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2 *Self-Organizing Systems Perspective in the Study of Organizational Communication*

The more freedom in self-organization, the more order!

Enrich Jantsch, *The Self-Organizing Universe*

During the 1970s, several communication and organizational theorists advocated a systems perspective to the study of organizational communication (Katz and Kahn 1978; Monge 1977). Theoretical approaches developed in the 1940s and triggered by interest in biological phenomena, resulted in the broad frameworks of General Systems Theory (Bertalanffy 1968; Miller 1978) and cybernetics (Wiener 1954). Inspired by these developments, organizational and communication scholars conceptualized organizations as "open" structural-functional systems that had clearly identified boundaries, through which they transacted information and materials with the environment, including vendors and clients (Monge 1977). In order to accomplish its functions, the organization itself comprised many interrelated "subsystems" such as managerial, technological, and strategic units (Kast and Rosenzweig 1973). This image of the organization spawned a new vocabulary, considerable theorizing, and a modest amount of empirical research.

Scholars operating from a systems perspective rejected the notion that there was one best way of organizing. Instead they offered contingency theories. For instance, Burns and Stalker (1961) proposed that the optimum structure for an organization was contingent on its

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environment. Woodward (1965) and her colleagues suggested that a fit must exist between the organization's structure and the technology it used. Lawrence and Lorsch (1967) suggested that the degree of differentiation and integration among the organization's subsystems must match the complexity in the organization's environment.

Discontent with traditional systems thinking

In the past two decades, several observers of organizational practice and research scholars have raised serious concerns about the conceptualization of organizations from a traditional systems perspective. Popular literature, inspired by traditional systems theories, had argued that organizational practitioners should respond to crises by being more adaptive, more flexible, more innovative, more quick to react, creating cross-functional organizational structures, and paying more attention to links with the environment. Sheldon (1980) notes that these palliatives represented attempts at incremental or "normal" changes in order to buffer the organization from its environment and preserve the equilibrium.

Contemporary writings in the popular press suggested that, as society enters a new phase of the information age, organizations are in the midst of discontinuous changes (Davis 1987; Davis and Davidson 1991; Ferguson 1980; Handy 1990). Ferguson (1980) describes the "2001 organization" as a network of relationships that are self-generating, self-organizing, sometimes even self-destructing. Further, these writings suggest that in order to be prepared for these discontinuous changes, organizations must recognize and thrive on chaotic changes in the organization and its environment (Peters 1987).

Scholarly concerns with the limitations of traditional systems thinking can be broadly classified into three categories. *First,* Weick (1979) argued that contingency theories erroneously conceptualized organizations as stable *static* structures that had to be buffered from the environment. To emphasize this criticism, Weick (1979) titled his book "The social psychology of organizing" in contrast to Katz and Kahn's (1978) book, based on a traditional systems approach, titled "The social psychology of organization."

Second, many scholars noted that systems contingency theories viewed "organizations and their environments as being far too concrete." (Morgan 1986, 74). Thus contingency theories tended to reify the material aspects of organizations, ignoring the fact that organizations are also the products of their members' visions, ideas, norms, and

beliefs (Pondy and Mitroff, 1979). This criticism of traditional systems thinking precipitated the emergence of interpretive and critical perspectives on organizational communication (Putnam and Pacanowsky 1983). These approaches focus on organizations as cultures and meaning systems (Pondy, Frost, Morgan, and Dandridge 1983). They reject traditional systems theory's assumption that the organization and all its subsystems share a harmonious functional unity. As a result, they do not view the existence of conflicting goals and multiple interpretations as necessarily dysfunctional (Eisenberg 1984; Monge and Eisenberg 1987).

Third, the research methods used in the study of contingency theories were perceived as being sorely inadequate. These studies, commonly characterized as functionalist research (Putnam 1983), were based on a unidirectional causal analysis of covariance among a small set of variables that measured static, easily observable, characteristics of the organization.

These concerns, by theorists and practitioners, prompted some scholars to conceptualize organizations in terms of patterned changes rather than stable, albeit complex, structures (Mohr 1982). For instance, Miller and Friesen (1984) propose that organizations be characterized in terms of momentum and revolution. They distinguish between quantum and piecemeal changes. Pettigrew (1985) describes these as revolutionary and evolutionary eras. Tushman and Romanelli (1985) conceptualize organizations as evolving systems with strategic reorientations punctuating periods of convergence. During periods of convergence, attempts at normal change are often resisted. However, during periods of strategic reorientation, relatively minor disturbances within the organization (or perturbations from the environment) can trigger large qualitative changes in the organization. Recognition of these discontinuities is an important first step in understanding organizational changes. It suggests a research agenda that points to the futility of seeking "predetermined timetables, of ordered and inevitable sequences or stages" (Pettigrew 1990,270). The remainder of this section reviews and discusses exemplars of this new research agenda at the work group, organizational and occupational levels.

