lissack

Every day voices in the mass media tell us that we live in a world in which complexity is rising and institutional orders are dissipating. In such a world, organizational science studies ways of fending off the forces of chaos that are, so to speak, always just around the corner. Management is portrayed as the process not only of fending off, but also of sometimes seizing hold, of those very forces. The traditional management literature—the stuff from which most of our MBA-led generation is taught—tends to speak of an objective world where interactions can be described in linear terms, where words have singular meanings, and where prediction and control are paramount. The focus on control provides one perspective on "chaos" and the manifold changes occurring all around us. A contrasting perspective evolves from complexity science. Complexity theory challenges the traditional management assumptions by noting that human activity allows for the possibility of emergent

IN THE STUDY OF EMERGENCE, COMPLEXITY SCIENCE AND ORGANIZATION CONVERGE

behavior. In the study of emergence, complexity science and organization converge.

Organizations can be viewed as systems of interpretation and constructions of reality (Berger and Luckmann, 1967). In order to survive, organizations must find ways to interpret events so as to stabilize their environments and try to make them more predictable; organizations must also find ways to interpret events so as to be one with the environment, an environment that they choose. A central concern of organization science is that of understanding how people construct meaning and reality, and exploring how that enacted reality provides a context for action. When managers "enact" the environment, as Weick (1995) put it they: "construct, rearrange, single out, and demolish many 'objective' features of their surroundings … they unrandomize variables, insert vestiges of orderliness, and literally create their own constraints." Through this process of sensemaking and reality construction, people in an organization give meaning to the events and actions of the organization. This occurs at two principal levels—the individual and the organization.

Organizations often experience change as an "emergent" process. Casti (1997) defines "emergence" as an overall system behavior that comes out of the interaction of many participants—behavior that cannot be predicted or "even envisioned" from a knowledge of what each component of a system does in isolation. This is the experience of change, yet this approach is scarcely found in the organization science literature. When emergent change is recognized within the literature, it is discussed superficially and metaphorically, with the organizational whole as the unit of analysis (Alvesson, 1990, 1995; Comfort, 1994). The emergent nature of change as experienced by other members of the organization is often overlooked. Change, instead, is treated as continuous, step like, or even chaotic, but with a definable scope and focus (Stacey, 1996). The experienced sense of change—that the whole is bigger than the sum of the parts, and that the patterns observed and felt are unexpected—is not captured. It is this sense

of the whole that points organization science to complex systems theory.

As Levy (1994) phrased it:

> By understanding industries as complex systems, managers can improve decision making and search for innovative solutions. … Chaos [complexity] theory is a promising framework that accounts for the dynamic evolution of industries and the complex interactions among industry actors. By conceptualizing industries as chaotic systems, a number of managerial implications can be developed. Long-term forecasting is almost impossible for chaotic systems, and dramatic change can occur unexpectedly; as a result, flexibility and adaptiveness are essential for organizations to survive. Nevertheless, chaotic systems exhibit a degree of order, enabling short-term forecasting to be undertaken and underlying patterns can be discerned. Chaos [complexity] theory also points to the importance of developing guidelines and decision rules to cope with complexity, and of searching for non-obvious and indirect means to achieving goals.

What is this complex systems theory? As of 1999, it is less an organized rigorous theory than a collection of ideas that have in common the notion that within dynamic patterns there may be underlying simplicity that can, in part, be discovered through the use of large quantities of computer power (Horgan, 1995; Casti, 1995, 1997) and through analytic, logical, and conceptual developments (Bar-Yam, 1997). It is also the discipline that has self-organized to examine the question of how coherent and purposive wholes emerge from the interactions of simple and sometimes non-purposive components. The theory includes such ideas as phase changes, fitness landscapes, self-organization, emergence, attractors, symmetry and symmetry breaking, chaos, quanta, the edge of chaos, self-organized criticality, generative relationships, and increasing returns to scale.

