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Complexity and the Role of Ethics in Health Care

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This article addresses the problem of organizational change in a rapidly changing institutional sector, the United States health care system. After a brief respite, the cost of health care has continued to rise. In addition, industry leaders are concerned about the rate of medical errors and other threats to quality that result in the needless deaths of between 44,000 and 92,000 Americans per year (Kohn *et al*., 2000). Thus, the health care system and its components are under pressure to improve the quality of processes and outcomes of care, but simultaneously they are wrestling with demands to reduce, or at least constrain, costs (Kleinke, 2001; Robinson, 1999; Scott *et al*., 2000).

Even when change is necessary, conflicts of values and goals can impede the capacity of a complex organization to implement those necessary changes. The extent to which the values of its members are congruent with and further the goals of the organization plays an important role in its success in initiating and surviving change. Congruence in values between the organization and its members can result in an ethical climate that is conducive to and supportive of change, but such congruence will depend on the appropriate identification of the systems and processes that make up the organization's culture.

The influential Institute of Medicine, a research organization devoted to problems of the US health care system, recently addressed the problem of improving that system's quality by recommending that it be approached as a complex adaptive system (Committee on Quality and Health Care in America, 2001; hereafter CQC). In what follows we

accept that committee's assumption that this approach will prove fruitful in addressing the problems of this troubled sector, and focus on one segment of the larger system, the health care organization. We distinguish between an adaptive and a mechanical approach to its subsystems and processes, and describe what we mean by a positive ethical climate, and its role as an indicator of organizational culture. We discuss actual and potential damaging effects of approaching adaptive systems mechanically, and recommend an organization ethics program to increase the flexibility of the health care organization's culture in a way that does not threaten its cohesiveness.

COMPLEXITY AND HEALTH CARE

There has been considerable work done in the last few decades applying complex systems theory, the study of the dynamics of change, to social systems. Despite significant success in generating applicable models in other disciplines, complexity is not yet a science when applied to some areas of human social interactions. However, complexity theory offers a new perspective on the relationships that make up various systems, and in particular, the approach can be useful in understanding the relationships that characterize organizations. As a *science* applied to organizations, complexity theory recommends the empirical study of organizational populations to develop models that can explain organizational dynamics and open up the possibility of interventionist strategies (Dooley & Van de Ven, 1999: 358).

This descriptive and analytical task, which "models how microstate events self-organize into emergent aggregate structures" (McKelvey, 1999: 5) is beyond the scope of this article. Our more modest goal is to adopt a complexity *perspective*. In this approach, complexity is not a methodology, but a way of thinking about organizations (Mitleton-Kelly, 1997: 3). Scholars occupied with particular problems in the social sciences have found the approach illuminating in their own areas, and there are a growing number of influential publications on strategy and organizational complexity (Mitleton-Kelly, 1997; Olson & Eoyang, 2001; Stacey, 1995, 1996, 2000).

A "system" is a complex of interacting components, together with the relationships between them, which permits the identification of a boundary-maintaining entity or process (Laszlo & Krippner, 1988: 51). Systems may be micro (small, self-contained, relatively autonomous) or macro (complex, with a large number of interconnections). There is a

difference between primarily mechanical and primarily adaptive systems. This distinction, in terms of rigidity, is fundamental. It describes how the system is designed and how it responds to external stimuli. Social systems differ from natural systems in that they incorporate human agents as components, affecting and affected by other agents and the environment, capable of free will and innovation. Approaching the health care organization as a complex adaptive system emphasizes interrelations, interactions, and connectivity (Zimmerman & Dooley, 2001: 73), an approach that is intuitively appealing when applied to health care, a service industry with human interaction at its core.

The Institute of Medicine report on quality suggests an orientation on the goal of the health care system: to continually reduce the burden of illness, injury, and disability, and to improve the health and functioning of the people of the United States (CQC: 39). It gives six specific aims to be kept in mind as values to be maximized in developing strategies for change: The resulting system should be safe, effective, patient centered, timely, efficient, and equitable (CQC: 40). The recommendations bring into prominence the normative aspect of organizational function: the values and obligations felt by individuals within the health care organization in carrying out their activities. The recommendations of this report, conceived and forwarded in the spirit of complex adaptive thinking, can be implemented in that spirit, in which case they will forward the goals of the report, or taken more mechanically, in which case they may not be of much help.

A health care organization is characterized by a number of complex functions, processes, and roles, where objectives are often divergent, leadership roles are shared, and power is diffuse (Denis *et al*., 2001). It is composed of interlocking micro systems, some of which may be primarily mechanical in nature. A system designed to produce predictable results where there is a strong consensus about what outcomes are desirable can usefully be viewed and treated as a mechanical system. In mechanical systems we can predict in great detail the interaction of each of the parts in response to a given stimulus. For instance, a health care organization may employ mechanical processes in its billing or in other procedures that are expected to occur in the same way time after time. When deviation from the anticipated interaction occurs, it is unexpected and generally provokes study and action to prevent recurrence (Plsek, 2001).

When a system has as its primary working parts human beings in interaction, however, the parts of the system "have the freedom and ability to respond to stimuli in many different and fundamentally unpre-

dictable ways" (Plsek, 2001: 310). A health care organization employs teams to evaluate, treat, and monitor patients. These teams will be composed of case managers, doctors, nurses, social workers, chaplains, and others. The interactions of the team members are not always identical and so their consequences cannot always be foreseen or planned. Unplanned consequences can be perceived as an error, or as "emergent, surprising, creative behavior" (Plsek, 2001: 310) If the right conditions are present, a patient team may interact together to produce surprising and creative solutions to specific problems.

Ethics and complexity

We said above that the recommendations of the Institute of Medicine report on quality bring into prominence the values and obligations felt by individuals within the health care organization in carrying out their activities. Organizations also demonstrate their values and obligations through their actions and decisions. For instance, an organization can be operating completely in accord with legal regulations and still be viewed as behaving "unethically" according to generally accepted social norms, by treating its employees unfairly, taking advantage of the ignorance of its patients, or treating objects of wider social concern—endangered species, the environment, underdeveloped societies—in ways with which constituent members of the organization feel uncomfortable. Conversely, an organization can clearly express its agreement with all the generally accepted social norms that govern its areas of activity, but fail to institute policies and procedures that accord with those values, creating dissonance in its membership between its espoused values and its actual behavior. Because the approach of the Institute of Medicine's report focuses on goals and values to be realized, the ethical climate of a health care organization becomes an important indicator of how successfully an organization is orienting itself on its ultimate objectives.

The terminology of "ethical climate" comes from a large body of studies of organizational culture and climate in organization theory (Collins & Porras, 1994; Sims, 2000; Trevino & Nelson, 1995; Victor & Cullen, 1988). Recent scholarship has noted that the terms "culture" and "climate" are sometimes used interchangeably and often refer to the same empirical indicators (Denison, 1996; Detert *et al*., 2000). We distinguish the *culture* of the organization—its structures, administrative style, priorities and values, degree of tightness of interrelations, and feedback loops—from the *climate*, its impacts on its constituent members. The reactions of the

individuals who make up the organization to the structures, processes, and rules that instantiate its espoused values result in a positive ethical climate if the organization furthers their feelings of agency and reinforces their personal and professional values, and a negative one if it impedes them. The culture of an organization conceived as a complex adaptive system may enact a different set of values and structures than an organization that conceives of itself as a mechanical system, and its ethical climate will be different as a consequence.

A positive ethical climate will have at least two important characteristics. First, it is the reflection of an organizational culture in which the mission and vision of the organization inform the expectations for professional and managerial performance and are implemented in its actual practices. Second, it embodies a set of values that reflect social norms for what such an organization should value. In a health care organization, a positive ethical climate will result if the organization's constituents are aware of its mission to provide excellent care at reasonable cost, and will work to bring their activities at all levels of function in line with that mission. An organizational culture that encourages, supports, and rewards excellent professional standards and expert professional judgment will have a positive ethical climate insofar as its constituent members have a wide knowledge of, and internalization of, organizational values, and perceive those values as consonant with their independent professional and individual values and standards. An organization in an environment that is forcing change upon it, or that desires to improve and adapt but has structures or rules that impede change or impose change without consensus, will have a negative ethical climate: low morale and impeded agency. In such a case, the individuals whose decisions and behavior constitute the organization will perceive it to be mouthing values on which it does not act, or to be impeding the processes that it is simultaneously demanding.

In health care organizations there are several loci for normative consideration of organizational and individual actions. The legal department attends to organizational compliance with federal, state, and local regulations and legislation. There may be a committee of medical staff to deal with professional conduct by physicians, and hospitals of more than 200 beds are required for accreditation to maintain an institutional ethics committee or process charged with consultation on conflicts arising in decision making for patient care (Joint Commission on Accreditation of Healthcare Organizations, 1992). Institutional ethics committees as presently constituted have primary responsibility for the clinician/patient

dyad and the policies associated with that relationship. This already-operating normative locus in the institution, if expanded and cultivated as recommended in this article, can serve some of the wider purposes of the organization by being the custodian of the organization's ethical climate.

In what follows, we suggest that the ethical climate of an organization is an indicator for the extent to which it is adapting to the requirements for survival and success in the current environment of turbulent change; that the more a health care organization adopts a "complexity" approach to appropriate systems and processes the more positive the ethical climate will be; and, finally, that an organization ethics process, introduced in an adaptive, rather than mechanical, spirit, can encourage and sustain a positive ethical climate.

We agree with the Institute of Medicine that the current situation in health care requires flexibility, adaptability, and a strong orientation on the goals and mission of the system: precision in areas of high predictability where there is a strong consensus about what outcomes are desirable, such as quality control and efficiency of process, combined with flexibility in areas of less predictability, where successful outcomes depend on expert judgment and experience. Needless to say, one of the greatest difficulties confronting any organization in tumultuous times is properly to distinguish the areas in which greater control is an advantage from areas in which it will prove an impediment. If these areas are misidentified, they will be treated inappropriately and the goals of the system may become obscure to those whose function it is to realize them, while if the areas are appropriately identified, the goals of the system components will be clear.

Quality and the Health Care Organization

Organization theorist Ralph Stacey calls the simultaneous presence of two self-contradictory, essentially conflicting forces a "paradox." It is possible, in some instances, to resolve the paradox by reframing the problem or by consistently choosing one force all the time. In other instances, it may not be possible to remove one or the other force; both must be accommodated at the same time, and it is only possible to do this by continually shifting priorities (Stacey, 2000: 12). The current situation in health care is rife with such competing pressures. We will discuss two such paradoxes, one a product of environmental pressures on the health care organization, one an internal one.

AN ENVIRONMENTAL PARADOX: COST CONSTRAINT VS. QUALITY IMPROVEMENT

The delivery of health care has always been a business, but in the US it has historically been a business that was generously funded by a society that believed health care was more than simply a market commodity. Despite criticisms that the industry was wasteful, and that payment mechanisms and government funding incentivized unnecessary treatment and excess capacity, it can be reasonably argued that the US health care system reflected the values of society concerning the delivery of care for most of the last century (Starr, 1982). But that has changed.

Much of the current disarray in the health care system can be traced to the reluctance of payers to continue to fund the increasing costs of care. This changing paradigm has caused assumptions about the values surrounding care to change as well. Both the costs and the quality of the system are in need of improvement. However, for an individual health care organization, the net effect can be its being subjected simultaneously to incompatible pressures: "improve quality, whatever the cost" and "constrain costs, whatever the impact on the quality of care." While use of computer-based clinical decision-support systems, for instance, can reduce errors in drug selection, dosage, interactions, and side effects, the initial expense of the technology may be prohibitive for a small hospital struggling for economic survival. Reducing staffing may save on payroll expenses, but have undesirable effects on patient satisfaction and safety.

As market problems began to have a greater impact on hospital management, market solutions began to appear as well. Health care organization leaders, faced with revenue squeezes, a radical departure from the past, looked to other industries to derive techniques that could help them restrain the costs of health care. These techniques included restructuring through merging, downsizing, consolidating to eliminate duplicate structures and excess capacity, and financial incentives to control clinician behavior. These techniques share the same goal, of controlling costs through changing the culture of the organization, and that has meant changing its ethical climate.

Many manufacturing industries have introduced various "quality improvement" technologies to improve the efficiency of their production processes, and these technologies later spread to service industries, including health care. The hope, and sometimes the promise, was that improving efficiency of process would also reduce costs. Many of these techniques were designed in the automotive and airplane industries and employed as highly mechanical systems (Grant *et al.*, 1994; Pande *et al.*,

2000). The technologies employed by these initiatives are not flexible, relying as they do on reducing waste or the misuse of resources through the elimination of variation in process, and monitoring outcomes through qualitative accountability mechanisms. Their application in health care delivery organizations is problematic, because they typically assume that tightening up the system will improve efficiency, and improved efficiency will lead to a more effective system.