At the *work group* level, Gersick (1988) rejects the received view that groups progress through generalizable phases, such as "forming, storming, norming and performing" (Tuckman 1965). Rather, Gersick (1988) notes, each work group weaves in and out of these "phases," following a trajectory shaped by the work team's initial disposition and ongoing history. Gersick (1991) argues that these apparently random temporal variations in the work group emerge from a stable and coherent "deep structure" (p. 12). Gersick (1991, 12) defines a deep structure as the "basic activity patterns" that provide the group with a "menu" of choices at each point in time. All work teams have the same basic activity patterns, and yet the manner in which they unfold may vary significantly depending on the choices made by the groups-especially their initial choices.

At the organizational level, Van de Ven and Poole (1990) note that many studies have examined the antecedents to, or consequences of, innovation (for a review, see Tornatsky et al. 1983). These studies, consistent with the tenets of traditional systems contingency theories, seek to explain organizational innovation in terms of structural characteristics such as centralization, differentiation, and integration. However, Van de Ven and Poole (1990,313) note that "very few studies have directly examined how and why innovations emerge, develop, grow or terminate over time." They seek to develop a "process theory that may produce some fundamental 'laws of innovating' useful for explaining how a broad class of processes, sequences and performance conditions unfold along the innovation journey" (Van de Ven and Poole 1990,313).

At the occupational level, Barley (1990,221) notes that studies examining the effects of technology on occupational roles were "wittingly, or unwittingly premised on Marx's notion that shifts in the technical infrastructure transform societies by altering modes and relations of production." Indeed, the sociotechnical perspective (Rice 1958; Trist and Bamforth 1951) is one of the best articulated systems contingency theories in the organizational literature. The sociotechnical systems perspective argues that the introduction of new technologies in the workplace must be accompanied by changes in the organization's manifest structural configurations. However, Barley (1990) argues that in order to understand the interrelationship of technologies with roles and structures, organizations are better conceptualized as manifestations "of a stream of ongoing actions, interactions, and interpretations that gradually define the contours of tasks, roles and relationships" (p. 223). From this standpoint, Barley (1990, 221) seeks to "chronicle the actions, interactions, and interpretations occasioned by specific machines to explain how technically induced changes in an interaction order (Goffman 1983) might lead to organizational and occupational change."

The three research examples, discussed above, do not seek to explain behavior in terms of contingencies predicated on the manifest structural configurations of group, organizational, or societal systems and subsystems. Instead, they focus explicitly on the emergent process of organizing-the deep processes of transformation that produce

overt patterns of behavior. Hence, in all three examples, "what is cr ical is not just events, but the underlying logics that give events mea ing and significance . . . logics which may explain how and why the patterns occur in particular chronological sequence" (Pettigrew 199 273). Understanding and explicating these underlying "logics change" (Morgan 1986,234) require a closer examination of five co ceptual issues that were ignored in research guided by traditional sy tems theory: (i) differences in knowledge claims made by cros sectional and dynamic research, (ii) mutual causality, (iii) historicit (iv) time-irreversibility, and (v) discontinuity.

The next section discusses these five conceptual issues and poin to the limitations faced by traditional systems theorists in addressir them. In subsequent sections, I will argue that self-organizing systen theory (Prigogine 1980) provides an opportunity to intellectually ac vance our understanding of organizational communication processe by responding to the limitations of traditional systems theory. Specif cally, self-organizing systems theory is offered as an appropriate cor ceptual framework to explicitly articulate the underlying logics c change and to systematically examine the processes by which these log ics of change generate, sustain, and change surface structures.

Issues neglected by traditional systems research

Dynamic inferences

The renewed emphasis on "process thinking" has underscored the importance of understanding the dynamics within organizations-a concern that has not been lost on contemporary functionalist research (Monge et al. 1984). It is therefore not surprising that most contemporary organizational communication researchers either examine dynamic hypotheses or, more likely, suggest that future research must validate their cross-sectional findings in a dynamic context. In this section I will argue, with the help of a research example, that there are fundamental distinctions between the nature of knowledge claims assocĳared with cross-sectional and dynamic hypotheses. These distinctions demonstrate why testing the adequacy of process theories on the basis of cross-sectional hypotheses will, in most cases, lead to misleading conclusions.

With the emergence of interpretive perspectives in the study of organizational communication, there has been a renewed interest in research examining the relationship between communication, shared understanding, and coordinated activity in the workplace. Some organizational researchers (e.g., Van Maanen and Schein 1979) have argued that coordinated activity, including but not restricted to communicative action, is made possible as a result of individuals sharing a common set of meanings and interpretations. Others (e.g., Weick 1979) have proposed that shared meanings, rather than being a precursor of coordinated activity, results from retroactive sense-making.