Some have chosen to distinguish the science components (both

qualitative and quantitative) as the study of complex systems, while allocating the word "complexity" to be inclusive not of the science but also of the more popular fad-like uses of complex systems terms. Whichever label one uses, the ideas of complexity are important. Witness this quote from Overman (1996) in his "The New Science of Management":

> Are traditional social science methods incapable of dealing with the complex and indeterminate problems facing management today? It is not so much the wedding of scientific logic and method to management theory and practice that is problematic, as it is the outdated models of scientific inquiry that slow our progress. The new sciences of chaos and quantum theory [complexity] offer valuable metaphors and methods that can challenge the management research agenda into the next century [with] … the image of self-organization, dissipative structures, and dynamic complexity.

A short list of books would be sufficient for those unfamiliar with the field to get a decent handle on complexity.[1] One might begin with *Complexity: the Emerging Science at the Edge of Order and Chaos* (Waldrop, 1992), which is an overview of the origins of complexity theory through the eyes of its explorers and the book with which to begin exploring this field. Although as early as 1986 there was an academic book published with the title *Complexity, Managers, and Organizations* (Streufert and Swezey, 1986), *Chaos: Making a New Science* (Gleick, 1987) is considered to be the classic work in the field and introduced laypeople to the complexities of complexity. *At Home in the Universe: the Search for the Laws of Self-Organization and Complexity* (Kauffman, 1995) explores what complexity theory might mean for the future of economics and organizations. *Leadership and the New Science: Learning about Organization from an Orderly Universe* (Wheatley, 1992) provides a broad survey of quantum mechanics as well as complexity theory and then extends its speculations to their relevance to leadership and organization. *Figments of Reality: the Evolution of the Curious*

Mind (Stewart and Cohen, 1997) and *The Collapse of Chaos: Discovering Simplicity in a Complex World* (Cohen and Stewart, 1994) bring some history of simplicity to the exploration of chaos and complexity. *Complexity and Creativity in Organizations* (Stacey, 1996) illustrates applications of new science to organizational dynamics and change.

THE COMPLEXITY METAPHOR: SOME EXAMPLES

Complexity theory, as used above, has its own vocabulary and its own metaphors. One such metaphor is the notion of an edge of chaos, the most fervent proponent of which is Kauffman. Through his research, Kauffman:

> began to see that living systems operated at their most robust and efficient level in the narrow space between stability and disorder—poised at "the edge of chaos." It was here, it appeared, that the agents within a system conducted the fullest range of productive interactions and exchanged the greatest amount of useful information. People recognize this in everyday life: A slightly messy office is a productive one; rollicking families are happy; economies flourish under scant regulation. The edge of chaos, but not quite chaos itself. (Petzinger, 1996b)

In a complex world, strategy is a set of processes for monitoring the behaviors of both the world and of the agents of the organization, observing where potential attractors are and attempting to supply resources and incentives for future moves. It may be that command and control are impossible (at least in the absolute and in the aggregate), but the manager retains the ability to influence the shape of what complexity theory (and biology) refers to as "the fitness landscape"(Lane and Maxfield, 1995).

Identification of value-added knowledge as a task can be represented by the metaphor of search for optimal fitness on a landscape. The landscape is rugged, in that there are hills and valleys,

and it is turbulent, in that it coevolves with both the outside environment and with the very participants (employees, customers, suppliers, regulators, competitors, etc.) who make up the essence of that landscape.

Kauffman carried out a number of studies of search on rugged landscapes, which demonstrate that, when fitness is average, search is best carried out far away across the space of possibilities. But, as fitness increases, the fittest variants are found ever closer to the current location in the space of possibilities (Kauffman, 1993).

On complex surfaces (i.e., rugged fitness landscapes with many hills and valleys), systems can become trapped on poor local optima (the wrong hill). Kauffman's research has developed a variety of approaches to "simulated annealing" to assist in getting organizations away from these local optima and moving toward a more "global optimum." Simulated annealing is an optimization procedure based on using an analogue of temperature, which is gradually lowered so that the system nearly equilibrates at each temperature and is gradually trapped into deep energy wells. The general concept lying behind simulated annealing is that at a finite temperature the system sometimes "ignores" some of the constraints and takes a step "the wrong" way, hence increasing energy temporarily. Ignoring constraints in a judicious way can help avoid being trapped on poor local optima (Kauffman, 1993, pp. 111–12).