However, in health care increased efficiency in processes may or may not improve the effectiveness of outcomes. Complexity thinking reminds us that in the real world a fixed set of inputs will never produce a predictable set of outcomes, even when those inputs are apparently similar and other factors are held constant. "In social systems, there are always an infinite number of inputs that cannot be accounted for fully or held constant" (Kleinke, 2001: 110). Changes in core functions need to be introduced in a way that acknowledges the complexity of the organization and allows for flexibility, monitoring their impact and accommodating to unexpected results.

An internal paradox: Evidence-based medicine vs. patient preferences

Change in the social environment of health care is imposing the conflict between cost containment and quality improvement on the health care organization, because of reluctance or inability to continue to support increasing costs. However, there are also competing values that must be negotiated by individual practitioners and by organizations in evaluating outcomes and the effectiveness of care.

Improving the quality of outcomes of clinical practice tends to focus on standardizing treatments of the same disease across practitioners and practice locations, through clinical guidelines and, in the last decade, through increasing emphasis on evidence-based medicine (Kimberly, 2003: 209). Early definitions of evidence-based medicine emphasized the "conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients" (Sackett *et al.*, 1996). It recommends utilization of population-based studies of treatment outcomes in different locations, and suggests that variation in care of similar cases is a negative value and that uniformity and consistency across cases are desirable.

At the same time, there is increasing attention to patient-centered care—care customized, as the Institute of Medicine report puts it, "according to patient needs and values" (CQC: 67). In the report, both

patient-centered care and evidence-based medicine are proposed as important values to be maximized in any reforms of health care delivery. Evidence-based medicine is defined as "the integration of best research evidence with clinical expertise and patient values" (CQC: 76). The emphasis on customization based on patients' needs and values suggests variety and flexibility, giving maximal weight to clinical expertise and patient values. The emphasis on standardization for uniformity of treatment constrains that maximal flexibility. Even within one central recommendation of the report, competing tensions toward mechanization and adaptation are therefore visible. Administrative changes that move the institution toward greater uniformity in clinical function may risk constraining clinical expertise or patient values.

How this tension is resolved will depend on whether or not the health care organization appropriately distinguishes subsystems that should be approached mechanically from those that should be treated adaptively, whether it is able to distinguish those areas where greater control is appropriate from those areas where it is not appropriate. While the employment of efficiency processes in some of the mechanical functions and subsystems of the health care organization may achieve savings, approaching direct patient care in a mechanical, rather than adaptive, way may be a threat to the flexibility that is crucial if professional expertise and patient values and preferences are going to be respected in clinical decision making. These choices will affect the culture and the ethical climate of the organization, and determine the relationship that the organization has with its constituents.

Changing the culture of the health care organization to reflect efficiency through a rigid approach has produced what many Americans view as unacceptable results. Quality of care has suffered as team empowerment has failed (Bednash, 2000), the physician–patient relationship is suspect (Feldman *et al*., 1998), nurses are leaving the field in droves (Bednash, 2000; Berliner & Ginzber, 2002), many people are frightened of health care organizations (Kao *et al*., 1998), and flexibility in care is giving way to utilization measurements, punitive accountability mechanisms, and what some physicians call "cook-book" medicine (Flores *et al*., 2000). Many of these results we attribute directly to the imposition of a complexity of rules formulated through the management techniques we mentioned above, and imposed without regard for their appropriateness for the system or subsystem in question, or for the beliefs, values, and obligations of those affected (Mills & Rorty, 2002).

CONFRONTING PARADOX

Balancing tensions or competing goals is nothing new. Organizations and individuals do it on a daily basis. The competing imperatives that we see in health care cannot be reconciled by reframing the issue, nor is it a simple matter of prioritization. The problem is one of balancing the provider mission of providing excellent patient care, with attention to patients' values and preferences, and the goal of achieving it at a reasonable cost, which many leaders of the "quality movement" in health care have taken to mean reducing variations in delivery (Becher & Chassin, 2001; Berkowitz & Checkley, 2000; Chassin *et al*., 1998). Complexity theory, however, highlights the importance of deciding what kind of system design is appropriate for the task at hand. If a health care organization can appropriately identify those systems that call for mechanization and those that require adaptivity, it can make appropriate choices within the context of achieving its goal of excellent patient care, thus sustaining an appropriate culture and aligning important values.

For reasons of internal and external pressures, the health care system is in a turbulent period of change. However, if we approach the health care organization as a complex adaptive, rather than a mechanical, system, and accept the assumption of complex adaptive systems theory that the ability to change and to encourage innovation will increase the likelihood of organizational survival and success, we need to consider what structures and programs the health care organization might need to promote congruity of values among its agents. How can a positive ethical climate be developed, articulated, and maintained? We explore below a process that the health care organization can introduce to encourage the flexibility and creativity necessary for its mission.

THE ORGANIZATION ETHICS PROCESS

In 1995, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) introduced a requirement for accreditation that requires health care organizations to conduct their business and patient care practices in an "honest, decent and proper manner," while maintaining the priority of excellent clinical care. The JCAHO called this mandate "organization ethics" (Joint Commission on Accreditation of Healthcare Organizations, 1996: 95–7). A broader, more process-oriented definition of health care organization ethics has been advanced by the Virginia Healthcare Ethics Network:

> Organization ethics consists of [a set of] processes to address ethical issues associated with the business, financial, and management areas of healthcare organizations, as well as with professional, educational, and contractual relationships affecting the operation of the healthcare organization. (Spencer *et al*., 2000: 212)

Either approach to "organization ethics" recognizes that the quality of care experienced by patients depends in part on the relationships that the health care organization has with its stakeholders. These relationships depend on stakeholder interactions. Both approaches insist that health care organizations pay attention to these relationships and interactions by creating a positive ethical climate throughout the health care organization. This approach directs attention to how the mission of the health care delivery organization—to provide excellent care at reasonable cost—is carried out in the organization's business, clinical, and professional practices (Spencer *et al*., 2000). Thus, it directs attention to the culture of the organization.

Although no particular structure for such a program or process is specified by the accrediting agency, a model exists in the clinical ethics committees already functioning in most hospitals. Some clinical ethics committees are expanding membership and responsibility to take on organization ethics roles; other institutions have established a separate committee to address broader organizational issues (West & White, 2001).

A program designed to meet the JCAHO organization ethics mandate could be approached mechanically or adaptively. Consonant with our approach in this article, we do not propose that an organization ethics program take on a rule-generating role, nor should it constitute yet another decision-making authority. Instead, it should include representatives of the main functions of the organization, report to either top management or the governing board, and function as a forum for the discussion of perceived conflicts of values arising in the course of organizational strategic change. It would have an advisory and educational mandate.

For instance, in the case of proposed changes to clinical functions for cost control, the program might form an *ad hoc* team to strategize about what form the changes might take to reduce costs while maximizing effectiveness. The mission and values of the organization include both financial survival and clinical excellence, so the organizational culture must include both these values, which means that the structure must

have some degree of flexibility, as well as some means of adjudicating when the two conflict. The organization ethics program represents an opening for communication and adaptability—a process to bring together all stakeholders associated with difficult decisions to ensure that the voices of affected parties are represented. Conflict of values can be treated as a threat to be avoided, or as inevitable, to be utilized as an opportunity for creativity and innovation, and resolved within a broad consensus on the value of patient care. Rather than serving as a source of rules, the organization ethics program could help make many rules dispensable by supporting flexibility and creative interaction among the various agents of the health care delivery organization.

The adaptive organization

The health care delivery organization is not an island, but rather a subset of a larger health care system that is itself subject to competing pressures that affect all aspects of care. It is not appropriate to assign part of its mission—excellent clinical care—to the clinical component, while leaving cost constraints to another component, the administration. The entire organization must function as an organic whole to achieve all its objectives, but that may require some adjustment of traditional roles and responsibilities. It is well advised to identify those expectations that persist through environmental alterations and define it as a health care delivery organization (i.e., reducing patient suffering, increasing clinical expertise), and work toward promoting an awareness of these expectations through the organization's beliefs, behaviors, and methods of decision making rather than through mechanical imposition of rules. However, it is important that expectations about the desired goal are clear, that the few simple rules are appropriate means to the desired goal, and that if and when the rules or expectations conflict, some way for adjudication is available.

Adaptability in an organization depends on the connections between its agents. The degree of communication and trust between organizational stakeholders is a better predictor of successful adaptation to a changing environment than are inflexible role definitions and tight compartmentalization of work units. Changes in policy or procedure will have the best chance of success if the proposed innovations are discussed in advance with those who will be most affected by them, and if their implementation is accompanied by ongoing feedback and fine tuning. Approaching the health care organization as a complex adaptive system,

as recommended by the Institute of Medicine reports, will have implications for the structure, administrative style, priorities and values, degree of tightness of interrelation, and availability of options for feedback—the culture of the organization. An organization that focuses on its defining values and works to further them in a flexible and dynamic way has the best chance of surviving and thriving in a changing environment.

SUMMARY AND CONCLUSION

A new approach to the health care delivery organization is needed—one that creates the conditions for fostering information flow, connectivity, relationships, and the emergence of creative problem solving from the members of the organization (Olson & Eoyang, 2001: 19). "Complexity is not a methodology or a tool," one advocate writes, "but a way of thinking" (Mitleton-Kelly, 1997: 3). Industry leaders are beginning to adopt this way of thinking about the health care system and are urging that all of its components adopt a few simple rules to support the goal of reducing the burden of illness in the US.

We have accepted the premise of the Institute of Medicine report that problems of quality improvement in the health care system can best be addressed by adopting an adaptive, rather than a mechanical, model of that system, and have examined some implications for the health care organization, itself viewed as a complex adaptive system. To view the health care system as a complex adaptive system, as the Institute of Medicine report recommends, or the health care organization as a complex adaptive system, as we have attempted to do in this article, is to adopt a perspective on an organization that foregrounds processes, not structures, relations, and interactions, not rigid institutional roles or atomistic individuals. It takes rules and roles as thumb rules, goals, and guidelines for action, not rigid prescriptions or constraints, and emphasizes the extent to which any locus of agency, be it an individual or organization, reacts to and can influence the whole of which it is a part.

Focusing on two possible sources of conflict that affect the daily functioning of the health care organization, we have recommended adopting an organization ethics program, conceived as an internal forum for addressing conflicts of value. Positioning an organization ethics program as facilitator and guardian of a positive ethical climate can increase the health care organization's chances of attaining its long-term goals while simultaneously preserving enough flexibility to allow beneficial emergent behavior.

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Using the Creative Problem Solving Profile (CPSP) for Diagnosing and Solving Real-World Problems

Min Basadur & Garry Gelade

Organizations around the world face a common challenge: the need to improve their performance in order to capitalize on rapid change. In North America, restructuring and downsizing have become a way of life as organizations struggle to regain market share from global companies producing higher-quality products. In eastern Europe, managers and employees strive to establish new behaviors and procedures that will allow their companies to compete in the free market. In the developing world, countries hungry for economic development look for growth markets abroad. In Japan, organizations that once had a clear target—to overtake their western competitors—now lack a blueprint for further progress.

A SIMPLE BLUEPRINT

Mott (1972) presented evidence that effective organizations display three characteristics: efficiency, adaptability, and flexibility. The efficient organization follows well-structured, stable routines for delivering its product or service in high quantities, with high quality, and at low cost. In a stable world, efficient organizations may be successful. But in a changing world, organizations also need adaptability. While efficiency implies mastering a routine, adaptability means mastering the process of changing a

routine. Adaptable organizations monitor the environment for new technologies, ideas, and methods, anticipate threats and opportunities, and implement changes accordingly. They deliberately and continually change their routines to improve quality, raise quantities, reduce costs, and stay ahead of their competitors. The most effective organizations are both efficient and highly adaptable. While adaptability is a proactive process of looking for ways to change, flexibility is reactive. Flexibility allows the organization to react quickly to unexpected disruptions without getting mired in organizational bureaucracy. It allows the efficient organization to deal with disruptions while maintaining its routines. In today's rapidly changing world, leaders of effective organizations aiming to achieve sustained competitive edge induce not merely efficiency and flexibility but adaptability.