A third group of organizational researchers (e.g., Barley 1986; Contractor and Ehrlich, 1993; Contractor and Eisenberg 1990; Pettigrew 1990; Poole and DeSanctis 1990; Ranson, Hinings, and Greenwood 1980; Riley 1983; Yates and Orlikowski 1992) suggest that coordinated activity and the existence of a common set of shared meanings and interpretations are recursively linked to each other—each shapes the other in an emergent pattern. Their arguments for this recursive model are grounded in Giddens' (1984) metatheory or structuration. According to Giddens (1984, 2), "Human social activities, like some self-reproducing items in nature, are recursive. That is to say, they are not brought into being by social actors but continually recreated by them via the very means whereby they express themselves as actors. In and through their activities agents reproduce the conditions that make these activities possible." The underlying logic generating this recursive process is termed modalities (Giddens 1984) or appropriations (Poole and DeSanctis 1990).

Traditional functionalist research would test the relationship between coordinated activity and shared interpretations by positing the following cross-sectional hypothesis: Organizational members who coordinate their activities with each other are more likely to share common interpretations than members who do not coordinate activities with others.

However, it is important to recognize that lack of empirical support for this cross-sectional hypothesis does not, in and of itself, indicate lack of support for the proposed recursive model linking coordinated activity and shared interpretations. The relationships between coordinated activity and shared interpretations described above refer to the *underlying* logic-not its manifestations at a particular point in time. Hence, even though the underlying logic posits a reinforcing recursive relationship between coordinated activity and a shared set of interpretations, organizational members with a diverse set of interpretations can in certain situations coordinate their activities—an organizational communication phenomenon described by Eisenberg (1986) as the "unified diversity." Indeed, Donnelon, Gray and Bougon (1986) found that group members were able to coordinate their activities in the absence of a shared set of interpretations by the process of

developing equifinal interpretations. Interpretations are said to be equifinal if despite their differences, they lead to similar outcomes.

The arguments presented above indicate that cross-sectional hypotheses are inappropriate to test the adequacy of the proposed recursive model. Instead, consider the following four dynamic hypotheses:

1. The current level of coordinated activity between organizational members will be significantly influenced by their prior level of coordinated activity.
2. The current level of shared interpretations among organizational members will be significantly influenced by their prior level of shared interpretations.
3. Prior levels of coordinated activity between organizational members will influence their current level of shared interpretations, beyond that predicted by their prior levels of shared interpretations alone.
4. Prior levels of shared interpretations between organizational members will influence their current level of coordinated activity, beyond that predicted by their prior levels of coordinated activity alone.

The first and second hypotheses explicitly acknowledge that organizational processes are, in part, self-generating-a process referred to as *autocatalysis* or *self-referencing* by systems theorists (Eigen and Schuster 1979). The third hypothesis posits that variable x (coordinated activity) causes variable y (shared interpretations) in a dynamic context, if and only if, changes in variable x can predict changes in variable y above and beyond those predicted by past values of variable y. Likewise, the fourth hypothesis proposed variable y (shared interpretations) causes variable x (coordinated activity) in a dynamic context, if and only if, changes in variable y can predict changes in variable x above and beyond those predicted by past values of variable x. The definition of dynamic causality employed in the third and fourth hypotheses was first proposed by Granger (1980), and is referred to as *Granger causality.*

The above example serves to underscore the differences in knowledge claims made by cross-sectional and dynamic hypotheses. Notwithstanding its widespread currency, there is *no* substantive reason to believe that support, or lack thereof, for the cross-sectional hypothesis must be consistent with the corresponding dynamic knowledge claims. Indeed, Abell (1971, 2) proves mathematically that causal coefficients obtained from cross-sectional and dynamic knowledge claims would correspond if, and only if, the two variables are in "aggregate equilibrium" (p. 3). Two variables are in aggregate equilibrium if one of two conditions are valid: (i) there is no change over time in the level of coordinated activity ***and*** the level of shared interpretations, or (ii) the rates of change for the level of coordinated activity and shared interpretations are exactly equal. Both of these assumptions are unlikely to be valid, rarely made explicit, and almost never tested. Abel1 (1971, 3-4) notes that, "The ease with which correlations between variables are taken as significant parameters without any reason to suppose the variables have reached a joint equilibrium distribution is disturbing."

Like most communication theories, the structurational arguments being forwarded here are fundamentally of a processual nature-and must therefore lead to the test of dynamic knowledge claims. These arguments, therefore, do not offer an intellectual rationale to deduce and expect support for the cross-sectional hypothesis relating the amount of coordinated activity and shared interpretations. The arguments presented above do not discount the significance of cross-sectional research. Rather, they underscore intellectual differences in inferences gleaned from the examination of covariance across cases (such as, individuals) at one point in time, and the covariance across time (that is, change) for each case.

