SELF-ORGANIZING SYSTEMS RESEARCH IN THE SOCIAL SCIENCES
Reconciling the Metaphors and the Models

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Since the 1980s, there has been considerable popular and academic interest in self-organizing systems theory (Prigogine & Stengers, 1984) and chaos theory (Gleick, 1987). These two theories are premised on a closely related set of nonlinear mechanisms that underscore a system's sensitivity to initial conditions and the system's ability to exhibit discontinuous behavior. Despite these similarities, the two theories explicate different patterns of dynamic behavior (Briggs & Peat, 1989). Chaos theory examines the processes and conditions that lead deceptively simple systems to exhibit seemingly random or chaotic dynamic behavior. Self-organizing systems theory, on the other hand, seeks "to explain the emergence of patterned behavior in systems that are initially in a state of disorganization" (Contractor, 1994, p. 51). Thus, whereas chaos theory seeks to explain the creation of chaos from order, self-organizing systems theory seeks to explain the emergence of order from chaos. The metaphorical connotations of both these theories have captured the imagination of organizational scholars and practitioners.

In this article, I argue that we need to reconcile the metaphorical richness of these theories with their theoretical and logical exigencies. In the absence of a deliberative discussion on this reconciliation, communication research from a self-organizing systems

AUTHOR'S NOTE: *Paper presented to the International Communication Association, Jerusalem, Israel, July 1998. Preparation of this article was supported by National Science Foundation Grant ECS-94-27730.*

Management Communication Quarterly, Vol. 13, No. 1, August 1999 154-166

perspective runs the risk of being either overwhelmingly metaphorical (some would argue "hand waving") or an unenlightened and inappropriate attempt at importing models and theories from the physical and life sciences to the study of social phenomena. This article initiates a deliberative discussion by reviewing the strengths and limitations of using self-organizing systems as a metaphor and as a model in the study of organizational communication.

SELF-ORGANIZING SYSTEMS

SELF-ORGANIZING SYSTEMS AS METAPHOR: THE BENEFITS

Since the 1980s, there have been several well-articulated, and well-received, books in the organizational literature that advocate the study of organizations from a self-organizing systems perspective. In his book, *Images of Organizations*, Morgan (1986) proposed that the metaphor of organizations as a self-organizing, self-producing system offered a powerful suite of conceptual tools to examine "organizations as flux and transformation" (p. 233). In *The Fifth Discipline*, Senge (1990) proffered a model of the organization as a complex nonlinear system, directed by the vision of a charismatic leader who could control the system by identifying leverage points at which key interventions can be implemented.

Wheatley (1992, pp. 6-7) continued this advocacy about organizations as self-organizing systems by conveying, "new images and metaphors for thinking about our own organizational experiences." She acknowledges that "some believe that there is a danger in playing with science and abstracting its metaphors because, after a certain amount of stretch, the metaphors lose their relationship to the tight scientific theories that gave rise to them." But, she emphasizes, "Others would argue that all of science is metaphor—a hopeful description of how to think of a reality we can never fully know." For example, following an introduction of the concept of strange attractors in self-organizing systems, Wheatley writes,

> Ever since my imagination was captured by the phrase “strange attractor,” I have wondered if we could identify such a force in organizations. . . . My current belief is that we do have such attractors at work in organizations and that one of the most potent shapes of behavior in organizations, and in life, is meaning. . . . When a meaning attractor is in place in an organization, employees can be trusted to move freely, drawn in many directions by their energy and creativity. (pp. 133-134, 136)

Stacey (1996) extends this approach, arguing that organizations are complex adaptive systems (p. 23), with “dissipative structures” (p. 47) and “self-organizing learning systems at the edge of chaos” (p. 72). Stacey concludes,

> Perhaps the science of complexity adds most value because it provides new analogies and metaphors for those in the research community who are inclined to play in that community’s recessive schema, in tension with the dominant schema, to produce creative change in our understanding of organizations. (p. 265)

Others, such as Goldstein (1994) and Warnecke (1993), use self-organizing systems metaphors to describe *The Unshackled Organization* and *The Fractal Company*, respectively. All of these authors illustrate the power of metaphorically reconceptualizing organizations as dynamic, chaotic, nonlinear systems, with self-similar structures, given to sudden disruptive changes, often triggered by small actions that may be random. The authors offer several illustrative anecdotes of organizational activities and structures that appear to bear out these characteristics.