Within this language clearly is a "how." Kauffman says break up the organization into patches, yet emphasizes that these patches must interact. This advice is different from the old management standby of the independent, self-sufficient business unit. It is in the nature and quantity of the interactions that Kauffman finds that the organization as a whole can be moved toward a global optimum, even though each patch is acting selfishly. Interactions require language or some other mechanism of fairly continual communication. He stresses that the patches must be coupled. In management jargon, the pieces must communicate, and not just at quarterly review sessions:

> The basic idea of patch procedure is simple: take a hard, conflict-laden task in which many parts interact, and divide it into a quilt of non-overlapping patches. Try to optimize within each patch. As this occurs, the couplings between parts in two patches across patch boundaries will mean that finding a "'good" solution in one patch will change the problem to be solved by the parts in adjacent patches. Since changes in each patch will alter the problems confronted by neighboring patches, and the adaptive moves by those patches in turn will alter the problem faced by yet other patches, the system is just like our model co-evolving ecosystems. (Kauffman, 1995, pp. 252–3)

Kauffman's other two procedural suggestions are to ignore some of the inputs coming into the organization (the theory seems to be that accommodating all inputs leads to freezing and that the necessary degrees of freedom for better finding optima can only be accomplished by deliberately ignoring some of the inputs), and to recognize that too much data ceases to be information (that which informs the agent or actor) but instead acts like a brake on the system.

The annealing process can also be looked at as one of deliberately introducing noise into a system to see what happens. Guastello refers to this as "the chaotic controller":

> Chaotic control works counter-intuitively by first adding a small amount of low-dimensional noise into the system. The reasoning is that the amount of sensitivity to initial conditions is not uniform throughout the attractor's space; sensitivity is less in the basin of the attractor and least in its center … Adding noise to the system allows the attractor to expand to its fullest range. (Guastello, 1995, Ch. 4)

This is a very different concept of noise than the statistical view (which suggests that noise should be discarded). Where traditional managers may have wished to delete the extraneous, the complex-

ity research-educated manager may be attempting to cause the deliberate addition of noise at various places along the way. Of course, noise can still be noise, and search strategies must be able to separate wheat from chaff if the enterprise is to be at all successful.

Managers who can make use of the metaphors of complexity see their companies in a different light than those who do not and, in a sense, are competing in a different world (Lakoff and Johnson, 1995). Corporate managers may, for example, view their companies as being in a race—be it for success, market share, revenues, or survival. That metaphor influences the way they see the world and the way they manage their companies.

MANAGERS WHO CAN MAKE USE OF THE METAPHORS OF COMPLEXITY SEE THEIR COMPANIES IN A DIFFERENT LIGHT THAN THOSE WHO DO NOT

In the race metaphor, the landscape is fixed even if the course is not. One has an identified goal and a set of competitors. In the fitness landscape metaphor, the landscape itself is always changing. One's goals, course, and competitors are but factors, which can and do affect the shape of the landscape itself. The objective is to climb to a nonlocal peak and your peaks may be very different from your competitors'.

In the race metaphor, information and data can be confused. Too much data leads to a loss of vision, a potential diversion from the goal, and the risk of overload. In the complexity metaphor, data is merely unused potential information. Information changes the landscape and data becomes information when it is ascribed value (whether correctly or not). Noise is a risk and a diversion in the race metaphor and a source of new understanding and potential information in the complexity metaphor.

Table 1 illustrates some of the complexity theory metaphors. What these metaphors can do is provide access to new ideas and analogies for use in confronting the unexpected and the unfamiliar:

Table 1 Complexity theory metaphors

Metaphorical concept	Inference	Practical application
Fitness landscape	Local vs global optima	Search (for improvement) strategies
Fitness landscape	Coevolving deformations	Be aware of feedback loops and interactions with all levels of stakeholders
Attractor	Behavior that passively follows a pattern	Choice is more important than trying to influence predestined behavior
Simulated annealing	Use "chaos" to control "chaos"	A bit of bedlam can be a good thing for crowds, data flow, and information retrieval
Simulated annealing	"Noise" can add creativity	Seek out controlled elements of noise, new voices, and outside perspectives
Patches	Selfish bits can be better than a holistic whole	Subdivide the organizing into interactive pieces with constant communication
Tau	Too much data causes a clogging of the pipes	Limit the quantity of simultaneous change that the organization attempts to recognize
Generative relationships	Seek tomorrow's returns in each encounter today	Approach each encounter by asking how this will help me grow
Increasing returns	Knowledge-based components of economy differ from traditional	Promote network and community affects where possible
Sensitive dependence on initial conditions	Prediction is impossible	Control *per se* won't work

> When any aspect of our experience strikes us as worth understanding, either for the first time or in a new way, we begin to search for [analogous instances] … I would say that just as we turn to a dictionary for the definition of unknown words in terms of unfamiliar words, so we look to phenomena of other sorts, whether natural or artificial, for analogs of things, qualities and events—including aspects of our own experience and activity—that we wish to comprehend. (Leary, 1990)

COMPLEXITY SCIENCE AND ORGANIZATION SCIENCE: A LONG RELATIONSHIP?

While complexity science may only, thus far, have contributed metaphors and models to the organization science literature, it would be foolhardy to write off such contributions as insignificant or minor. These metaphors and models are world constituting for those who use them (Astley, 1995; Cilliers, 1998). Both complexity science and organization science have a common problem they wish to address: uncertainty. And in their joint concern for uncertainty lies the basis for what is likely to be a very long relationship.

A lesson from complexity science is that it is always valuable to examine what occurs when foreground and background are shifted (Bechtel and Richardson, 1993; Mitchell, 1994; Bar-Yam, 1997). The added insight can suggest new relationships and new categories of thought. Management theory rarely takes up this challenge, yet much can be gained. For what a different picture emerges when one reverses the prominence of the boxes and the arrows in the typical management and leadership models taught to most MBAs and popularized in business texts. These models are likely to use boxes and similar shapes to indicate reified entities—things that have an ontological status.

IT IS ALWAYS VALUABLE TO EXAMINE WHAT OCCURS WHEN FOREGROUND AND BACKGROUND ARE SHIFTED

They use arrows to indicate relationships, flows, and exchanges—items to which is granted no ontological basis other than fleetingness. By contrast, consider models that reverse the ontology. The relations, flows and exchanges are deemed to be "real" and "extant," while the items formerly designated by shapes—the organization, its hierarchical structure, work climate, systems, mission, and strate—are afforded only the fleeting recognition of a snapshot in time. The analogy here is to a balance sheet or to those bad Polaroid pictures one takes on vacation. Each is but an inadequate reflection of a flowing reality temporarily stopped for the purpose of having a record created.

Consider the notion of "uncertainty." Thirty years ago, Thompson (1967) was able to write: "Uncertainty appears as the fundamental problem for complex organizations, and coping with uncertainty, as the essence of the administrative process." The intervening decades have marked little progress. Connell and Nord (1996) write of the "Infiltration of Organization Science by Uncertainty and Values," making note of the increased emphasis on language and meaning. Gergen and Thatchenkery (1996) note that methods may be sought to generate "new realities." Jacobson and Jacques (1997) can write of "Destabilizing the Field" by introducing a poststructuralist approach to the questions of meaning within organizations.

If the study of organizations is itself plagued by uncertainty and doubt, that is a reflection of the uncertainties felt by organizations themselves and their members. Perhaps what is occurring is that, as time marches inexorably forward, we are encountering more of what Rittel described as "wicked problems"—"a class of social system problems which are ill formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing" (Churchman, 1967). Or perhaps we just feel like we are.

For 50 years organization science has focused on "controlling uncertainty." For the past 10 years complexity science has focused

on how to understand it so as to better "go with the flow" and perhaps to channel that flow. In the possibilities created when we question whether the control or the uncertainty occupies the foreground lies the potential convergence of complexity science and organization science. John Seely Brown of Xerox PARC refers to such convergence items as "boundary objects."