The tenuous connection between cross-sectional and dynamic knowledge claims have long been emphasized by social scientists (Coleman 1964). However, the early practitioners of traditional systems theory, many of who were social demographers interested in cross-sectional knowledge claims, invested considerable efforts in proposing and testing models that posited direct and indirect causal relationships among a large set of cross-sectional variables (Blalock 1960). Abbott (1988) notes that this investment of effort also resulted in the development and cornmodification (in canned computer packages, such as Statistical Package for Social Sciences SPSS) of sophisticated multivariate statistical techniques, ranging from regression analysis to structural equation modelling. Unfortunately, their efforts also led to the unquestioned deployment of these statistical techniques by researchers who were seeking to test process theories.

Mutual causality

With its emphasis on identifying contingencies, research conducted from a traditional systems framework typically hypothesized and tested unidirectional causal relationships from organizational antecedents to outcomes. However, unidirectional causal models are not appropriate to articulate and test process theories that explicitly posit circular relationships (Monge 1982). The concept of circular relationships has received considerable attention from contemporary systems

theorists. Two elements that have a circular relationship are described as being ***mutually causal.*** Maruyama (1982) described different ways in which mutually causal "loops" can help preserve or change a system. In ***cybernetic*** systems, the two elements influence each other to preserve the system at some stable state. However, in ***morphogenetic*** systems, the two elements transform each other and thereby change the system. In the structurational example discussed above, a cybernetic explanation would be appropriate in situations where organizational members engage in stable patterns of coordinated activity guided by stable shared interpretations. In such situations, a departure from existing levels of coordinated activity would be viewed as an aberration, and members would be guided by their stable shared interpretations to reduce any future aberrations. In contrast, a morphogenetic framework would be more appropriate in explaining the emergence of new patterns of coordinated activity and the elaboration of new interpretations (Archer 1982).

Traditionally, functionalist researchers in organizational communication have avoided positing mutually causal relationships, in large part because they are confined to the logic of unidirectional causal modeling. For instance, following the example discussed earlier, structurational arguments explicitly acknowledge a circular relationship between members' coordinated activity and their shared interpretations. However, there have been very few attempts at developing dynamic models that explicate such mutually causal relationships (Erickson 1988; for preliminary work, see Abelson 1979; Coleman 1957).

Historicity

The logic of univariate causal modeling has also limited functionalist researchers' ability to adequately take into account the historicity of organizational communication procsesses. Historicity refers to the time-dependent nature of relationships among a set of variables. For instance, Abbot (1988, 173) notes that functionalist research "seldom take the position, common in historical writing, that 'at time t, x was important, while later, the conjuncture of things, made y more important'." Statements of this form are theoretically intuitive and have long constituted the bedrock of interactionist and ethnomethodological perspectives (Blumer 1956; Sacks, Schegloff, and Jefferson 1974).

In the terminology of systems theory, this problem can be traced to the flawed assumption of linearity in contemporary functionalist research. In a linear system, a unit change in the value of a variable x will always cause a specific change in the value of variable y. However, in nonlinear systems, the change in variable y resulting from a unit change in variable x will depend on the magnitude of variable X.

As discussed earlier, structurational arguments lead to the dynamic propositions that changes in coordinated activity among organizational members will influence their shared interpretations, and vice versa. In a linear system the magnitude of the mutually causal coefficients would be assumed to be constant. That is, regardless of their history, a unit change in organizational members' coordinated activity will always result in a specific change in their level of shared interpretations, and vice versa. This proposition is not consistent with process arguments nor is it borne out by empirical observations. For instance, several scholars have noted that the processual dynamics at the early stages of organizing are qualitatively different from later stages (Eisenhardt and Schoonhoven, 1990; Gersick 1988, 1991; Stinchcombe 1965). In a nonlinear system, the magnitude of the mutually causal coefficients will themselves vary depending on the existing and prior levels of coordinated activity and shared interpretations. Hence, using nonlinear systems models, it is possible to posit, for instance, that in cases where there is moderate coordinated activity among organizational members, a unit increase in the activity will result in a substantial increase in their shared interpretations; in cases where there is already a high level of coordinated activity among members, a unit increase in activity will have a smaller impact on their shared interpretations.

While, functionalist researchers have not generally hypothesized nonlinear models, there have been some attempts to capture the historicity of organizational processes using transfer function and autoregressive integrated moving average (ARIMA) models (Monge, Cozzen,sand Contractor 1992). These models allow variables to depend on their own past levels and on past random disturbances (Box and Jenkins 1976).

Time irreversibility

The phenomenon of time-irreversible effects have been discussed extensively in thermodynamics (Prigogine 1980) and electromagnetics, where it is referred to as "hysteresis." In general terms, it can be used to describe a wide range of organizational communication processes that take the following form: A unit increase in a variable x will result in an increase in variable y. However, a subsequent unit decrease in variable x will *not* result in a corresponding decrease in variable y.