However, the plural of anecdote is not empirical evidence. Instead, these anecdotes are intended—and must be construed—as metaphorical attempts to “imaginize” organizations. Morgan (1993) argues that using such metaphors to imaginize organizations have at least six payoffs:

> (i) metaphors always involve a sense of paradox and the absurd, because it invites users to think about themselves or their situations in ways that are patently false; (ii) metaphors requires its user [sic] to find and create meaning . . . and also helps to create ownership of the insights; (iii) when different people generate different

> metaphors that have a great deal in common, one knows that one is dealing with highly resonant insights; (iv) resonant metaphors can energize a group and "take hold;" (v) metaphors invite a conversational style where meaning and significance emerge through dialogue; and (vi) the tentative nature of metaphorical insights mean that they cannot be taken too seriously or made too concrete. (pp. 289-291)

SELF-ORGANIZING SYSTEMS AS METAPHOR: THE LIMITATIONS

Although scholars have succeeded in popularizing the self-organizing systems metaphor, their expositions raise two issues that may hinder the durability and longevity of this perspective: (a) the intellectual value added by these metaphors, and (b) the conflict between the metaphorical and technical interpretations of the concepts used in self-organizing systems.

First, in a dialog sponsored by the Santa Fe Institute and moderated by Jen (1994), Stevens wonders if these perspectives are

> a restatement of things we already know in a different language and there's no new result. Sometimes this can be useful but it's not a theory. I would be interested to hear the extent to which people think that complex systems theory has been a restatement or the extent to which, in all the various areas, there are results where we know something we didn't know before. (p. 559)

Stevens's questions about the intellectual insights derived from complexity theory invoke memories of a trenchant critique made more than 20 years ago by Lilienfeld (1978) in his book, *The Rise of Systems Theory.*

> Systems thinkers exhibit a fascination for definitions, conceptualizations, and programmatic statements of a vaguely benevolent, vaguely moralizing nature. . . . They collect analogies between the phenomena of one field and those of another . . . the description of which seems to offer them an esthetic delight that is its own justification. . . . No evidence that systems theory has been used to achieve the solution of any substantive problem in any field whatsoever has appeared. (pp. 191-192)

In the context of studying organizations from a self-organizing systems perspective, what new insights can be gleaned by metaphorically describing, as Wheatley (1992, p. 133-134) does, "meaning" in organizations as a "strange attractor?" Perhaps we can better appreciate that *meaning* in the organization is not constant (in which case it would be a point attractor), nor changing in cycles (in which case it would be a periodic attractor), but appears to change randomly within certain bounded realms. However, even this conjecture begs several questions: What components in the system influence the trajectory of *meaning*? Under what conditions is *meaning* likely to become a point attractor, a periodic attractor, or a different strange attractor?

Second, there is considerable misunderstanding surrounding the terminology used in the self-organizing systems perspective. Goldstein (1995), an organizational researcher and consultant on self-organizing systems, confesses, "I often have had the experience of not quite understanding what others are talking about, as well as the sense of being misunderstood myself" (p. 40). He argues that one source for this misunderstanding is when the terminology is used metaphorically. "For example," Goldstein notes,

> I have said, on occasion, and I have heard a number of people in organizational appropriations of chaos theory say that to facilitate organizational transformation we need to add some chaos into organizations. What exactly is being referred to here as chaos? Most likely, it is not any kind of behavior in a system that could be typified by a chaotic attractor. And even if it did fit such a technical definition, how does one add this kind of chaos to an organization? Isn't chaos per se a matter of deterministic evolution following some simple nonlinear rules? How exactly is such a thing added to an organization? (p. 42)

Goldstein notes that this confusion is created because meaning is not always clear when scholars use the terms metaphorically. Hence, to build intellectually on the evocative power of metaphors, it is imperative to move up the operational hierarchy of these concepts. That next step in the hierarchy is the specification of models, which the philosopher of science Max Black (1962) describes as systematically developed metaphors.