THE PROCESS APPROACH TO APPLIED CREATIVITY

Basadur (1992, 1995) provided evidence that organizations can attain sustainable competitive edge by institutionalizing creativity as an organization-wide process. In this article, we suggest a multi-stage process model for understanding and implementing organizational creativity. We outline this multi-stage process in terms of different ways of gaining and using knowledge. Recognizing that individual preferences vary for different stages of the process, the article describes the Creative Problem Solving Profile (CPSP) inventory, a practical tool that helps in understanding organizational creativity as a process and serves as a method of diagnosing and solving real-world problems. We outline several real-world applications of the CPSP and suggest avenues for future research.

A NEW THEORY OF CREATIVITY AS A CIRCULAR, MULTI-STAGE PROCESS

Adaptability is driven by organizational creativity, which can be defined as a continuous process of thinking innovatively, or of finding and solving problems and implementing new solutions. Various researchers have focused on the circular nature of adaptability, or the creative process. Gordon (1956, 1971) recognized that knowledge acquisition (learning) and knowledge application (for inventing) flow continuously and sequentially into one another. Field research by Carlsson *et al.* (1976) supported Gordon's approach by showing that the organizational research and development (R&D) process follows a continuous, circular flow of

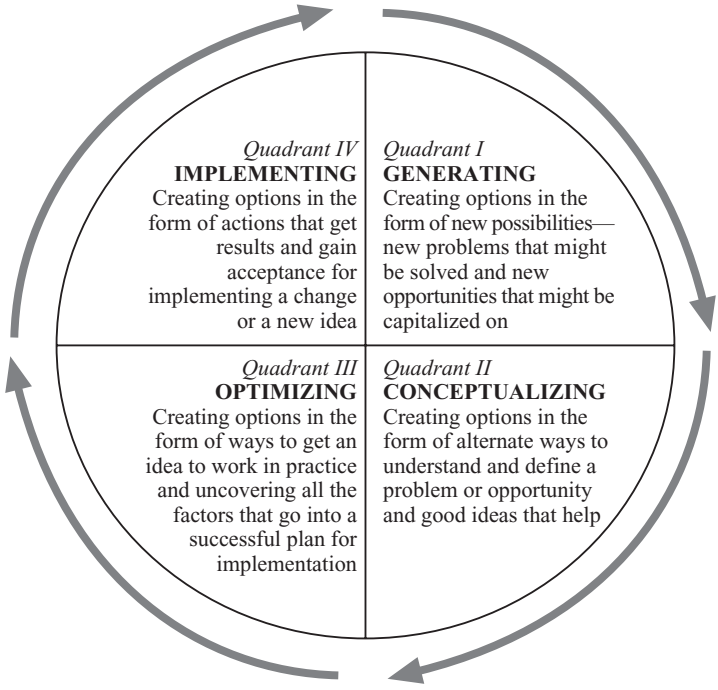

Figure 1 *The four stages of the creative process*

creating new knowledge to replace old knowledge. Consistent with these findings, Basadur's field work (1974, 1983) on organization-wide deliberate change depicted the creative process as a circle, recognizing that new problems and solutions lead continuously to further problems and opportunities. Each quadrant in the circle corresponds to a specific stage of a four-stage creative process. The first two quadrants represent the components of problem finding: generation and conceptualization. The third and fourth quadrants represent problem solving (optimization) and solution implementation as the final two stages of the creative process. In each stage, people gain and use knowledge and understanding in various ways.

The complete process is called the Simplex Creative Problem Solving process (Figure 1). Basadur *et al*. (1982) demonstrated that individuals and organizations could deliberately develop skills in executing each stage of this process, and in executing the complete process. Additional field research supporting the practicality of applying this process in organizations is summarized in Basadur (1994, 2000).

THE FOUR STAGES OF CREATIVITY

Following is a brief description of the four quadrants integrating the concepts of the various researchers above.

Quadrant 1: Generating

The first quadrant gets the creative process rolling. Creative activity in this quadrant involves gaining knowledge and understanding by physical contact and involvement in real-world activities, and utilizing this knowledge to create new problems, challenges, opportunities, and projects that are potentially worth defining and undertaking through subsequent solving and implementing. Understanding is derived from what is experienced, including emotions and feelings of self and others through empathy. New possibilities are imagined from what is concretely experienced. Quadrant 1 activity thus consists of sensing, seeking, or anticipating problems and opportunities, and is called *generation*. An outcome of this stage is a problem worthy of investigation but not yet clearly defined or understood.

Edwin Land, in a *Life* magazine cover story (Callahan, 1972), told the tale of his invention of the Polaroid camera. Having snapped the last exposure on his film, he suggested to his young daughter that they take the film for processing so that they could see the pictures in about a week's time. Her frustrated response was, "Why do I have to wait a week to see my picture?" Like a flash bulb going off in his mind, her simple question sparked a challenge that had never occurred to him: "How can we make a device that yields instantaneous pictures?" Within about an hour, he had formulated several directions toward a solution. And within about four years, he had commercialized a product that has changed our lives. Looking back, the then-chairman of Polaroid said that the most important part of the process was not finding the solution itself—the camera—but finding the problem—how to get instantaneous pictures. If Land had not experienced the chance encounter, he might never have created the problem to be solved. He thus demonstrated the generation stage of the creative process: initiating problems to solve instead of waiting for problems to be provided.

At Japan's electronics giant Toshiba, most engineers and scientists beginning their careers in research and development actually start working in the sales department (Basadur, 1992). This apparently backward approach is designed to teach them the process of problem finding. Since they will spend their working lives creating products to solve customers' problems, what better start than by learning first-hand about their

customers, their needs, their habits, and their problems—both visible and hidden. At Nippondenso, a major auto parts supplier, employees are trained and encouraged from day one to find problems, to be discontented with their jobs. Employees write down their "discontents" and post them for co-workers to read. Here and at many other Japanese companies, this is the start of the creative process called the employee suggestion system. What is important is that the entire suggestion system hinges on problem finding.

Quadrant II: Conceptualizing

The second quadrant, conceptualizing, keeps the creative process going. Creative activity in this quadrant involves gaining knowledge and understanding mentally, or working in the abstract—analyzing, pondering, and theorizing about the information received to create a sound conceptualization or model of the problem domain. Understanding is not gained by direct experience, but instead by detached, abstract thinking. What is understood through rational, systematic analysis is turned into new insights that help define problems, and create theoretical models and ideas to explain things. Quadrant II activity consists of turning a problem recognized in Quadrant I into a well-understood problem definition and some fledgling solution ideas and, thus, is called *conceptualization*.

For example, the senior author was once asked for help by a Procter & Gamble product development team formed at short notice to respond to a competitor's new product. Colgate's green-striped Irish Spring had been the first striped soap bar introduced to North America. With its aggressive advertising campaign emphasizing "refreshment," Colgate's new product was finding ready consumer acceptance. Procter & Gamble worked by the rule that, if a team (or person) was the second entrant into a new market, it had to demonstrate a product's competitive advantage before it could carry out a market test. When asked what was going wrong, the team members said that they had been unable to produce a green-striped bar that worked better than Irish Spring in a consumer preference blind test. The team had experimented with several green-striped bars, all of which merely equaled Irish Spring in blind testing. It became evident that the team had chosen to define its problem as: "How might we make a green-striped bar that consumers will prefer over Irish Spring?"

During a creative problem solving meeting, one of the important activities was to develop alternative ways to define the challenge. The flash of inspiration came from an answer to a question posed from a con-

sumer's point of view: "We want to make a bar that makes people feel more refreshed." This led to the new conceptualized challenge: "How might we better connote refreshment in a soap bar?" This less restrictive conceptualization, which included no mention of green stripes, provided more room for creative solutions. The team broke this new problem into three separate components: "How might we better connote refreshment in appearance, shape, and odor?"—a new conceptualization—and then focused their imaginations on ideas. Beginning with the product's appearance, they visualized scenes, images, and situations that suggested refreshment. One pictured himself at the sea coast. Another imagined sitting on a beach and looking at a blue sky and white clouds. Later, when the team sat back to evaluate its many ideas, these two ideas were selected and combined. The result was the concept of a blue-and-white-swirled bar with a unique odor and shape. The concept later achieved market success under the brand name Coast. By leaping prematurely into solutions, the team had wasted almost six months before coming up with a superior conceptualization.

Quadrant III: Optimizing

The third quadrant moves the creative process further. Creative activity in this quadrant involves gaining knowledge and understanding mentally by working in the abstract: thoroughly analyzing a defined problem and utilizing this knowledge to develop and evaluate ideas and options and create an optimal, practical solution. What is understood through rational, systematic, and orderly analysis is used to mentally evaluate situations and options to convert abstract ideas into practical solutions and plans. Quadrant III activity is called *optimization*. At this point, a good solution to an important, well-defined problem exists, but has not yet been implemented.

For example, the newly defined concept of a refreshment bar in the example above still had to be converted into a practical solution. The team's engineering members created and evaluated several optional versions of the new appearance, odor, and shape. The options were evaluated on several criteria, including cost, feasibility, and time to implement. A final optimal prototype was chosen and successfully tested with consumers, demonstrating an exploitable competitive advantage over its competitor.

Quadrant IV: Implementing

The fourth quadrant completes the creative process. Apprehension in this quadrant involves gaining knowledge and understanding by physical

contact and involvement in the real world. Utilization consists of employing evaluation to convert this knowledge into implemented solutions that work and accomplish valuable results. What is experienced and felt is used to evaluate. Creative activity in this quadrant consists of gaining experience with new solutions, evaluating the outcomes, and making adjustments to implement them successfully. Thus this stage is called *implementation*.

For example, in the above refreshment bar example, the team was still not finished. Before the new soap formula could be sold, a patent problem in the machinery design had to be overcome. There were already no fewer than six worldwide patents restricting how blue-and-white soap pastes could be blended. The team had to find a machine design to make the new product without infringing on anybody else's technique. The team assembled diverse points of view in a special group of engineers, technicians, lawyers, and even a few people who were unfamiliar with soap technology. Sketches and prototypes of the patented processes were displayed and examined and the equipment was adjusted and rebuilt repeatedly until a breakthrough insight emerged and the new product was finally produced satisfactorily for delivery and purchase. A full cycle of the creative process was now complete.

CONSTRUCTING THE FOUR-STAGE CPSP THEORY

In most of the research literature from the 1950s to the 1980s (see review by Basadur, 1994), creativity was perceived largely as generating ideas to presented problems using techniques such as brainstorming. However, practitioners who employ such limited conceptions of the creative process seldom attain practical results (Sternberg *et al.*, 1997). More recently research has focused on creativity as a multi-stage process (Basadur, 1994, 1995; Kabanoff & Rossiter, 1994; Rickards, 1994). Other models of creativity as a process of stages include Wallas's (1926) four stages of preparation, incubation, illumination, and verification; the Osborn–Parnes five-step process of fact finding, problem finding, idea finding, solution finding, and acceptance finding (Parnes *et al.*, 1977); Amabile's (1988) five stages of presentation, preparation, generation, validation, and assessment; Boyd's OODA (Observe, Orientate, Decide, Act; Hammond, 2001); and Kelly's (1955) theory of personal constructs. Additional models are provided in Rickards (1994), Kabanoff & Rossiter (1994), and Basadur (1995).

Beyond merely identifying stages or steps, our model explains and measures each of four stages through established psychological cognitive

constructs that differentiate each stage from the others. Each stage represents a different kind of creativity that contributes to the complete creative process of Figure 1. These explanations and measures are based on selected fundamental theories and constructs of intelligence and mental operations associated with creative thinking. These theories are Guilford's (1967) landmark Structure of Intellect (SOI); Sternberg's (1988) triarchic intelligence; Osborn's (1953) pioneering four brain functions concept; and Parnes *et al.*'s (1977) disciplined freedom paradigm.

Osborn's four brain functions and Guilford's five mental operations

Osborn (1953) modeled the brain as having four distinct functions: absorb (gaining knowledge), retain (memory), imagine, and judge. Osborn advocated developing skill in deferring judgment, or using the imagination and judgment functions independently. Developing Osborn's model further, Parnes *et al.* (1977) created a simplified formula for creativity as follows: C (creativity) = K (knowledge) × I (imagination) × E (evaluation). Their term "disciplined freedom" emphasizes that creativity requires a balance of knowledge and imagination and good judgment.

Guilford (1967) identified two very different ways of gaining knowledge. One way is the mental operation of cognition, or gaining knowledge by experiencing, which he described as the immediate discovery, awareness, rediscovery, or recognition of information. We suggest that some people gain understanding preferentially by such physical processing of information—what we call experiential intelligence (Basadur & Gelade, 2002). The other way of gaining knowledge is what Guilford called the mental operation of convergent production. Guilford described convergent production as the generation of information from given information to achieve unique or conventionally accepted best outcomes in which the given information often fully determines the response. This is also what Sternberg (1996) defined as theoretical, analytical intelligence. We suggest that some people gain understanding preferentially by such mental processing of information. Further, we suggest that people use knowledge by two very different methods, no matter how that knowledge is gained. One way of using knowledge is what Guilford called the mental operation of divergent production, or creating options from information. This operation resembles Sternberg's construct of creative intelligence. The other way of utilizing knowledge is what Guilford called the mental operation of evaluation, or evaluating options (the main component of what Sternberg called practical intelligence).