Structurational arguments, discussed earlier, provide an example of the time irreversibility phenomenon. An increase in the level of coordinated activity among organizational members will influence their shared interpretations. However, it is plausible that organizational members will maintain these shared interpretations even if there is a modest reduction in their level of coordinated activity. Functionalist researchers have, as a rule, not articulated or tested hypotheses that capture this phenomenon (see Oliva, Day, and MacMillan 1988 for an exception). This is because of the implicit assumption in the logic of unidirectional causal modeling that if an increase in variable x results in an increase in variable y, it must follow that a decrease in variable x will always result in a corresponding decrease in variable y.

The phenomenon of time irreversibility, like the notion of historicity discussed earlier, is a characteristic of nonlinear systems and entered the mainstream of systems discourse with the emergence of catastrophe theory (Thorn 1975; Zeeman 1977) As mentioned earlier, the magnitude of the mutually causal relationships between variables x and y in a nonlinear system are *not* assumed to be constant. Rather, the magnitude of the causal coefficient varies as a function of the existing and prior levels of the variables. In cases where time-irreversible effects occur, the magnitude of the causal relationships are determined not only by the prior levels of the variables, but also the *direction* in which they are changing, that is, if they are increasing or decreasing. For instance, the causal effect of x on y will have one magnitude if x is increasing, and a different magnitude if x is decreasing.

Discontinuity

In the introduction to this chapter, discontinuous changes were identified as one of the intriguing phenomena observed in contemporary organizations. The term discontinuity is used to characterize sudden qualitative change in the emergence of an organizational process—a discontinuous change in one variable resulting from a continuous change in another variable. In its simplest form, a discontinuity can be used to describe organizational processes that take the following form: "In cases where a variable x is below a certain threshold level, a unit change in variable x has a certain effect on variable y. At values higher than the threshold level, a unit change in variable x has a qualitatively different effect (or no effect whatsoever) on y." The threshold level of x represents the point of discontinuity, sometimes referred to as a bifurcation point (Thorn 1972).

Such a discontinuity can occur in the relationship between organizational members' coordinated activity and their shared interpretations. A modest decrease in the level of shared interpretations can prompt organizational members to ***increase*** their level of coordinated activity-with the expectation that this increase in activity would reduce their differences in interpretation. However, if the decrease in the level of shared interpretations crossed a threshold level, members would, in frustration, drastically ***reduce*** their level of coordinated activity. A study conducted by Schachter (1951) points to a similar discontinuity in the causal relationship between agreement among individuals and their interpersonal communication. Schachter found that a modest level of disagreement among students in a dormitory prompted them to ***increase*** their communication with one another—but only to a point. If the disagreement among individuals increased beyond this point, individuals chose to drastically ***reduce*** their communication with one another.

The systematic study of "discontinuities" from a systems perspective was first articulated by catastrophe theorists (Thorn 1972; Zeeman 1977). Catastrophe theory developed a formal model to describe discontinuous changes in a system from one state to another. For instance, Flay (1978) applied catastrophic models to explicate Fishbein and Ajzen's (1975) theory relating attitude and behavior. Flay (1978) employed a catastrophe model to specify conditions under which minimal changes in individuals' attitudes could result in sudden discontinuous changes in their behavior.

Prigogine (1980) proposed a more general form of discontinuity. It extended the concept of discontinuity to include sudden shifts between random behavior and systematic patterns. Thus, according to Prigogine (1980), a discontinuity marks a point where a system of variables that exhibit random behavior are transformed into self-organized systematic patterns.

The phenomenon of discontinuity, like historicity and time-irreversibility, can only be articulated and tested in nonlinear systems models. Not surprisingly functionalist research have neglected examining the nature of discontinuities in organizational processes. Unlike historicity and time irreversibility, discontinuity as conceptualized by Prigogine (1980) only occurs in nonlinear systems that are "far-from-equilibrium." A system is defined as being "far-from-equilibrium" when (i) it imports a large amount of energy from outside the system, (ii) uses the energy to help renew its own structures, a process referred to as "autopoeisis" (Varela, Maturana, and Uribe 1974) and (iii) expels, rather than accumulates, the accruing disorder (entropy) back into the environment.

It is important to distinguish between the traditional notion of an "open" system and a "far-from-equilibrium" system. In both cases, the system transacts energy and/or information with the environment. In the case of traditional "open" systems, the energy and information drawn from the environment is used to keep the system at a desired equilibrium state. Thus the order in traditional "open" systems refers to the stable configuration of various structures within the system. However, in "far-from-equilibrium" systems, energy and information are drawn ***to*** keep the system in a state of ongoing flux. At a point of discontinuity, this flux takes on an ordered pattern. Thus the order in "far-from-equilibrium" systems, termed "***process structure***" (Jantsch 1980a, 21), refers to the stable patterns associated with the dynamics within the system. Prigogine (1980) suggests that the shift in interest from traditional "open" systems to "far-from-equilibrium" systems reflects a shift in intellectual interests from questions about "being" to questions about "becoming"-a transition reflected in recent organizational scholarship.