SELF-ORGANIZING SYSTEMS AS MODELS IN THE STUDY OF ORGANIZATIONAL COMMUNICATION

SELF-ORGANIZING SYSTEMS AS MODELS: THE POTENTIAL

Turner (1997) argues that the theoretical machinery of complexity theory, combined with the exponential increase in computational power, yield modeling as a critical fifth tool, in addition to the four tools used by classical science: observation, logical or mathematical analysis, hypothesis, and experiment. Today, the computer serves as an exploratorium, permitting researchers in a variety of disciplines to examine with a relatively small effort and at a high speed the aggregate, dynamic, and emergent implications of multiple nonlinear generative mechanisms. These new subareas in a variety of disciplines are collectively referred to as computational sciences (Carley & Prietula, 1994; McKelvey, 1997). The potential of computational modeling prompted Pagel (1988) to observe that just as microscopes revealed new frontiers of knowledge in the 17th century, today the frontiers of knowledge are being revealed via the "macroscope" of computers.

From a methodological standpoint, complexity theory has spawned several modeling techniques, such as cellular automata, neural networks, fractals, catastrophe models, and binary nets (or Boolean nets). The selection of an appropriate modeling technique must be guided by decisions about the genre of mechanisms and the nature of the variables being specified in the model. For instance, fractals are more useful to specify models of self-similar nested entities, whereas neural networks (Woelfel, 1993) are more appropriate for modeling networked entities. Likewise, cellular automata models (Corman, 1996) are most appropriate for studying actors whose attributes are influenced by the attributes of those in their immediate network "neighborhood" (of four other actors). Moreover, binary nets (or Boolean nets) are more appropriate when the attributes of actors (which must be considered binary in nature, i.e., present or absent) are influenced by other actors in the network, including those not in their immediate neighborhood. For instance, Varela, Maturana, and Uribe (1974) were exploring the most appropriate modeling environment to simulate autopoiesis in cells. They sought to model a network of processes in which components of the cell and its boundary helps produce, transform, and maintain other components of the cell and its boundary. After reviewing several models, they decided that cellular automata models were more appropriate than binary network models.

In the past decade, there have been several examples of modeling self-organizing social systems. Just in the past 4 years, four books have served as important compilations of studies of social systems from a self-organizing systems perspective. Cowan, Pines, and Meltzer's (1994) edited volume from the Santa Fe Institute, *Complexity: Metaphors, Models, and Reality*, Guastello's (1995) *Chaos, Catastrophe, and Human Affairs*, Robertson and Combs's (1995) edited volume, *Chaos Theory in Psychology and the Life Sciences*, and Eve, Horsfall, and Lee's (1997) edited volume, *Chaos, Complexity, and Sociology* present several nonlinear models of phenomena including human decision making, organizational motivation and conflict, stress and human performance, disaster relief, organizational adaptation, and innovation and creativity.

SELF-ORGANIZING SYSTEMS AS MODELS: THE LIMITATIONS

Previous excursions into computational modeling, or what was more commonly referred to as computer simulations, underscore two important limitations that must be addressed. First, there is a need for social scientists to develop domain-specific computational models, rather than import models from the physical sciences. Second, there is a need to empirically validate the results of computational modeling.

Domain-specific self-organizing systems models. There is general agreement that unlike many physical or chemical systems, living systems must include mechanisms that specify self-referencing, self-producing, and/or self-renewing. Maturana and Varela (1980) refer to these as autopoietic systems. However, as others (Capra, 1996; Staubmann, 1997) have noted, there is considerable disagreement on whether the generative mechanisms for living systems can also be applied to social systems. Maturana (1988) and Varela (1981) have expressed varying degrees of ambivalence about the viability of studying social systems as autopoietic. However, Luhmann (1990) argues for the study of social systems as autopoietic systems that "use communication as their particular mode of autopoietic reproduction. Their elements are communications that are recursively produced and reproduced by a network of communications and that cannot exist outside of such a network" (p. 3). Debates, such as the one between Luhmann (1990), Maturana (1988), and Varela (1981), are a critical step in the specification of models appropriate to social systems. It preempts the blind appropriation of models from the hard sciences—a problem that has plagued earlier generations of social scientists. The remainder of this section describes a set of generative mechanisms that are grounded in a view of organizations as self-organizing networks.