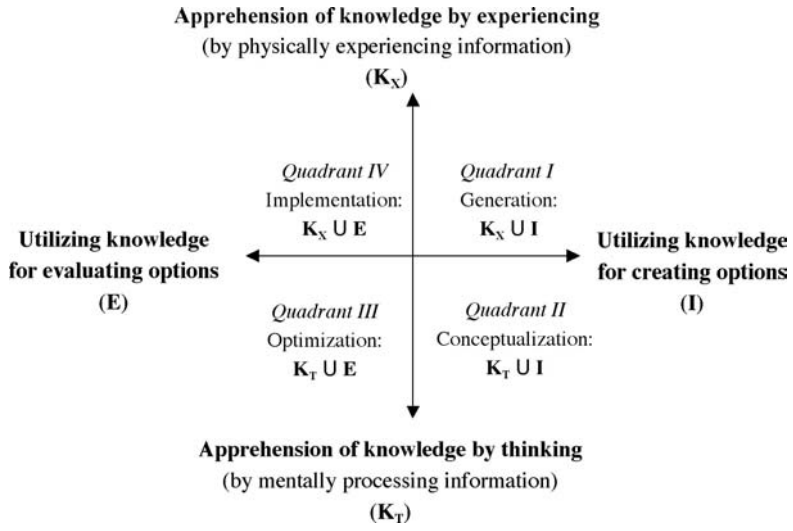

Figure 2 *Four combinations of different methods of gaining and using knowledge*

We suggest a new simplified formula: $C = (K_X + K_T) \times I \times E$, in which K_X is knowledge apprehension by experiencing and K_T is knowledge apprehension by theoretical analysis (thinking); see Figure 2. We also suggest that there are two dimensions underlying the process of Figure 1. The first dimension, apprehension, involves acquiring knowledge or understanding in two different ways. One is relatively more open, nonrational, experiential, nonanalytical, and divergent (cognition); the other is more closed, rational, theoretical, analytical, and convergent (convergent production). The second dimension of Figure 2, utilization, involves applying knowledge or understanding (however acquired) in two different ways: nonjudgmentally creating new information to increase the variety of options (divergent production), and judgmentally reaching decisions about new information to reduce the variety of options (evaluation).

In Figure 2, the four stages depicted in Figure 1 are explained as combinations of these two bipolar dimensions. Combining the preference for learning experientially (K_X) with the preference for creating options (I = ideation) yields a measure of preference for the first stage of the process, or generation ($K_X \cup I$). Combining the preference for learning theoretically (K_T) with the preference for creating options (I) yields a measure of preference for the second stage, or conceptualization ($K_T \cup I$). Combin-

ing the preference for learning theoretically (K_T) with the preference for evaluating options (E) yields a measure of preference for the third stage, or optimization ($K_T \cup E$). Combining the preference for learning experientially (K_X) with the preference for evaluating options (E) yields a measure of preference for the fourth stage, or implementation ($K_X \cup E$).

MEASURING INDIVIDUAL STYLES AND PREFERENCES

Individuals in organizations have varying preferences for each of the quadrants or stages in the creative process because they have varying preferences for the bipolar modes of apprehension and utilization. Generating ideas for new products, services, and methods must start somewhere. Individuals inclined toward generating are continually experiencing and scanning the environment, picking up data and cues from customers, suppliers, and others, and suggesting possible opportunities for change and improvement. Thus, the generation stage is where new information and possibilities are raised—usually not fully developed but in the form of starting points for new projects. People with dominant conceptualizer styles lead in compiling facts and idea fragments from the generator stage into well-defined, insightful problems and challenges and more clearly developed ideas and projects worth further evaluation. Skilled conceptualizers give sound structure to fledgling ideas and opportunities. People inclined toward optimization usually lead in taking these well-defined ideas and finding a practical best solution and detailing efficient plans for proceeding. Finally, implementers lead in carrying forward the practical solutions and plans, including convincing colleagues or customers of the worth of the changes, and adapting the solutions and plans to make them fit real-life situations and conditions.

THE CREATIVE PROBLEM SOLVING PROFILE (CPSP) INVENTORY

The Creative Problem Solving Profile (CPSP) inventory measures an individual's unique blend of preferences for the four stages of the process in Figures 1 and 2. Plotting inventory scores on a two-dimensional graph displays an individual's preferred blend of the four different stages. The largest quadrant on the graph represents the preferred or dominant style, with relative sizes of the other quadrants representing supporting orientations. The unique blend of styles is the individual's profile. Figure 3 shows how individual differences in orientation can yield different creative problem solving process styles and profiles. If the area of quadrant

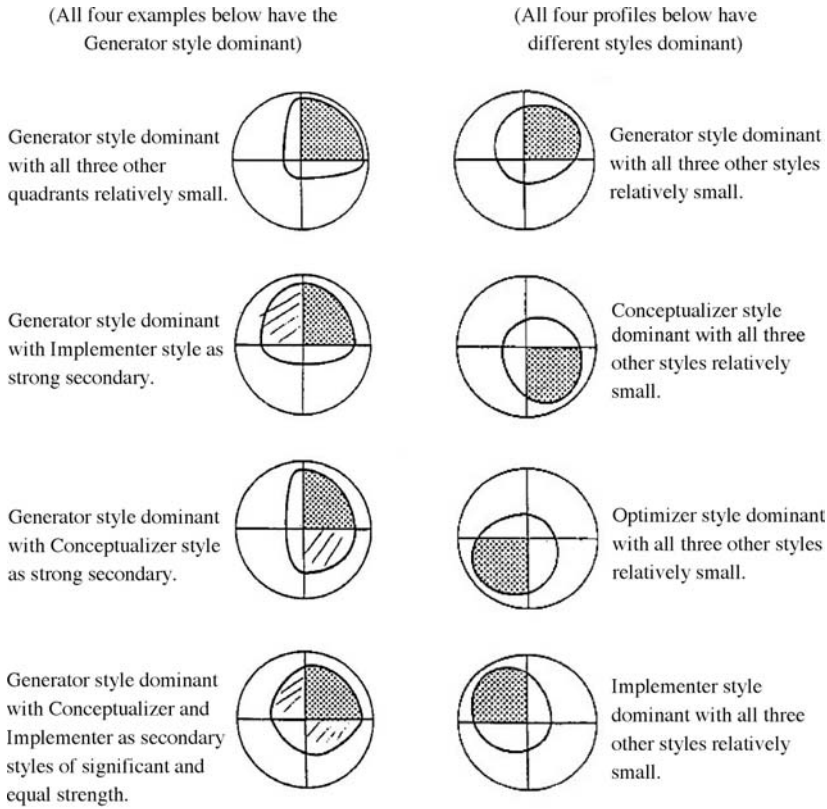

Figure 3 *Examples of different profiles of creative problem solving with the same style dominant and with different styles dominant*

1 is largest, the primary process style is generating; if quadrant 2, then conceptualizing; if quadrant 3, then optimizing; and if quadrant 4, then implementing. Each of these styles reflects individual preferences—and preferences of teams and entire organizations—for ways of gaining and using knowledge.

The CPSP's scale construction, scoring, interpretation, reliability, and validity have been fully described by Basadur and Gelade (2002), but a brief summary is presented here.

The CPSP questionnaire consists of 12 scored items, and six distractor items that are not scored. Each scored item consists of four words, descriptive, respectively, of learning experientially (K_X), learning theoretically (K_T), creating options (I), and evaluating options (E). Respondents are asked to decide which words are most characteristic of their problem

solving style, and to rank the four words from one ("least characteristic of me as a problem solver") to four ("most characteristic of me as a problem solver") within each item accordingly. An individual's CPSP profile is obtained by summing their scores on K_X, K_T, I, and E respectively; plotting the resulting totals on the axes shown in Figure 2, and constructing the quadrants as shown in Figure 3, gives a pictorial representation of the respondent's problem solving preferences.

As reported in Basadur and Gelade (2002), factor analysis of the questionnaire scores confirms the existence of two orthogonal bipolar dimensions corresponding to K_X–K_T and I–E, and scores on these dimensions show satisfactory reliability (alpha = .80). Convergent validity has also been demonstrated with the Kirton Adaptation Innovation Inventory and the Myers-Briggs Type Inventory (Basadur *et al*., 1990; Basadur, 1998; 2000).

STATES NOT TRAITS, AND ALL FOUR QUADRANTS ARE CREATIVE

This Creative Problem Solving Profile (CPSP) inventory measures *states*, not *traits*. No one quadrant is considered any more "creative" than any other. All four quadrants require creativity of different kinds. Each quadrant contributes uniquely to the overall innovative process and innovative results. An individual's unique creative problem solving profile shows only their preferred activities within the Simplex Creative Problem Solving process. Most people enjoy some stages more than others. A particular style reflects relative preferences for each of the stages of the process: generating, conceptualizing, optimizing, and implementing. A person's thinking processes cannot be pigeonholed in any single quadrant. Rather, they are a combination or blend of quadrants. A person will likely prefer one quadrant in particular, but also have secondary preferences for one or two adjacent quadrants, as shown in Figure 3. Skills are needed in *all* stages.

Everyone has a different valuable creative contribution to make to the innovation process as a whole. One goal is to capitalize on an individual's preferred orientation, thus making their work more satisfying and pinpointing development opportunities. Another goal is to tap resources in all four quadrants to help the individual, team, or organization cycle skillfully through the complete innovation process.

ORGANIZATIONS HAVE THEIR OWN PROFILES

Entire organizations also have creative process profiles. An organization's profile reflects such factors as the kinds of people it hires, its culture, and

its values. For example, if an organization focuses almost entirely on short-term results, it may be overloaded with implementers with few conceptualizers or generators. The organization will show strengths in processes that deliver its current products and services efficiently. But it will show weaknesses in long-term planning and product development that might help it to stay ahead of change. Rushing to solve problems, this organization will continually find itself reworking failed solutions without pausing to conduct adequate fact finding and problem definition. By contrast, an organization with many generators or conceptualizers and few implementers will continually find good problems to solve and great ideas for products and processes to develop. But it will never carry them to their conclusion.

Following are a case study and additional real-world examples of how organizations may apply the CPSP to diagnose problems and improve creativity and innovation performance.

REAL-WORLD APPLICATIONS OF THE CPSP

A CASE STUDY

By 1981, an automobile manufacturer had suffered several losing business quarters. In an effort to change its operations, the company had launched many initiatives. One of the most important was its decision to involve its people in improving quality and customer satisfaction and increasing innovation. The company wished to involve managers in actually "managing the business" rather than just "doing my job."

The company and its union had agreed to implement a joint employee involvement (EI) program for unionized employees. Both sides provided resources, including both unionized and salaried employees, to diagnose important training needs and to create strategies and programs to meet those needs. Their first step was to form problem solving groups in the plants, guided by local and national joint steering committees. To build skills in problem solving, these groups had been taught standard analytical tools borrowed from statistical process control and total quality management programs (such as "cause-and-effect diagramming" and "cause-unknown diagnosis").

The company now wished to expand employee involvement to include salaried employees, and to develop problem solving processes that were better suited for their jobs. The organization hoped that these employees and their managers would take more initiative in identifying opportunities for improvement and tackling them creatively. During a

preconsult and preliminary training workshop for several key employees, we agreed on a strategy to train a number of employees in applying the Simplex process and in training others in the company.

During this training, we had a chance to apply the process to a problem at a newly modernized plant that made a major component of the company's new front-wheel-drive automobiles. The plant was setting new records for quality and low cost, but one department was struggling. Only about one-third of its output met the company's high quality standards, and employees had to work heavy overtime schedules in order to keep up with orders. The plant managers had tried several quick-fix solutions to resolve the production and quality problems, but none had worked. We established a cross-functional team of 15 plant managers and supervisors in order to apply the Simplex Creative Problem Solving process to the problem.

Along with one of the company's internal consultants who was training as a Simplex facilitator and trainer, the senior author conducted the application session with this team. About half a day was set aside for training in the Simplex process and process skills, and two and a half days to apply the process to the team's fuzzy situation. During the training, the team members were asked to complete the Creative Problem Solving Profile (CPSP) inventory to identify individual differences in preferences for various stages of the creative problem solving process.