Summary

This chapter began with the observation that, in the past decade, there has been widespread disenchantment with the application of traditional systems theory to the study of organizational communication. This section has described five classes of organizational phenomena that are consistent with many of the arguments proposed in process theories, but have been virtually ignored by functionalist research in the area of organizational communication. ***Contemporary,*** in contrast to traditional, systems perspectives, offer a vocabulary to precisely conceptualize these phenomena. It therefore seems appropriate for scholars to reevaluate the utility of systems perspectives in the study of organizational communication. The next section describes the theoretical assumptions and requirements of one of the most influential systems perspectives to emerge in the past decade-self-organizing systems theory.

Theoretical requirements for self-organizing

Broadly speaking, self-organizing systems theory seeks to explain the emergence of patterned behavior in systems that are initially in a state of disorganization. From the start of this century, researchers in many of the physical and life sciences had observed that systems initially in a state of disorganization (high entropy) would under certain conditions ***spontaneously*** demonstrate patterned behavior.

In 1900, the French physicist Henri Benard reported that heating a thin layer of liquid wedged between two glass plates can cause organization to appear in the form of a honeycomb consisting of hexagonal cells of convecting liquid. In the early 1950s, Belousov, a biophysicist at the Soviet Ministry of Health, and a fellow Russian Zhabotinsky were studying how enzymes helped the body's metabolic processes. While studying a set of chemical reactions they noticed that as they continued to add reactancts and agitate the mixture, the solution started to oscillate between being colorless and of a yellow hue. The oscillations were extremely stable and the reaction was dubbed as a "chemical clock." Both of these studies were perceived by the scientific community as curiosities. After all, the laws of thermodynamics predicted that the addition of energy to a system should increase the system's state of disorder.

Starting in the late 1950s, systematic investigations into the processes of self-organization were undertaken by Ilya Prigogine and his colleagues at the Free University of Brussels and Heinz von Foerster and his colleagues at the Biological Computer Laboratory at the University of Illinois (Jantsch 1980a). The critical breakthrough occurred when Prigogine and his colleagues mathematically derived four key features that were common to all systems that exhibited the emergence of spontaneous order (Glansdorff and Prigogine 1971):

1. At least one of the components in the system must exhibit autocatalysis.
2. At least two of the components in the system must be mutually causal.
3. The system must be open to the environment with respect to the exchange of energy and matter.
4. The system must operate in a far-from-equilibrium condition.

Prigogme and his colleagues mathematically proved that these four characteristics were necessary, but not sufficient, theoretical requirements for a system to self-organize. Further, Prigogine mathematically deduced that the emergence of spontaneous order was not theoretically inconsistent with principles of nonequilibrium thermodynamics-a landmark accomplishment that earned him the Noble Prize in 1977 (for technical discussions of self-organizing systems theory, see Nicolis and Prigogine 1977, 1989; Prigogine 1980; Schieve and Allen 1982; for nontechnical overviews, see Briggs and Peat 1989; Coveney and Highfield 1990; Jantsch, 1980b; Prigogine and Stengers 1984).

During the past decade, the notion of self-organizing systems have galvanized scholars interested in a wide range of issues. Researchers

have drawn on self-organizing systems theory to describe heart rhythms (Noble 1979; Glass and Mackey 1988), creation of biological shapes (Meinhardt 1982), population dynamics among species (May 1976), the epidemiological spread of diseases (Schaffer, Olsen, Truty, and Fulmer 1990), the physiology of perception (Freeman 1991), the psychology of optimal experiences (Csikszentmihalyi 1990; Eisenberg 1990), strategies for collective action in social systems (Garfinkel 1987), cultural evolution (Loye and Eisler 1987), the dynamic evolution of urban centers (Allen and Sanglier 1980), the redistribution of wealth across nations (Gierer 1980), the evolution of economies (Boldrin 1990; Radzicki 1990), the pattern of business cycles (Sayers 1990), the dynamics of international security (Grossman and Mayer-Kress 1989; Mayer-Kress 1990; Saperstein 1990), the emergence of civilizations (Iberall 1987), theories on the evolution of life (Gould 1987; Dawkins 1987), the "Gaia" theory of earth as a living system (Lovelock 1979, 1990; Margulis and Sagan 1986), and the design of self-organizing technological networks (Bellman and Roosta 1987).