At the overlapping boundaries of complexity science and organization science is where the importance of vocabulary, language, metaphors, and models comes in to play. The possibility space of the organization is constrained by the language of interpretation available to it and its members—for it is in that language that their reality will be constructed. Managers choose the environments they attend to, and their internal views shape these choices. The choice of frames (which endow meaning) and metaphors (which can provoke new images) within an organization can be determinative of what an organization can both extract and absorb from the environment around it. Kauffman (1996) refers to nearby possibilities as "the adjacent possible." The sequence of activities within and by an organization represents both movement within the possibility space and an enactment of how it defines the adjacent possible. In the interplay between language and activity, one finds both meaning and tension. Organizations must not only act, but their understanding of those actions—their sensemaking—must be coherent if identity is to be preserved (Lissack and Roos, 1999).

Weick, in his (1995) work on sensemaking, notes that "as ways of talking and believing proliferate, new features of organizations are noticed." New features of the organizations' environments are surely noticed as well. The use of metaphor, in as simple a form as in naming a situated activity, is a generative process. Any given label is also an invitation to see an object as if it were something else; through the resonance of possible connotations, new contextual meaning can be created. Word choice is thus a fundamental tool for the manager, whose role is to shape and create contexts in which appropriate forms of self-organization can occur.

The adoption of complexity science terms into the day-to-day lingo of corporate managers is much more than a Wittgensteinian "language game" (cf. Astley and Zammuto, 1992). Word choice in usage delimits possibility space and helps to determine the adjacent possible. Thus, it is an active process with real consequences and not just a symbolic toy. Management must deal with the consequences of the language adopted, and it is the managers' choice whether or not to do so in a purposeful manner. What complexity science metaphors do for an organization is give its members access to both new words and new possibilities for action. With the access to new actions comes the potential for new identity. The most prominent example of this is Monsanto, which not only adopted complexity science lingo, but also reorganized the entire company around it.

> Experience teaches us that thought does not express itself in words, but rather realizes itself in them. A word in context means both more and less than, the same word in isolation: more, because it acquires new context; less, because its meaning is limited and narrowed by the context. The sense of a word … changes in different minds and situations and is almost unlimited. It is not merely the content of a word that changes, but the way reality is generated and reflected in a word. (Vygotsky, 1986)

Monsanto's chairman, Robert Shapiro, grabbed hold of complexity science concepts and, in the immortal words of Microsoft, chose to embrace and extend. The result was a spinoff of Monsanto's chemical businesses and a headfirst rush into becoming the largest biotech company in the world.

Complexity science words and models give new tools to business leaders. By actively seeking to guide language choice, managers can influence the perceptions and actions of the remaining members of the organization. Leaders' effectiveness lies in their ability to make activity meaningful for those they lead. They do this not by changing behavior, but by giving others a sense of

understanding about what they are doing. In this sense lie the potential strengths of complexity as a management tool—and the conceptual underpinnings of the journal the first issue of which you have just finished reading.

NOTE

1 The next issue of *Emergence* will contain a review of more than two dozen books on complexity and management.

REFERENCES

Alvesson, M. (1990) "Organization, From Substance to Image?", *Organization Studies*, 11(3), 373–94.

Alvesson, M. (1995) *Management of Knowledge-intensive Companies*, Berlin/New York, Walter De Gruyter.

Anderson, P. (1996) Call for Papers by *Organization Science*, posted on the Internet.

Arnold, J. (1996) *Emergent Complexity: the Evolution of Intermediate Societies*, London: International Monographs in Prehistory.

Astley, W. (1985) "Administrative Science as Socially Constructed Truth," *Administrative Science Quarterly*, 30, 497–513.

Astley, W. and Zammuto, R. (1992) "Organization Science, Managers, and Language Games," *Organization Science*, 3 (4), 443–74.

Barton, S. (1994) "Chaos, Self-Organization, and Psychology," *American Psychologist*, January, 49 (1), 514.

Berger, P. and Luckmann, T. (1966) *The Social Construction of Reality*, New York, Doubleday.

Burrell, G. and Morgan, G. (1979) *Sociological Paradigms and Organisational Analysis*, London: Heinemann.