The team discovered a very revealing insight. Of the 15 team members, eight showed creative problem solving styles heavily oriented toward quadrant 4, or implementation. The other seven showed styles heavily oriented toward quadrant 3, or optimization. None had creative problem solving styles oriented toward quadrants 1 or 2 (generation and conceptualizing). The team was composed of people who preferred to jump quickly to action rather than carry out fact finding and problem definition. Team members were able to identify many instances when they had mistakenly made assumptions about this particular problem, leading to one failed solution after another. Rather than take the time to define the problem accurately, they had simply jumped from the fuzzy situation to one solution after another. They had spent all of their time alternating between quadrants 3 and 4, and none in quadrants 1 or 2 (Figure 4).

These solution- and action-oriented individuals agreed to spend two days in quadrant 1 and 2 activity, gathering facts and defining problems (Figure 5)—even though the whole exercise was against their nature. Three specific problem definitions emerged from this exercise. On the third day, the group was able to create simple but specific solutions to

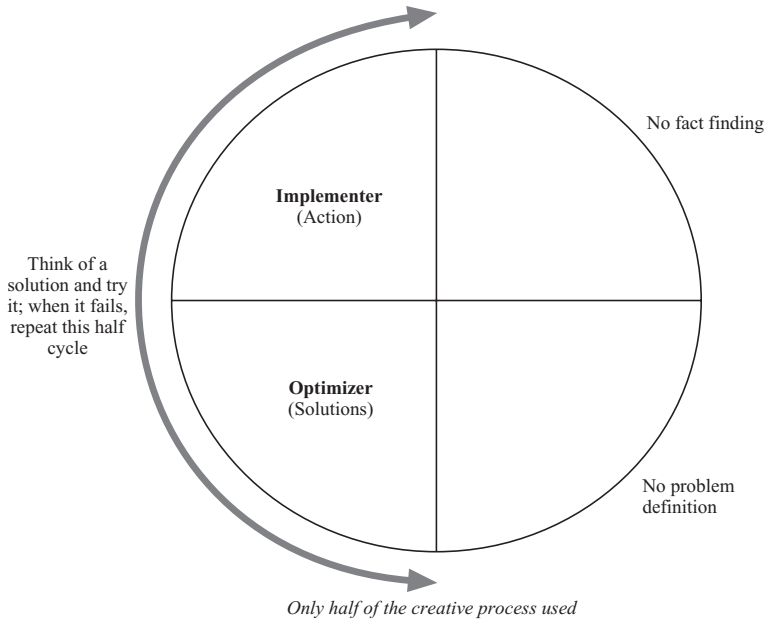

Figure 4 *The results of heavy orientation toward quadrant 3 and 4 thinking styles*

each defined problem that it could quickly implement. Within several months, most of the plant's production was high quality and was still improving.

A DIAGNOSTIC TOOL

On the following pages are four examples of CPSP scatter diagrams, which depict the array of preferences for each of the four quadrants of the creative process for individuals within a team or organization. Each ⊕ symbol represents an individual's pair of coordinates derived from their score on the vertical apprehension axis (XT) coupled with their corresponding score on the horizontal utilization axis (IE).

The first scatter diagram displays the preferences of a typical group of managers in a large engineering company servicing the aircraft, airline, and aerospace industries (Figure 6). Most middle and senior managers in the company are strongly oriented toward action rather than toward generating new opportunities. The company has established high growth targets into new products and markets, but is failing to achieve them because of a strong organizational culture that favors quick fixes to short-term problems. To improve its short- and long-term balance, the company

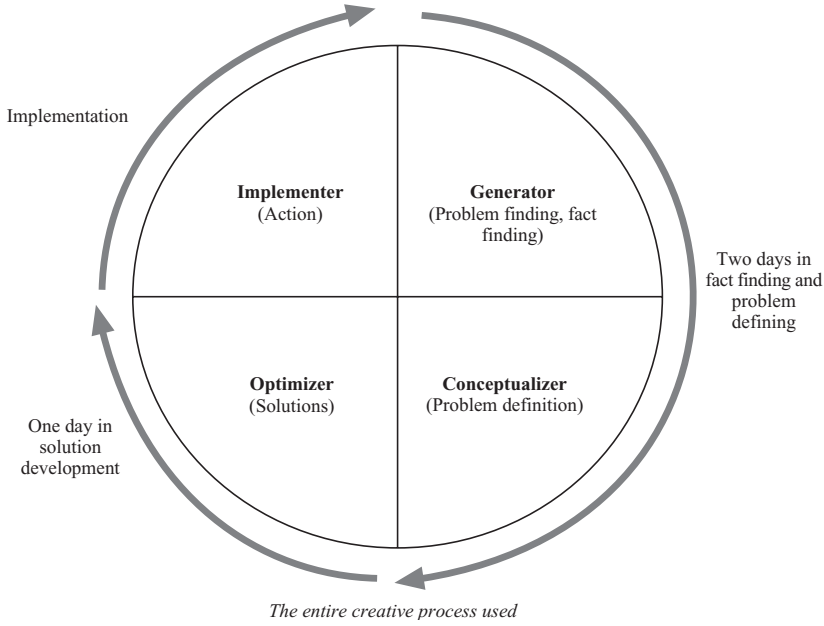

Figure 5 *Balancing orientations toward all four thinking styles*

is developing a major training effort to increase awareness and encourage more generation and is also creating structures that will encourage employees to participate more in quadrant 1 and 2 activities.

In the second example, a large bank had formed teams to bring many new financial products to market quickly in a very competitive environment, but those teams were encountering a high percentage of failures. The organization's teams were found to be heavily weighted toward implementers (Figure 7). Further discussion showed that the teams often developed new products by rushing from an initial idea directly into implementation, without spending much time in conceptualization and optimization. Had the teams taken more time for conceptualization, they likely would have identified more limitations in many new product ideas. With more time in optimization, they would have reduced the frequency of product flaws reaching the market. By taking more time through these second and third stages of the process, the teams began to make wiser choices about which new, fledgling ideas to pursue (and which to terminate) and to develop more reliable product designs for market testing.

In the third example, a new managing director was hired specifically to develop a breakthrough product concept and bring it to market. He assembled a team that, in very little time, created a great new idea.

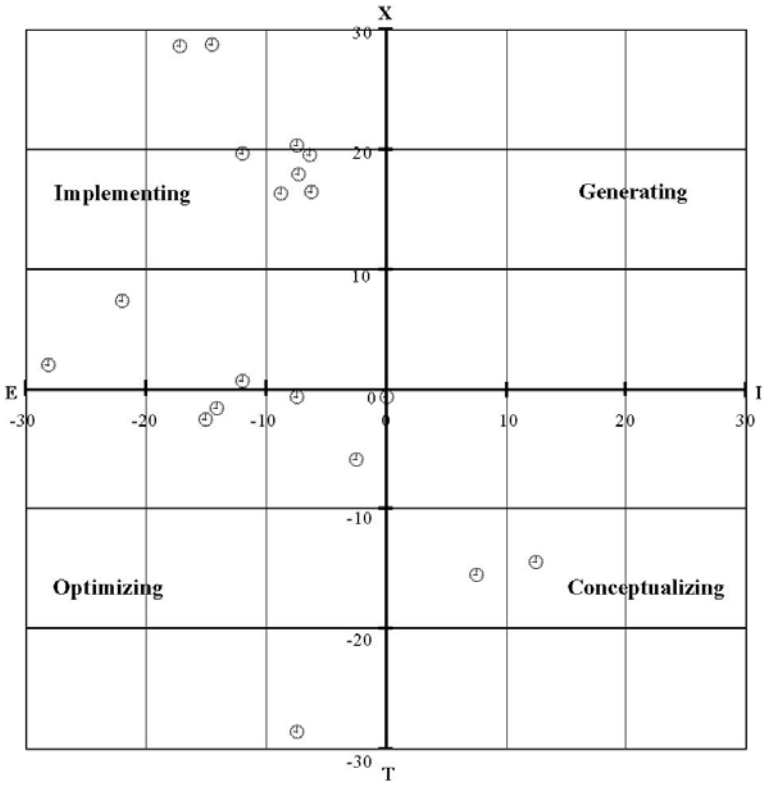

Figure 6 *Scatter diagram example #1: Not enough generators*

However, the team had subsequently ground to a standstill. Members failed to attend meetings regularly and several felt that there was nothing important remaining to be done. Subsequent diagnosis found that all of the team members whom the managing director had intuitively selected were oriented toward quadrants 1 and 2. In Figure 8, the managing director is the lone individual in quadrant 3, and there is no one in quadrant 4, implementation. He now realized that the team needed to add people oriented toward quadrants 3 and especially 4 in order to implement the new product concept successfully.

The fourth example comes from the management team of a small engineering company that was growing too quickly, allowing many human resource problems to pile up. The company had more business than it could handle: new engineering projects were being designed and implemented with customers all over the world. Left unidentified and ignored by the busy management team, the human resource problems left people

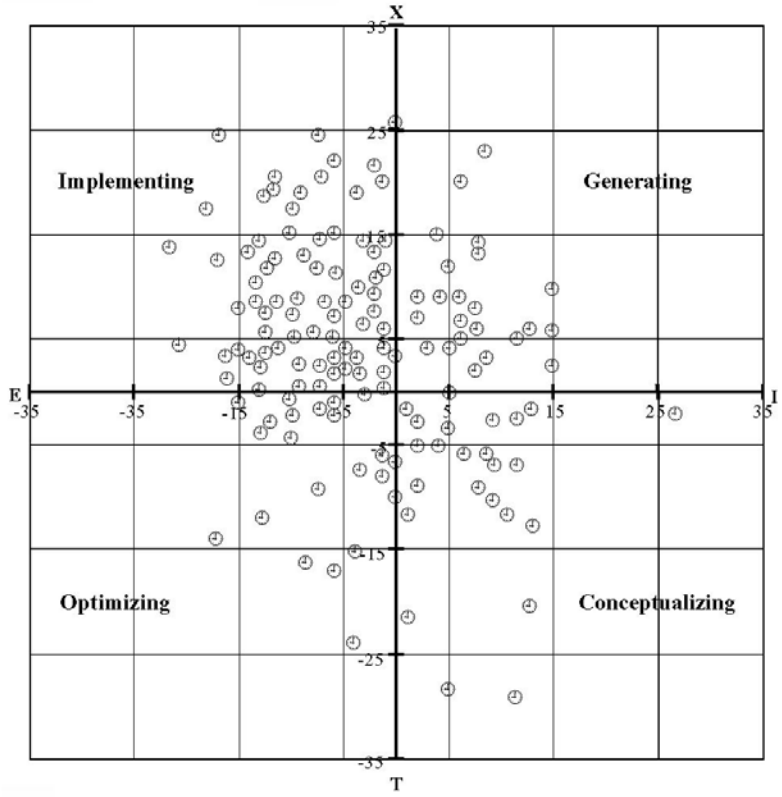

Figure 7 *Scatter diagram example #2: Not enough time devoted to conceptualization and optimization*

feeling severely stressed, overworked, and underappreciated. Resulting high turnover and its deteriorating corporate reputation made it difficult for the company to hire replacements or new staff. As shown in Figure 9, the management team was unbalanced, being virtually devoid of generators and optimizers. Most members were implementers or conceptualizers, demonstrating little interest in either surfacing problems or solving them. As a first step toward ensuring that it identified and solved important people problems, the company hired its first human resources manager for this explicit purpose.