Self-organizing systems theory is explicitly concerned with understanding the emergent pattern of organization that bridges micro and macro features of the complex system (Smith, 1997). Capra (1996) notes that the most important property is that it is a network pattern: "The pattern of life, we might say, is a network pattern capable of self-organization. This is a simple definition, yet it is based on recent discoveries at the very forefront of science" (pp. 82-83).

Although Capra (1996) makes this argument in the context of living systems, the network framework can also be applied to studying self-organization in the organizational context. However, because of its metatheoretical status, self-organizing systems theory does not offer content-specific generative mechanisms for organizational networks. These mechanisms must be either derived from existing social scientific theories or deduced by extending these theories. Monge and Contractor (in press) identify 10 families of such theoretical mechanisms that have been used to explain the emergence of communication networks in organizational research. These include (a) theories of self-interest (social capital theory and transaction cost economics); (b) theories of mutual self-interest and collective action; (c) exchange and dependency theories (social exchange, resource dependency, and network organizational forms); (d) contagion theories (social information processing, social cognitive theory, institutional theory, structural theory of action); (e) cognitive theories (semantic networks, knowledge structures, cognitive social structures, cognitive consistency); (f) theories of homophily (social comparison theory, social identity theory); (g) theories of proximity (physical and electronic propinquity); (h) uncertainty reduction and contingency theories; (i) social support theories; and (j) evolutionary theories.

These 10 families of generative mechanisms for the creation, maintenance, and dissolution of organizational networks illustrate the need to ground the modeling of systems in domain-specific social scientific theories. For example, one of the mechanisms enumerated above, cognitive social structures (Krackhardt, 1987), is of particular importance from a self-organizing systems perspective. Some scholars (Krippendorf, 1984; Steier & Smith, 1985) have argued that self-organizing systems must be modeled as observed by the participants in the network (rather than by outside observers). Consistent with the view of those scholars, cognitive social structures model actors' behaviors on the bases of their perceptions of the overall communication network, even if these perceptions are at variance with the observed communication network.

Computational modeling: A tool for theory building versus theory testing. Although computational modeling can lead to several important insights into the dynamic implications of social scientific theories, it manifests many of the problems endemic to past research using simulations. There is a growing sense within the research community that individual studies within this area can arguably be indicted based on one or more of the following seven criteria. The modeling techniques and programs used to study nonlinear systems frequently are (a) not logically consistent (i.e., the model specification among the variables allowed for some logical inconsistencies), (b) not theoretically grounded (i.e., the models, although perhaps being intuitively appealing, were not contributing to cumulative theory building), (c) not sufficiently complex (i.e., the models do not include variables that substantively were critical), (d) based on simulation programming environments that do not have a good user interface and are not well documented, (e) not easily replicable by a third party using different simulation programming environments, (f) not comprehensible to scholars interested in the substantive domain who are not quite as familiar with computational modeling, and (g) not validated using empirical data collected from field or experimental studies, hence leaving their substantive validity and import in question.

One important reason for these criticisms is the well-intentioned, but limited, ability of individual scholars to try to accomplish the various facets of the research enterprise: mathematical modeling, formal logic, organizational and communication theory, expertise in designing field and experimental studies, sophisticated statistical techniques, visualization, user interface, computer programming, domain expertise, and end-user cooperation. There is much wisdom in the aphorism that “Computers are wonderful at turning good scientists into lousy programmers,” to which one may add, “Experiments and field studies are wonderful at turning good programmers into lousy empiricists.” Clearly, a systematic response to these criticisms requires the assembly of heterogeneous teams of scholars with the multiple skills required for such an enterprise.