Camerer, C. (1995) "Individual Decision Making," in J.H. Kagel and A.E. Roth (eds), *The Handbook of Experimental Economics*, Princeton, NJ: Princeton University Press, 587–703.

Carr, C. (1996) *Choice, Chance and Organizational Change: Practical Insights from Evolution for Business Leaders and Thinkers*, New York: Amacom.

Casti, J. (1995) *Complexification: Explaining a Paradoxical World Through the Science of Surprise*, New York: Harper Perennial.

Casti, J. (1997) *Would Be Worlds*, New York: John Wiley.

Chia, R. (1995) "From Modern to Postmodern Organizational Analysis," *Organization Studies*, 16(4), 579–604.

Chia, R. (1996) *Organizational Analysis as Deconstructive Practice* (De Gruyter

Studies in Organization, No. 77), Berlin: Walter De Gruyter.
Churchman, C. (1967) "Wicked Problems," *Management Science*, 4 (14), B141–2.
Cilliers, P. (1999) *Complexity and Postmodernism: Understanding Complex Systems*, London: Routledge.
Cohen, J. and Stewart, I. (1994) *The Collapse of Chaos: Discovering Simplicity in a Complex World*, New York: Penguin.
Comfort, L. (1994) "Self-Organization in Complex Systems," *Journal of Public Administration Research and Theory*, 4 (3), 393–410.
Conger, J. (1991) "Inspiring Others, the Language of Leadership," *Academy of Management Executive*, 5 (1), 31–45.
Connell, A. and Nord, W. (1996) "Infiltration of Organization Science by Uncertainty and Values," *Journal of Applied Behavioral Science*, 32 (4), 407–27.
Crossan, M., White, R. *et al.* (1996). "The Improvising Organization, Where Planning Meets Opportunity," *Organizational Dynamics*, March.
Gergen, K. and Thatchenkery, T. (1996) "Organization Science as Social Construction, Postmodern Potentials," *Journal of Applied Behavioral Science*, 32 (4), 356–77.
Gleick, J. (1987) *Chaos*, London: Sphere.
Guastello, S. (1995) *Chaos, Catastrophe and Human Affairs*, Mahwah, NJ: Lawrence Erlbaum.
Hatch, M. and Tsoukas, H. (1997) "Complex Thinking about Organizational Complexity, the Appeal of a Narrative Approach to Organizational Theory," paper presented at the AMA 1997 meeting in Boston.
Hogarth, R.M. and Reder, M.W. (eds) (1987) *Rational Choice: the Contrast between Economics and Psychology*, Chicago: University of Chicago Press.
Homans, G.C. (1950) *The Human Group*, New York: Harcourt.
Horgan, J. (1995) "From Complexity to Perplexity," *Scientific American*, June, 104–9.
Jacobson, S. and Jacques, R. (1997) "Destabilizing the Field, Poststructuralist Knowledge-Making Strategies in a Postindustrialist Era," *Journal of Management Inquiry*, 6 (1), 42–59.
Kauffman, S. (1993) *The Origins of Order: Self Organization and Selection in Evolution*, Oxford: Oxford University Press.
Kauffman, S. (1995) *At Home in the Universe*, Oxford: Oxford University Press.
Kauffman, S. (1996) "Investigations," Santa Fe Institute Working Paper #96-08-072.
Kellert, S. (1995) "When Is the Economy not like the Weather? The Problem of Extending Chaos Theory to the Social Sciences," in Albert, A. (ed.), *Chaos and Society*, Amsterdam: IOS Press.

Kelly, K. (1994) *Out of Control*, London: Fourth Estate.

Lakoff, G. and Johnson, M. (1980, 1995) *Metaphors We Live by*, Chicago: University of Chicago Press.

Lane, D. and Maxfield, R. (1995) "Foresight Complexity and Strategy," Santa Fe Institute Working Paper #95-12-106.

Langlois, R. and Everett, M. (1992) "Complexity, Genuine Uncertainty, and the Economics of Organization," *Human Systems Management*, 11, 67–75.

Leary, D. (ed.) (1990) *Metaphors in the History of Psychology*, New York: Cambridge University Press.