IMPROVING TEAM PERFORMANCE

In a creative organization, everyone is responsible for doing at least one of the four stages defined by Figure 1. Some people initiate new things. Some are responsible for understanding and defining new initiatives and

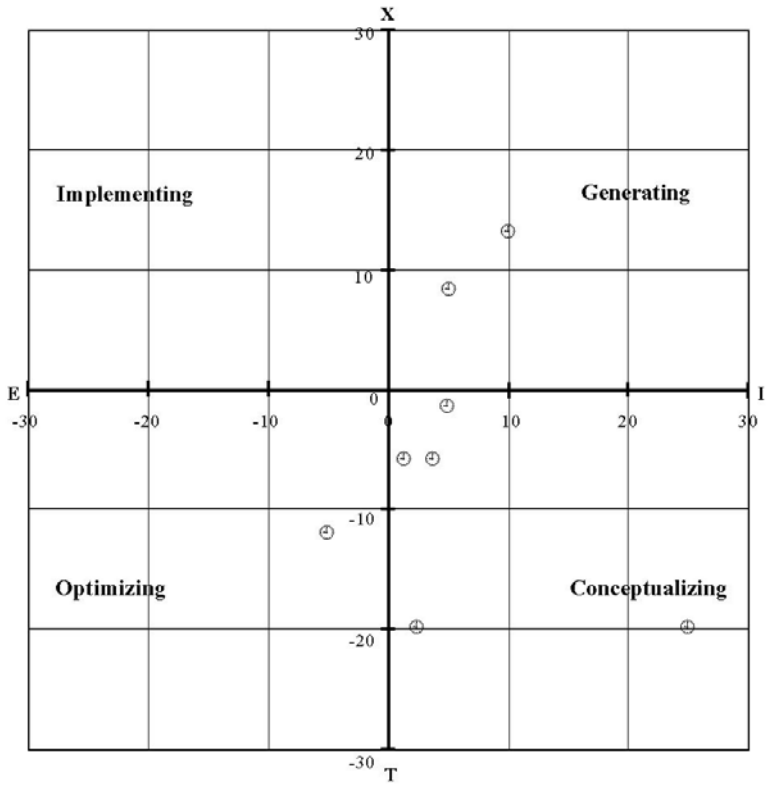

Figure 8 *Scatter diagram example #3: Not enough implementers*

planning. Some produce practical solutions to new problems and initiatives. Others are responsible for finishing things off, or taking action to implement new solutions. If the four-stage process of creativity outlined above adequately represents the creative process, it would be expected that teams with a heterogeneous mix of preferred creative process styles (Figure 1) would significantly outperform teams with a homogeneous mix of creative process styles in innovative work. In the former case, all stages of the process are readily available within the team. One could also predict that members of homogeneous teams would experience more satisfaction working with like-minded team mates.

The predictions were confirmed by a study by Basadur and Head (2001), which assessed groups of MBA students on a problem solving task. Groups including individuals with different styles (heterogeneous groups) outperformed homogeneous groups whose members all had the same style. Rated by a judges' panel on four dimensions of innovative

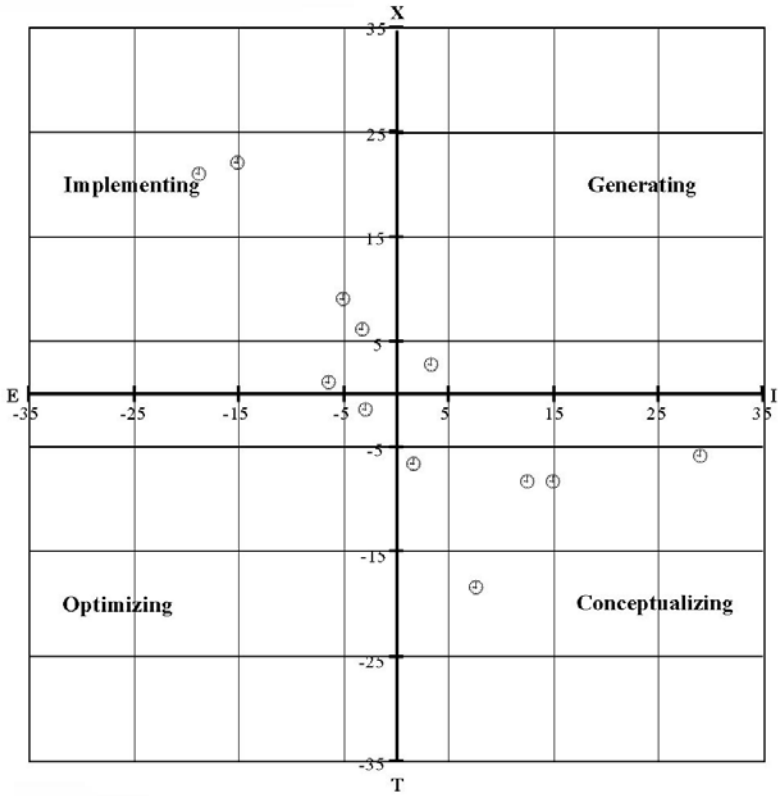

Figure 9 *Scatter diagram example #4: An imbalance—not enough generators or optimizers*

performance, the mean score for the 21 heterogeneous groups was 4.22 (sd = 0.42) and the mean for the homogeneous groups was 3.69 (sd = 0.64); a statistically significant difference (Student's t = 3.0, $p < .01$). Asked about their teamwork experience, individuals in the heterogeneous groups expressed less satisfaction than those in the homogeneous groups. The mean overall satisfaction for the 57 participants in the heterogeneous groups was 7.50 (sd = 1.98) compared to 8.15 (sd = 1.32) for the 85 participants in the homogeneous groups; a statistically significant difference (Student's t = 2.2, $p < .05$).

Heterogeneity is often an inherent characteristic of cross-functional teams, as people in various occupations favor different CPSP styles. For example, people in industrial engineering, training and development, and other improvement and change-initiation departments often favor the generator style. Employees in market research, strategic planning, and

R&D often favor conceptualizing. People in accounting, finance, engineering, and systems development gravitate toward optimizing. People in manufacturing production, logistics/distribution/warehousing, sales, administrative support, customer service, and operations favor implementation.

No matter which process style an individual prefers, however, a team's members have to learn to use their differences to advantage. Teams, especially those involved in continuous improvement and innovation, require a mix of people who enjoy working in different steps around the Simplex Creative Problem Solving process: finding new problems and opportunities, clarifying and refining those problems and creating ideas, developing practical solutions and plans, and making new solutions work. Whether in teams or not, helping individuals learn to shift among orientations also ensures that the entire organization has a complete blend of process styles. In fact, an individual's dominant orientation is less important than their ability to shift among the different orientations. Preferences for certain quadrants within the innovation process are not static "traits," but dynamic "states." Individuals can learn to work in any of the four CPSP quadrants in order to complement others in a given situation.

Application to organizational ecosystems

Basadur and Gelade (2002) report CPSP scores for a sample of 3,942 adults (39 percent female, 61 percent male) in 38 different occupations and working in a wide variety of organizations, including large and small corporations, banks, schools, universities, and hospitals. In this sample, 36 percent were in nonmanagement or supervisory roles, 27 percent in managerial roles, and 25 percent in professional or technical roles; the remainder were in other roles or did not specify their role. High percentages of generators were found in fields such as teaching (56 percent), academia (38 percent), and art (34 percent), and low percentages in fields such as IT systems development (9.5 percent), manufacturing engineering (9 percent), and engineering/engineering design (7.5 percent). Overall, the results suggested that few business and industrial occupations had a high proportion of generators (see Figure 10).

This raises some interesting questions, because the most perplexing challenge for many organizations is how to be more innovative in the face of accelerating change. Indeed, many leading management consultants exhort corporations to "begin their revolutions"—to expand their thinking and do things differently. Rather than simply improve existing methods and procedures, they advocate deliberate change. They advise

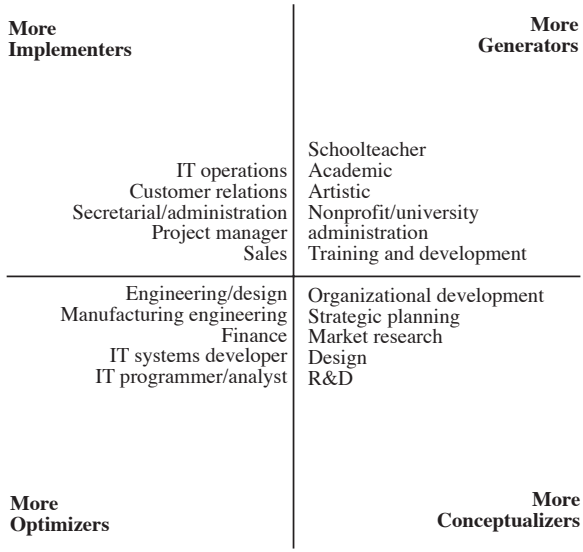

Figure 10 *Occupations by dominant quadrant mix*

corporations not to defend old markets, but to explore new ones. Many corporations find this an appealing strategy, although one that is difficult to implement. While one could speculate that a reason for this difficulty may be the lack of employees who prefer the generator style of thinking, this may be an overly simplistic explanation. For example, a single generator might initiate enough work for ten "implementers." A more productive approach might be to raise broader questions and hypotheses about the appropriate mixes or ratios of the four quadrant preferences within various organizational departments and functions, or within an organization as a whole.

From an *intra*-organizational perspective, different ratios of the four quadrants might be appropriate within, say, manufacturing or service organizations, or within the particular departments of a given organization, such as R&D, sales, IT, or finance. The optimal mix for a top management team might differ from that for a lower-level team. Our previous research (Basadur, 1994, 1995) has suggested that a business unit's optimal ratio may depend on the typical proportion of work oriented toward problem finding rather than toward problem solving or implementation.

From an *inter*-organizational perspective, management consultants exhorting client organizations to initiate deliberate change could be viewed as performing the generator function from outside the organization. However, outside consultants are considered as being weak at

delivering whole projects (e.g., IT implementations). On the other hand, organizations are often seen as too reliant on outside consultants to identify problems for them and suggest solutions. Perhaps a successful consultant–client relationship requires an optimal blend of quadrant styles among the organization's staff and the consulting or advisory team. Analysis of organizational quadrant styles might identify organizations that would benefit from hiring consultants, and whether project management consultants (project implementers) or change-initiating consultants might be more effective. We also speculate that successful consultants or consultant teams function effectively in more than one CPSP quadrant in order to maintain an optimal balance of quadrant styles when working with organizational teams. Other inter-organizational ecosystems, such as customer–supplier relationships, may be viewed similarly. The success of inter-organizational strategic alliances, mergers, or acquisitions may also be dependent on achieving an optimal blend of creative thinking styles, especially at the top level.

SUMMARY AND FUTURE RESEARCH

We have presented a theory of organizational creativity as a process comprising four stages: generating, conceptualizing, optimizing, and implementing. We explain and measure each stage of the process using cognitive constructs from established models of intelligence and educational psychology. These constructs differentiate the mental activities in each stage of the process from those of the other stages. Each stage represents a different kind of creativity that contributes to the complete creative process.

We have also presented a psychological instrument that measures the constructs and stages of the process, called the Creative Problem Solving Profile (CPSP) inventory. Individuals, teams, and organizations may use the CPSP to help diagnose inadequate organizational problem solving and performance. The CPSP also provides a blueprint for people to understand organizational creativity as a process of continually finding and defining important organizational problems, solving those problems, and implementing the solutions.

The four-stage process represented by the CPSP is built on two underlying dimensions: apprehension and utilization. Apprehension involves *acquiring* knowledge or understanding in two different ways: more open, nonrational, experiential, nonanalytical, and divergent, versus more closed, rational, theoretical, analytical, and convergent. Utiliza-

tion involves *applying* knowledge or understanding in two different ways: nonjudgmentally creating new information to increase the variety of options, versus judgmentally reaching decisions about new information to reduce the variety of options. The four stages of the creative process are explained as combinations of these two bipolar dimensions. Individuals in organizations have varying preferences for each of the stages because they have varying preferences for the bipolar modes of apprehension and utilization. The CPSP inventory measures an individual's unique blend of preferences of the four stages, or their creative process "profile."

Teams and entire organizations also have unique creative process profiles, and the CPSP can be applied to diagnose problems and improve creativity and innovation performance. Heterogeneity of CPSP styles is often an inherent characteristic of interdisciplinary teams, as people in various occupations tend to favor different CPSP styles. Because CPSP preferences are not static "traits" but dynamic "states," individuals can learn to work effectively in any of the four CPSP quadrants in order to complement other team members' preferences and help the team move smoothly through the four-stage process. Research has shown that more heterogeneous teams outperform more homogeneous teams in innovative work but experience less satisfaction.

Our research indicates that generators (people who prefer stage 1 activity) are the least represented of the four CPSP styles in industrial (business) organizations. In fact, few industrial occupations had a high proportion of generators. The other three stages were better represented occupationally. The overall distribution favored implementers (highest) followed by conceptualizers, optimizers, and generators (lowest). These data suggest several interesting intra-organizational and inter-organizational ecosystem questions that might be approached through the framework presented in this article. For example, the effectiveness of organizations, departments, or functions—and relationships among organizations, advisers, customers, suppliers, and strategic partners—may depend partly on the ability to exploit diverse thinking styles and on how well the mix of available styles matches the cognitive work.

Similar considerations might, in principle at least, be extended to the dynamics of creativity and change at higher (supra-organizational) ecosystem levels. Dealing effectively and creatively with change is a challenge not merely for organizations but for entire economic systems, industries, and societies. Our experience of innovation at this level has generally been painful. The charismatic and visionary "generator" with a

remedy for society's ills is a well-known archetype. But even the best-intentioned of these is likely to cause more harm than good if the thinking stops at this stage. Continued inertia and excessive conservatism are likely either to cause atrophy and decay or build irresistible pressures, leading to an uncontrolled and destructive catharsis. A better understanding of the dynamics of creativity, and the diversity of thinking processes needed to navigate change at the micro level, might contribute to a better understanding of how to avoid such difficulties at the macro level.