In addition, there have been calls for the application of self-organizing perspectives in management (Malik and Probst 1984; von Foerster 1984); organizational change (Ford and Backoff 1988; Gersick 1991; Goldstein 198 8), the appropriation of new communication technologies (Contractor and Seibold 1993), communication and societal development (Braman, in press; Krippendorf 1987), communication and cultural evolution (Kincaid 1987), and mass communication technologies and society (Batra 1990). The theory of self-organizing has also caught the attention of humanists. Hayles (1990,291) investigating the parallels between postmodernism and the theory of self-organizing systems, notes that they share a "a deeply ingrained ambivalence toward totalizing structures!" The next section provides an example of how structurational arguments to study the emergence of shared meaning in organizations can be articulated in a self-organizing systems framework.

Explicating a theory in a self-organizing systems framework

The first two of the four dynamic hypotheses, presented earlier in this chapter, proposed that organizational members' coordinated activity and their shared interpretations are, in part, self-generating. The third and fourth hypotheses proposed mutually causal relationships between members' coordinated activity and their shared interpretations. This section begins by casting these hypotheses in a self-organizing systems framework.

(i) Shared interpretations (Shared *Interp*) are sustained and developed among organizational members who coordinate their activity (Coord. *Act.*).

$$K_1$$

$$\textbf{\textit{Coord. Act.}} + \textbf{\textit{Shared Interp}} \Rightarrow \text{Increase in } \textbf{\textit{Shared Interp}} \quad (1)$$

(ii) Coordinated activity ***(Coord. Act.)*** is sustained and developed among organizational members who share their interpretations ***(Shared Interp.).***

$$K_2$$

$$\textbf{\textit{Coord. Act.}} + \textbf{\textit{Shared}}\ \textit{Interp} \Rightarrow \text{Increase in } \textbf{\textit{Coord. Act.}} \quad (2)$$

where, K_1 and K_2, the nonlinear causal coefficients, are referred to as the system's parameters.

According co self-organizing systems theory, the underlying logics described in equations 1 and 2 do ***not,*** by themselves, meet the four theoretical requirements necessary to describe the emergent processes suggested by structurational arguments. This is because, equations (1) and (2) meet only two of the four theoretical requirements for self-organizing. In equation (1), shared interpretation among organizational members is hypothesized to reproduce itself, while in equation (2) coordinated activity is hypothesized to reproduce itself. These two hypotheses meet the requirement of ***autocatalysis.*** Further, equations (1) and (2) indicate a ***mutually causal relationship*** between coordinated activity and shared interpretation among individuals, meeting the requirement of mutual causality. However, equations (1) and (2) do not met the third and fourth theoretical requirements for self-organizing. The equations do not specify how the system is open to the environment; further, the equations do not specify the mechanisms under which the system can operate in a ***far-from-equilibrium*** condition.

In terms of organizational theory, the underlying logics offer an incomplete characterization, because they do not explicitly posit that demand and supply from the organization's environment provide the rationale for members' coordinated activity. Even though this obser-

vation is not inconsistent with structurational arguments, it has not been explicitly discussed by theorists as a key element of the underlying logics of change. Equation (3), below, is one attempt at responding to this limitation. Specifically, it posits that material and symbolic resources from the organization's environment ***(Environmental Resources)*** influence the levels of coordinated activity ***(Coord. Act.)*** among organizational members.

$$K_3$$

$$\textbf{\textit{Environmental Resources}} \Rightarrow \textbf{\textit{Coord. Act.}} \quad (3)$$

where, K_3, a nonlinear causal coefficient, is a system parameter.

The three equations offer one possible representation of the underlying logics of change that are based on structurational arguments ***and*** meet the theoretical requirements of a self-organizing systems model. As mentioned in the previous section, the four theoretical requirements for self-organizing articulated by Glansdorff and Prigogine (1971) are necessary, but not sufficient conditions. This implies that the underlying logics described in the three equations do not ensure the emergence of a self-organized meaning system. Rather, they describe the "design of the playing field and the rules of the game," while the emergent patterns that may arise from these logics might be "compared loosely to a game in play" (Gersick 1991, 16).

Even though the system is relatively simple-three variables (coordinated activity, shared interpretations, and environmental resources) in three equations-it is well nigh impossible for any human to mentally construe the wide variety of long-term dynamics that can be generated by the underlying logic (Poole 1990). Further, because the system of equations are nonlinear, they do not, as a rule, have closed form solutions and are therefore not analytically tractable. However, recent developments in computational science make it possible to use simulations as a tool to observe the long-term dynamics implied by the proposed underlying logics. Simulations help the researcher add precision to the verbal descriptions of the underlying logics in three areas.

First, verbal descriptions of the structurational process posit that coordinated activity and shared interpretations influence each other in a recursive process. In the self-organizing model proposed here, these influences are represented by the system parameters (the nonlinear causal coefficients, K_1, K_2, and K_3). Due to the lack of precision in the verbal formulation, a researcher can only make an educated guess on the nature of these coefficients. Simulations help the researcher examine if, and how, changes in the specification of the system's parameters will qualitatively alter the structurational processes.