Levy, D. (1994) "Chaos Theory and Strategy, Theory, Application and Managerial Implications," *Strategic Management Journal*, 15 (Summer), 167–78.

Lissack, M. and Roos, J. (1999) *The Next Common Sense: Mastering Corporate Complexity Through Coherence*, London: Nicholas Brealey Publishing.

Loye, D. and Eisler, R. (1987) "Chaos and Transformation, Implications of Nonequilibrium Theory for Social Science and Society," *Behavioral Science*, 32, 53–65.

McKelvey, W. (1998) "Thwarting Faddism at the Edge of Chaos: on the Epistemology of Complexity Research," presented at the Workshop on Complexity and Organization, Brussels, Belgium, June 8–9.

Mitchell, W. (1994) *The Reconfigured Eye: Visual Truth in the Post-Photographic Era*, Cambridge, MA: MIT Press.

Overman, E. (1996) "The New Science of Management, Chaos and Quantum Theory and Method," *Journal of Public Administration Research and Theory*, 6 (1), 75–89.

Petzinger, T. (1996a) "The Front Lines," *Wall Street Journal*, July 12.

Petzinger, T. (1996b) "The Front Lines," *Wall Street Journal*, October 18.

Phelan, S. (1995) "From Chaos to Complexity in Strategic Planning," paper presented at the Academy of Management 55th Annual Meeting, Vancouver, Canada.

Piccardo, C. *et al.* (1990) "Car Makers and Marathon Runners, in Pursuit of Culture through the Language of Leadership," in P. Gagliardi (ed.), *Symbols and Artifacts*, Berlin: Walter De Gruyter.

Pondy, L. (1976) "Leadership Is a Language Game," in M. Mccall and M. Lombardo (eds), *Leadership, Where Else Can We Go?*, Greensboro, NC: Center for Creative Leadership.

Reed, M. and Hughes, M. (eds) (1992), *Rethinking Organization: New Directions in Organization Theory and Analysis*, London: Sage.

Scott, W.R. (1995) *Institutions and Organizations*, Thousand Oaks, CA: Sage.

Silverman, D. (1971) *The Theory of Organisations*, New York: Basic Books.

Stacey, R. (1996) *Complexity and Creativity in Organizations*, San Francisco, CA: Berrett Koehler.

Staw, B.M. (ed.) (1991) *Psychological Dimensions of Organizational Behavior*, Englewood Cliffs, NJ: Prentice-Hall.

Stern, C. and Stalk, G. (1998) *Perspectives on Strategy: from the Boston Consulting Group*, New York: John Wiley.

Streufert, S. and Swezey, R. (1986) *Complexity, Managers, and Organizations*, London: Academic Press.

Stewart, I. and Cohen, J. (1997) *Figments of Reality: the Evolution of the Curious Mind*, Cambridge: Cambridge University Press.

Thietart, R. and Forgues, B. (1995) "Chaos Theory and Organization," *Organization Science*, 6 (1), 19–31.

Thompson, J. (1967) *Organizations in Action, Social Science Bases of Administrative Theory*, New York: McGraw-Hill.

Vygotsky, L. (1962, 1986) *Thought and Language*, Kozulin, A. (ed.), Cambridge, MA: MIT Press.

Waldrop, M. (1992) *Complexity*, New York: Simon and Schuster.

Warglien, M. (1995) "Hierarchical Selection and Organizational Adaptation," *Industrial and Corporate Change*, 4 (1), 161–86.

Weick, K. (1979) *The Social Psychology of Organizing*, Reading, MA: Addison-Wesley.

Weick, K. (1995) *Sensemaking in Organizations*, Thousand Oaks, CA: Sage.

Westhoff, F., Yarbrough, B. and Yarbrough, R. (1996) "Complexity, Organization, and Stuart Kauffman's The Origins of Order," *Journal of Economic Behavior and Organization*, 29 (1).

Wheatley, M. (1992) *Leadership and the New Science: Learning about Organization from an Orderly Universe*, San Francisco, CA: Berrett-Koehler.

Zucker, L.G. (1988) *Institutional Patterns and Organizations: Culture and Environment*, Cambridge, MA: Ballinger.