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The Redefinition of Memes: Ascribing Meaning to an Empty Cliché

Michael R. Lissack

> Memetics has reached a crunch point. If, in the near future, it does not demonstrate that it can be more than merely a conceptual framework, it will be selected out. While it is true that many successful paradigms started out as such a framework and later moved on to become pivotal theories, it also true that many more have simply faded away. A framework for thinking about phenomena can be useful if it delivers new insights but, ultimately, if there are no usable results academics will look elsewhere. Such frameworks have considerable power over those that hold them for these people will see the world through these "theoretical spectacles" (Kuhn, 1969)—to the converted the framework appears necessary. The converted are ambitious to demonstrate the universality of their way of seeing things; more mundane but demonstrable examples seem to them as simply obvious. However such frameworks will not continue to persuade new academics if it does not provide them with any substantial explanatory or predictive "leverage." Memetics is no exception to this pattern. (Edmonds, 2002)

While the popular media has had several rounds of fascination with the concept of memes, the application of memes to management and to complexity has been negligible. The Edmonds quote above ascribes the problem to the stage of development of memetics: that memetics needs to provide explanatory leverage to get past the "crunch point."

This article suggests that the answer to memetics' "crunch point" lies in turning the concept of memes inside out. If memes are "units of cultural transmission which propagate themselves" (Dawkins, 1976) or "the least unit of sociocultural information relative to a selection process that has favorable or unfavorable selection bias that exceeds its endogenous tendency to change" (Wilkins, 1998), then the failure of the field of memetics to meet the three challenges outlined by Edmonds (a conclusive case study; a theory for when memetic models are appropriate; and a simulation of the emergence of a memetic process) is problematic and perhaps indicative of "irrelevance." Indeed, there have been few managerial examples of the potency of a meme to explain or cause anything—and in the absence of explanatory or casual power, it is difficult to find the relevance of a concept for managers.

If, on the other hand, memes are redefined such that the evolutionary selection process is no longer an aspect of the ontology of memes but rather of the environmental niche (cf. Laland & Odling-Smee, 2000; Laland *et al*., 1999; Odling-Smee *et al*., 2003) of which the memes are evidence, then the field may have other avenues of advancement and a potential relevance to managers. Such a redefinition would entail recognition of the relationship between a given meme and the context of the social and ideational environment of which it is an affordance and which it demands be attended to. Memes in this casting are a label for successful boundary object indexicals and lose their privileged status as replicators. Instead, the replicator status is ascribed to the environmental niches and the memes are their representatives, symbols, or semantic indexicals.[1]

With this definition, memes are repackaged as symbols and their impact on management is not that of a viral contagion but rather as an indicator of success and change in environmental niches. If an environmental niche has an important managerial role, then paying attention to its symbols and affordances can also be important. Memes are stripped of their casual role and instead become semantic tokens capable of evoking ascribed meanings. It is the process of evoking and the efficacy of the meme as the trigger for attention, recall, and repetition of the ascribed meaning that give memes relevance to managers.

The argument herein[2] thus assumes that memes exist, but that their definition is not that of replicator but rather that of indexical token. The meme tokens are representatives of the environmental niche in which they flourish and about which they offer efficient communicative potential. Memes, it is argued, succeed when they are accepted and used as

tools for the accomplishment of a communicative purpose. Memes fail when their ontic status itself becomes a focus. Memes have longevity only if they both succeed and serve as a useful tool for a successful environmental niche. Memes can be short-lived due to the failure of their communicative efficacy or the failure of the niche they represent or both.

Memes as indexicals

Indexicals are concepts that we make use of nearly every day but, for most of us, they are unknown and unthought about. The dictionary or encyclopedia entries are actually of little help. Take this entry from the *Stanford Encyclopedia of Philosophy*:

> Indexicals are linguistic expressions whose reference shifts from utterance to utterance. "I," "here," "now," "he," "she," and "that" are classic examples of indexicals. Two people who utter a sentence containing an indexical may say different things, even if the sentence itself has a single linguistic meaning. For instance, the sentence "I am female" has a single linguistic meaning, but Fred and Wilma say different things when they utter it, as shown by the fact that Fred says something false, while Wilma says something true.

Indexicals are words used to stand for a set of other words; that is, they function like an index on the stock market. The Dow Jones Industrial average, for example, stands for a basket of particular stocks and stands for many of us as an indicator of the market as a whole. Pronouns as described above are indexicals in that they stand for the noun and take on different meanings in different situations. "Where a word acquires its sense from the context in which it appears; in different contexts, it changes its sense" (Vygotsky, 1986).

In American society the most commonly heard indexical is the mythical "they" who do things to us or others. "Look at what they are doing now." Perhaps the second most popular indexical is "You know…, you know who I mean." Indexicals are often distinguished by the fact that their reference systematically varies with the context of usage. Indexicals offer a simple means of making, expressing, and communicating our references, and they are particularly useful when proper names or descriptions are either cumbersome or unavailable. Similarly, in interpreting someone's "that way" in response to a request for direction, one must be able to determine independently what direction the person is indicating.

One must discover what relations one bears to the indexical referents in order to locate and act on them, but there is nothing indexical about these relations themselves (Millikan, 1993). To interpret an indexical, therefore, is to establish what other items, entities, and representations it coincides with. By itself, it tells us neither about its contents—what it bears its adapting relation to—nor about its contexts; context determines the indexical's content, but context is not what content is about. As David Kaplan (1989) puts it:

> What is common to [indexicals] is that the referent is dependent on the context of use and that the meaning of the word provides a rule which determines the referent in terms of certain aspects of the context.[3]

Indexical language possesses a quality that Barwise and Perry (1983) call efficiency. This refers to the capacity of an indexical representation to refer to different individuals on different occasions. The efficiency of an indexical relates to the engineering quality of efficiency in the notion that the same symbol is capable of standing for a multiplicity of meanings—the greater the number of potentially stood-for meanings, the greater the efficiency of the indexical. In organizations, management frequently refers to the company, a team, a symbol, or mission, vision, and values as absolutes without being aware of their indexical content. Thus, despite the likelihood that an organizational symbol carries a multiplicity of meanings, managers might make use of such symbols as if the only possible referents are the ones conceived of by the manager him- or herself. Yet, it is possible by ethnographic observation for a careful outsider to discern at least some of the various referents summoned up by the use of these "unintended" indexicals in situ. Indeed, by such processes of observation a corporate ethnographer or anthropologist can reach tentative conclusions about the corporate culture and climate of the organization being observed.

Indexicals are situated. The use of an indexical succeeds when the combination of context and symbol evokes an intended meaning. The indexical provides a locating space into which many variants of personalized and situated meaning can be ascribed, attributed, or devolved. This space is the container of which Prigogine first spoke when describing self-organizing systems. In the absence of such containers, self-organization is nearly if not totally impossible. In the arena of culture, the meme as indexical is a locator or referent affording the evocation of situated meaning. Efficacy of memes is determined by that evoking and the relevant situating.

The efficiency of indexicals means that they can break, that the context and situatedness that help to afford meaning to the indexical can stretch it beyond breaking points. When indexicals break or are challenged, they raise questions of boundaries, frames, and identities. While the challenges to indexicals can be very subtle, when they break they break the entire frame of how a situation is understood. Americans were made aware of this when Senator Jim Jeffords of Vermont switched his party affiliation from Republican to Independent (and thereby altered control of the US Senate). His speech of explanation was a discussion of his perceived limits to the indexical "republican." If memes are understood to be indexicals, then their success or failure is not marked by evolutionary inheritance but rather by the longevity of their efficacy. That longevity is in many ways determined by the situation and the meaning "carrying capacity" of the meme indexical.

Donati (1992) observes that people frame an object around which an issue revolves rather than the issue itself, and that the study of frames involves identifying how people understand an issue, rather than determining if they are "for" or "against" a proposition. Gratton (2000) notes,

> working to create a shared and coherent meaning in line with corporate aspirations demands an understanding of the current meanings within the organization. We strive to interpret our world, not simply by imposing structure but by translating events and developing frameworks for understanding.

Frames are patterns of organized information by which people make sense of the world. These "patterns," "schemas," or "frames" form part of the "discursive universe" in which people interact with each other. People learn frames as they learn to use a language fluently and as they learn the narrative structures and ideologies present in the cultures that use that language. When people encounter new information or a new experience, they make sense of that information or experience by fitting it into an existing frame. Nevertheless, people will generally be able to fit any given collection of information into multiple frames; though, at the same time, they will also tend to perceive information selectively, focusing on details that most readily fit into the frames they know.

As humans, we seek to solve problems as presented; we acquiesce in their frames. Indeed, we become prisoners of the frame. Shira White (2002) tells an illustrative story of such prisons:

> Scientists have done some fascinating and suggestive experiments with ordinary houseflies. If you capture and keep houseflies in a jar and then remove the lid after a few days, most of them will not fly away. In fact, they stay right where they are—inside the jar—even though they could escape if only they could see their way to freedom. But they seem "committed" to a lid that is no longer there. Psychologists have identified this phenomenon as "premature cognitive commitment." It is premature cognition in the sense that it occurs, more or less automatically, before we are aware of or fully understand the stimulus. It is "commitment" because we are locked into a specific set of thoughts. Like the houseflies, we give up the freedom to choose once we become committed to the nonexistent lid. The first step in challenging a commitment is recognizing that you have made it in the first place.

The American philosopher John Dewey prefigured this situation in his 1934 book, *Art and Experience*:

> No matter how ardently the artist might desire it, he cannot divest himself, in his new perception, of meanings funded from his past intercourse with his surroundings, nor can he free himself from the influence they exert upon the substance and manner of his present being. If he could and did there would be nothing left in the way of an object for him to see.

The symbols and signs that we use to express meaning or hope will evoke meaning in others not only as communication devices but also as boundary setters. The words and the meanings that they evoke set up boundaries with regard to our ability to attend to, cognize, or be aware of aspects of our situation.

> According to what can loosely be described as "boundary theory" (Michaelsen & Johnson, 1997; Nippert-Eng, 1996a, b; Zerubavel, 1991), individuals create and maintain boundaries as a means of simplifying and ordering the environment. "Mental fences" (Zerubavel, 1991: 2) are erected around geographical areas, historical events, people, ideas, and so on that appear to be contiguous, similar, functionally related, or otherwise associated. The process results in the creation of slices of reality domains that have particular meaning for the individual(s) creating and maintaining the boundaries. "Home," "work," and "church" are examples of the social domains created by boundaries (Nippert-Eng, 1996a). The boundaries are real in the sense that the individual perceives them as such and

> acts as though they are real (cf. Weick, 1979). Although a given domain may be socially constructed and more or less institutionalized (e.g., people share a general consensus on what home means), Nippert-Eng (1996a, b) has shown that the boundaries around that domain are somewhat idiosyncratically constructed (e.g., one person allows home to cross over into work, whereas another keeps them separated). Further, by circumscribing domains, boundaries enable one to concentrate more on whatever domain is currently salient and less on other domains. (Ashforth *et al*., 2000)

These boundaries can be triggered by repetition and word choice. Gould (2000) suggested that they were triggered by "canonical stories"—the shorthand for which are often labeled by the media as "memes."

> The vertebrate brain seems to operate as a device tuned to the recognition of patterns. When evolution grafted consciousness in human form upon this organ in a single species, the old inherent search for patterns developed into a propensity for organizing these patterns as stories, and then for explaining the surrounding world in terms of the narratives expressed in such tales. As for mind, even when we can attribute a pattern to conventional nonrandom reasons, we often fail to apprehend both the richness and the nature of those causes because the lure of canonical stories leads us to entertain only a small subset among legitimate hypotheses for explaining the recorded events. Even worse, since we cannot observe everything in the blooming and buzzing confusion of the world's surrounding richness, the organizing power of canonical stories leads us to ignore important facts readily within our potential sight, and to twist or misread the information that we do manage to record. In other words, and to summarize my principal theme in a phrase, canonical stories predictably "drive" facts into definite and distorted pathways that validate the outlines and necessary components of these archetypal tales. We therefore fail to note important items in plain sight, while we misread other facts by forcing them into preset mental channels, even when we retain a buried memory of actual events.