In summary, computational modeling of self-organizing systems must be seen as one component in an interdisciplinary effort to assist the building of theory. It cannot, by itself, serve as a surrogate for the testing and empirical validation of theory (Hanneman, 1987). Until we demonstrate these values in our research, the modeling of self-organizing systems will justifiably be criticized for adding little intellectual and practical value to our understanding of the process of organizing.

CONCLUSION

Prigogine and Stengers (1984), heralding the dawn of the self-organizing systems paradigm, wrote, “Classical science, the mythical science of a simple, passive world, belongs to the past, killed not by philosophical criticism or empiricist resignation, but by the internal development of science itself" (p. 55). In the physical sciences, this new paradigm does not displace the majority of past research (Robertson & Combs, 1995). Rather, "the new paradigm demonstrates that knowledge gained under the old paradigm is true under specific boundary conditions" (Eve, 1997, p. 275). These boundary conditions refer to situations in the physical sciences in which making simplifying and linearizing assumptions of nonlinear phenomena are defensible. However, in social systems, which are far more nonlinear than their physical counterparts, there are very few instances in which making linearizing assumptions are theoretically plausible or defensible. As Turner (1997) wrote,

> Social science, dealing as it must with complex two-way interactions of many complex organisms, themselves feedback systems of almost unimaginable depth and complication, has until now been forced to use logical and mathematical instruments originally designed to deal with hugely simpler systems. (pp. xxvi-xxvii)

Hence, the new self-organizing systems paradigm, with its conceptual and modeling tools that are particularly appropriate for studying nonlinear phenomena, has an even greater potential for unleashing intellectual progress in the social sciences than it has in the physical sciences. For the better part of the 20th century, the common sense nature of hypotheses tested by social sciences has often been chided as being the "deliberation of the obvious." A judicious use of computational modeling from a self-organizing systems perspective holds the promise of ushering in a new millennium where the world will witness a generation of social science research deliberating, explaining, and predicting the nonobvious.

REFERENCES

Black, M. (1962). *Models and metaphors: Studies in language and philosophy.* Ithaca, NY: Cornell University Press.

Briggs, J., & Peat, F. D. (1989). *Turbulent mirror: An illustrated guide to chaos theory and the science of wholeness*. New York: Harper & Row.

Capra, F. (1996). *The web of life*. New York: Anchor.

Carley, K., & Prietula, M. J. (Eds.). (1994). *Computational organizational theory.* Hillsdale, NJ: Lawrence Erlbaum.

Contractor, N. (1994). Self-organizing systems perspective in the study of organizational communication. In B. Kovacic (Ed.), *New approaches to organizational communication* (pp. 39-65). Albany: SUNY Press.

Corman, S. R. (1996). Cellular automata as models of unintended consequences of organizational communication. In J. H. Watt & C. A. Van Lear (Eds.), *Dynamic patterns in communication processes* (pp. 191-212). Thousand Oaks, CA: Sage.

Cowan, G. A., Pines, D., & Meltzer, D. (1994). *Complexity: Metaphors, models, and reality.* Reading, MA: Addison-Wesley.

Eve, R. (1997). Afterword: Where are we now? A final word. In R. A. Eve, S. Horsfall, & M. E. Lee (Eds.), *Chaos, complexity, and sociology* (pp. 269-280). Thousand Oaks, CA: Sage.

Eve, R., Horsfall, S., & Lee, M. E. (Eds.). (1997). *Chaos, complexity, and sociology.* Thousand Oaks, CA: Sage.

Gleick, J. (1987). *Chaos: Making a new science.* New York: Penguin.

Goldstein, J. (1994). *The unshackled organization: Facing the challenge of unpredictability through spontaneous reorganization*. Portland, OR: Productivity Press.

Goldstein, J. (1995). The Tower of Babel in nonlinear dynamics: Toward the clarification of terms. In R. Robertson & A. Combs (Eds.), *Chaos theory in psychology and the life sciences* (pp. 39-48). Mahwah, NJ: Lawrence Erlbaum.

Guastello, S. J., (1995). *Chaos, catastrophe, and human affairs: Applications of nonlinear dynamics to work, organizations, and social evolution*. Mahwah, NJ: Lawrence Erlbaum.