Second, verbal descriptions of the structurational process do not offer precise predictions of how the initial levels of coordinated activity, shared interpretations, and environmental resources would influence the self-organizing process. Simulations help the researcher explore transient and long-term effects, if any, of these initial conditions.

Third, though verbal descriptions of the structurational process suggest that the dynamics of coordinated activity and shared interpretations display the effects of historicity, time irreversibility, and discontinuity, they do not offer specific conditions for their occurrence. Simulations provide the researcher an opportunity to precisely identify conditions under which the dynamics implied by the underlying logics would display historicity, time irreversibility, and discontinuity.

The information obtained in these three areas will help researchers deduce precise hypotheses about the transient and long-term dynamics implied by the proposed underlying logics of change. Empirical support for these hypotheses would indicate that the self-organizing system reformulation of the structurational arguments were not falsified. Notice that the goal is to deduce hypotheses based on the observation of *qualitative* changes in the long-term dynamics, not to make numeric predictions about the level of coordinated activity or shared interpretations among organizational members. Hence, the absolute values of the parameters used in the simulation are not in and of themselves consequential. Using simulations to help social scientists better comprehend and appreciate the process structures implied by the proposed underlying logics was first proposed by Forrester (1973) and more recently advocated by Hanneman (1988) and Poole (1990). It represents the use of simulation for theory building, as compared to its conventional use in the physical sciences for model predictions and forecasting.

It must be emphasized that the model described above, while illustrating the process by which structuration theory can be reformulated in terms of a self-organizing system, is exceedingly simplified. Two limitations warrant special mention. *First,* the equations imply that the set of coordinated activities and shared interpretations are treated homogeneously. That is, shared interpretations on issue A are assumed to have the same influence as shared interpretations on issue B. Likewise, coordination on activities P and Q are considered to have the same impact on the self-organizing process. While this assumption helps simplify the illustration above, it is inconsistent with the tenets of structuration theory, and must be discarded in any rigorous implementation of the self-organizing systems model. *Second,* the model illustrated above is wholly deterministic and does not allow for external random disturbances. This simplifying assumption is problematic on two counts. It violates our social sensibilities of naturally occurring systems. More importantly, from a self-organizing systems framework, the absence of external random variations imply that the model can only describe the persistence or change in shared interpretations and activity. It precludes the ability to model the emergence or elaboration of new interpretations or activity.

Conclusion

There is widespread consensus that traditional systems theory failed to realize its promise as an appropriate framework for the study of organizational communication. There are intellectual as well as pragmatic reasons that contributed to this failure. In this chapter I have described many of the *intellectual* shortcomings of traditional systems theory. In many instances, these shortcomings were first brought to the attention of the field by interpretive and critical researchers. Their conceptual contributions have motivated proponents of systems perspectives to reexamine the theoretical assumptions of traditional systems theory. In retrospect, traditional systems theory was appropriate in understanding how to stabilize and control systems with a large number of components. This made it very useful in the domain of technology. However, it proved less useful to scholars who were interested in examining process structures in systems where equilibrium was not a desirable goal.

The self-organizing systems perspective outlined in this chapter has the potential of renewing interest in systems approaches to the study of organizational communication. More importantly, and perhaps more controversially, it bears the promise of building on insights gained from contemporary interpretive and critical research. Many of the central concepts in interpretive-critical research (such as intersubjectivity, structure, production and reproduction, symbolic convergence, and interpretive schemes) are richly evocative but highly abbreviated verbal descriptions that are inadequate both in defining the concepts and articulating their interrelationships. Poole (1990) characterizes this as the interpretive-critical version of a "reductionist" problem. Contemporary systems perspectives, such as self-organizing systems theory, offer the vocabulary and the mechanisms to add precision to many of the concepts and relationships of interest to interpretive-critical research.

In closing, it is also instructive to review some of the *pragmatic* issues that contributed to the failed promise of traditional systems theory. When it was first introduced, many researchers in organizational communication embraced the systems metaphor in their work. However, as Poole (1990, 6) notes, "Most often, systems theory became a metaphor, rather than an instrument of analysis." In a review of social science systems models, Berlinksi (1976) observed that several of them lacked precision and tended to use systems terminology in a ceremonial way.

One potential reason for this lack of precision was the lack of easily accessible computational resources. This obstacle has been overcome in the past decade, with the development of several easy-to-use simulation and modeling programs for the personal computer including DYNAMO (Richardson and Pugh 1981), STELLA (Richmond and Peterson 1990) and MATHEMATICA (Wolfram 1992).

Another potential reason for the ceremonial use of systems concepts may be due to researchers' lack of training in systems methodology. As Poole (1990, 17) observes, "Communication researchers must grapple with modelling software, learn the necessary mathematics and computer languages, and struggle with shaping the formalisms to our needs." It would be a tragedy if the intellectual promise of contemporary systems perspectives in the study of organizational communication were stymied because of our inability to overcome these pragmatic hurdles.

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