Hanneman, R. (1987). *Computer-assisted theory building: Modeling dynamic social systems*. Beverly Hills, CA: Sage.

Jen, E. (1994). Interactions between theory, models, and observations. In G. A. Cowen, D. Pines, & D. Meltzer (Eds.), *Complexity: Metaphors, models, and reality* (pp. 553-576; Proceedings Volume XIX, Santa Fe Institute, Studies in the Science of complexity). Reading, MA: Addison-Wesley.

Krackhardt, D. (1987). Cognitive social structures. *Social Networks*, *9*, 109-134.

Krippendorf, K. (1984). Paradox and information. In B. Dervin & M. Voight (Eds.), *Progress in communication sciences*, *5* (pp. 45-72). Norwood, NJ: Ablex.

Lilienfeld, R. (1978). *The rise of systems theory.* New York: John Wiley.

Luhmann, N. (1990). The autopoiesis of social systems. In N. Luhmann (Ed.), *Essays on self-reference* (pp. 1-21). New York: Columbia University Press.

Maturana, H. (1988). The search for objectivity or the quest for a compelling argument. *Irish Journal of Psychology*, *9*, 25-82.

Maturana, H., & Varela, F. (1980). *Autopoiesis and cognition*. Dordrecht, Holland: D. Reidel.

McKelvey, B. (1997). Quasi-natural organization science. *Organization Science*, *8*, 352-380.

Monge, P. R., & Contractor, N. (in press). Emergence of communication networks. In F. M. Jablin & L. L. Putnam (Eds.), *The new handbook of organizational communication*. Thousand Oaks, CA: Sage.

Morgan, G. (1986). *Images of organization*. London: Sage.

Morgan, G. (1993). *Imaginization: The art of creative management*. Thousand Oaks, CA: Sage.

Pagel, H. (1988). *The dreams of reason*. New York: Simon & Schuster.

Prigogine, I., & Stengers, I. (1984). *Order out of chaos: Man's new dialogue with nature*. New York: Bantam.

Robertson, R., & Combs, A. (Eds.). (1995). *Chaos theory in psychology and the life sciences*. Mahwah, NJ: Lawrence Erlbaum.

Senge, P. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday Currency.

Smith, T. (1997). Nonlinear dynamics and the micro-macro bridge. In R. A. Eve, S. Horsfall, & M. E. Lee (Eds.), *Chaos, complexity, and sociology* (pp. 52-63). Thousand Oaks, CA: Sage.

Stacey, R. D. (1996). *Complexity and creativity in organizations*. San Francisco: Berrett-Koehler.

Staubmann, H. M. (1997). Self-organization and the economy: A system-theoretical reconsideration of Georg Simmel's Philosophy of Money. In R. A. Eve, S. Horsfall, & M. E. Lee (Eds.), *Chaos, complexity, and sociology* (pp. 79-90). Thousand Oaks, CA: Sage.

Steier, F., & Smith, K. K. (1985). Organizations and second order cybernetics. *Journal of Strategic and Systematic Therapies*, *4*, 553.

Turner, F. (1997). Foreword: Chaos and social science. In R. A. Eve, S. Horsfall, & M. E. Lee (Eds.), *Chaos, complexity, and sociology* (pp. xi-xxvii). Thousand Oaks, CA: Sage.

Varela, F. (1981). Describing the logic of the living: The adequacy and limitations of the idea of autopoiesis. In M. Zeleny (Ed.), *Autopoiesis: A theory of living organization* (pp. 36-48). New York: North Holland.

Varela, F., Maturana, H., & Uribe, R. (1974). Autopoeisis: The organization of living systems, its characterization and a model. *BioSystems*, *5*, 187-196.

Warnecke, H. J. (1993). *The fractal company: A revolution in corporate culture*. Berlin: Springer-Verlag.

Wheatley, M. J. (1992). *Leadership and the new science: Learning about organization from an orderly universe*. San Francisco: Berrett-Koehler.

Woelfel, J. (1993). Artificial neural networks in policy research: A current assessment. *Journal of Communication*, *43*(1), 62-80.

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