Word choices afford the possibility of new meanings, new analogies, and new insights, which, in turn, can lead to new or next activity. As people share framed information, they need not refer to all aspects of a frame directly to communicate which frame they have adopted to make sense of the information. Instead, they need only make reference to one dimension of a pattern to enable hearers or readers of their text to recall the

whole frame. This evocative "power" is one of the attractive aspects of the meme concept. By viewing signifiers of meaning such as memes as mediums with a context dependence, we can see how the frames that result from word choice can work to limit or expand the very possibilities that we recognize as being afforded by our current situation. Word choice matters as a delimiter of possibility space as well as a means of communication. This provides the context in which mechanisms of memes operate.

Mechanisms[4]

> 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. A complex is a word which does not function as a carrier of a concept but rather as a family name for a group of objects belonging together not logically but factually. (Vygotsky, 1986)

> It is through language that we construct reality. With words we define, shape, and experience. Without the words to think, communicate, experience, or understand our lives would be very different from what they are. Words expand our consciousness but also limit us as we can only fully experience those things that we have the words for. Language provides the framework through which we perceive, experience, and act. As language constructs reality, so symbolization constitutes objects. Symbolization constitutes objects not conceptualized before, objects which would not exist except for the context of social relationships wherein symbolization occurs. Language does not simply symbolize a situation or object which is already there in advance; it makes possible the existence or the appearance of the situation or object, for it is a part of the mechanism whereby that situation or object is created. (Mead, 1934)

One example of this is the word "set," which has more than 100 meanings. The multiplicity of such meanings is the substrate for the mechanisms of imitation, transmission, and evolution that are "normally" ascribed to memes. Words evoke families of meanings. In Lissack and Letiche (2004), these families of meanings are referred to as a glom. (Vygotsky, in his work, used a word that is usually translated as "complex."

Lissack and Letiche opted for "glom" so as to avoid confusion.) The multiplicity of meanings implicit in a glom allows, when each such meaning is viewed as a medium, new possibilities for action. Vygotsky distinguishes between more primitive gloms—a word that does not function as a carrier of a concept, rather as a family name for a group of objects belonging together not logically but factually—and higher-level concepts. First come the gloms, and it is when abstracted traits are synthesized anew and the resulting abstract synthesis becomes the main instrument of thought that a concept emerges (Vygotsky, 1986).

Gloms differ from indexicals. Gloms are primitive collections of families of meaning. Thus, when a child is learning about daddy going to the office, an entire realm of experience is built into the glom of "daddy's office," "office," and "going to the office." Only later will the child be able to separate the primitive wealth of experiences into distinguishable parts and associate a socially acceptable label with some of those parts to better "bound" the concept of daddy's office (the subway trip and its associated people and smells may be in the glom but will have been removed from the concept). By contrast, indexicals have no meaning independent from the situated context in which they are evoked.

Because indexicals have no inherent meaning independent from context, the use of an indexical is constrained by the variety of contexts in which it is deployed and the multitude of meanings from which the interplay between context and indexical is required to distinguish. The effective indexical serves as a medium to evoke meaning. The ineffective indexical will instead call attention to itself with the demand for further clarification. In essence, its ability to carry meaning will have been compromised. The overloaded indexical reveals itself via a lack of transparency to its medium-serving (medionic) functions and the implicit question of "this or that?" When something new is encountered (a perturbation) or emerges at another level, the prior sense of clarity in the fundierung between indexical and situation can break down, much like the tragedy of the commons as described by economists. When the context does not evoke a clarity of meaning and multiple meanings are possible, evoked, and present, the indexical is broken and what has been called a glom has been evoked instead.

The important observation is what Vygotsky says occurs when there is dissonance between the understood meaning of a concept and new input, whatever it might be. When a concept breaks down there is reversion back to the glom. That reversion allows for change. The dissonance produced thereby forces a reversion in the perceived meaning of the word.

Context dependence takes over. "It is not merely the content of a word that changes, but the way reality is generated and reflected in a word" (Vygotsky, 1986).

Inherent in the multiplicity of meanings is the recognition that only one meaning will be primary within the context of a given situated activity. That primary meaning will not be the solely representative meaning, but will take its primacy from the context. When there is coherence between the situation and the meaning, the word choice will display a transparency with regard to medionic function. When that coherence is weak or absent, the very act of picking a label will demand some amount of attention. What coherence there is about the meaning, if it is to exist, would be forced to overcome or overwhelm such attentional demands.

The multiplicity of meanings undercuts the effective use of analogy as the word tokens of memes. Metaphors and analogies create constraints by focusing attention on that which is like and the resulting tendency by the user to attempt to justify the analogy. These constraints may not be readily apparent when the weakness of the analogy or the affinity is being exposed. Analogy involves inexact likeness. Butchvarov (1970, 1979) distinguishes between conceptual clarity and conceptual distinctness. Via analogy we can see the relative position as far as distinctness but can never achieve clarity. The former is a location in conceptual space and can be determined by noting similarities and differences between the entity being compared and other entities in conceptual space. However, clarity involves the content of the entity itself. It can be modeled, but the limitations of the model must be noted. Understanding is the desire for clarity, not merely distinctiveness. There is a remainder between the two. While categorization can suffice on distinctiveness, understanding cannot.

When we use analogy we are calling attention to some "like aspect" of two entities (call them source and object). If we were to dialogue with full disclosure about the analogy—this is similar, this is different; notice how the similars might react in situation *x* and contrast that with the differences, and so on—we would lose the shorthand and efficiency evoked by the analogy. Thus, we tend to allow our use of analogy to emphasize similarity over difference and substitution over care. In practice, when we assert that *a* is analogous to *b*, we often then make use of *b* as a label or category into which *a* falls. Affording such primacy to the similarities is to grant supervenience to the characteristics of the source at the expense of a fuller description of the object. When the similarities of a metaphor or analogy are allowed to supervene such that the analogy source is

substituted in meaning for the description of the object, mistakes happen, possibility spaces are misconstrued, retrospective sensemaking might not make sense, and taken-for-granted fundierung relations may hide nasty surprises. To the extent that coherence is perceived, it may be based on fantasy. Indeed, much of the internet/telecom bubble of the late 1990s seems to have been fueled by the supervenience of the characteristics of an "insatiable appetite" associated with convenience and newness over the demands for infrastructure, use, and value. The same pattern has been displayed by many of the bubbles documented in the history of economics.

Word choice and metaphor use allow for the emergence of new memes, the replacement of memes, and the death of memes via a concept that Douglas Hofstadter (1995) has labeled "conceptual slippage." In essence, the use of a metaphor or analogy evokes a glom of meanings. Each such use of metaphor is a perturbation to the existing self-referencing system (be it an individual, the organization, or some part thereof). The perturbations (please notice the plural) caused by the glom or gloms interact in multiple dimensions with the self-referenced core. As this series of interactions and resultant emergent behavior self-organizes, the principle of "least action" takes over. The basin of attraction that is the least demanding of energy is likely to determine the "winning" meaning. The least-action principle suggests that the energy demands of attention or of the carrying of a full description are likely to be supervened by the efficacy of using an analogy, a label, or a name, even if incorrectly. Thus, one concept can slip to another via the energy demands of the least-action principle. The "whatever" of the current teen does not mean permission, tolerance, or inclusiveness, it means indifference—though most over-40s would not recognize that except after a series of painful experiences.

Thagard and Nerb (2002) make a similar claim to Hofstadter's conceptual slippage in describing emotional gestalts:

> Thagard (1996: Ch. 11) described how dynamical systems theory can be applied to psychological phenomena by means of the following explanation schema: Human thought is describable by a set of variables. These variables are governed by a set of nonlinear equations. These equations establish a state space that has attractors. The system described by the equations is chaotic. The existence of the attractors explains stable patterns of behavior. Multiple attractors explain abrupt phase transitions. The chaotic nature of the system explains why behavior is unpredictable. In the language of dynamical systems theory, the perceptual system has

> two attractor states, and the gestalt shift involves a phase transition from one attractor to the other. Analogously, we might think of an emotional state as a gestalt that emerges from a complex of interacting environmental, bodily, and cognitive variables, and think of emotional change as a kind of gestalt shift… Emotional gestalt shifts occur when changes in representations and their valences generate a new array of acceptances and valences that maximize constraint satisfaction differently from before. Through parallel constraint satisfaction, this shift may alter the acceptance status of other propositions.

When an emotional gestalt occurs, so too might conceptual slippage. Both undercut the effectiveness of a meme set in a new context.

Fauconnier and Turner (2002) go further in that they not only look for a slippage in conceptual meaning, but also for the activation of a new meaning. This is an extension of the emotional gestalt argument.

> In any theory of meaning, activation does not come for free. The existence of frames, knowledge, experience, scenarios, and memories does not come for free. Ease of activation and degree of entrenchment by themselves impose very strong constraints on the imagination and the use of language. Linguists, logicians, and, for the most part, even psychologists tend to focus on the entrenched cases, which are already built and usually easy to activate. When only the rigid and entrenched patterns are used, meaning becomes predictable based on the mapping schemes and those patterns… Blends arise in networks of mental spaces which they call conceptual integration networks. Conceptual integration networks can have several input spaces and even multiple blended spaces. In conceptual integration, there is partial matching between input spaces of many kinds: connections between frames and roles in frames, connections of identity or transformation or representation, analogical connections, and metaphoric connections. In blending, structure from two input mental spaces is projected to a new space, the blend. Generic spaces and blended spaces are related: Blends contain generic structure captured in the generic space but also contain more specific structure, and they can contain structure that is impossible for either of the inputs. Similarly, not all elements and relations from the inputs are projected to the blend. Thus, emergent structure can arise in the blend that is not copied there directly from any input.

Blends, emotional gestalts, and conceptual slippages are all evidence of the least-action principle (lower energy expenditure) at work.

Lower energy expenditure is the driving pursuit in the information space world (cf. Boisot, 1995). In Vygotskian terms, a group and its members begin with some existing set of concepts and they encounter change. The encounter reduces some of the concepts to the status of gloms, and in such a status, the possibility arises for new conceptual understanding to emerge. This understanding will be influenced by the metaphors and analogies available to label the gloms, for in the adjacent meanings implicit in the metaphors is the potential synthesis represented by the new concept. The premises of least action suggests that a context-dependent glom is an efficient vehicle (in the same manner that Perry and Barwise suggest that indexicals are efficient), provided that supervenience is possible. This is because we use words as tokens and allow context to evoke meaning from among the gloms represented thereby. If supervenience is possible, then such evoked meanings are triggered by the situated activity in which they occur. By contrast, gloms will not work well in a system that is dependent on representations, reductions, and causality. In such a world, evoked meanings become reified and are carried across new situated activities. Dissonance from the mismatch is the likely result.

To a group member, context includes ongoing change—which then disrupts the shared-context content of existing codification and disturbs the agreed meanings of abstractions. A key least-action observation is that personal coding of meaning is transformed within an organization into institutionalized codification, so as to both maximize the value of shared meaning and minimize the need for the energy expended to transmit shared context. Emergent change erodes the ability of codification to hold. In the absence of an offsetting response to this erosion, institutional codification recedes to personalized coding, and the ability of common abstractions to transmit shared meaning deteriorates. Concepts become gloms. Such disturbances can have an emergent character that itself is disturbing, because the cumulative effects thereof cannot be predicted or planned for. This lack of prediction or planning poses a threat to coherence. And coherence preservation is another energy-conserving action within the information space.

Thus, we have a mechanism for meme success and failure. Emergent change occurs in the environment. In Vygotskian terms, the dissonance introduced by emergent change forces previously accepted concepts to recede to gloms. Uncertainty of meaning is introduced. For our purposes, uncertainty can be regarded as a label better defined as the inverse of one's propensity to act (Dretske, 1981; Fransman, 1994). Given uncer-

tainty's threat to coherence, organizations must find a way to combat its increase, for uncertainty is a significant energy drain running counter to the principle of least action. Increases in uncertainty can be attributed to loss of identity, to a perceived need for more and "better data," and to an increase in the perceived threat from taking an incorrect action.

This translates into the lack of a well-understood model of the possibility space and thus the substitution of a need to search for a willingness to act. If identity is to be preserved, then there must be an offsetting emergent response to rebuild context so as to replace the content lost to uncertainty (i.e., that which was contained in the institutional codifications and abstractions that have now encountered disconfirming notions and been forced to revert to the more primitive gloms of meaning). Success is related to the evolution of the ideational niche for which the meme is a token. If that niche has failed, so too will the meaning-evocation powers of the token. The successful meme is one whose indexical quality can bridge both the old context and the new, such that the users of the meme token can dialogue about the meanings evoked by that token without asserting incommensurability. The unsuccessful meme is one whose indexical quality cannot bridge the gap between contexts and thus cannot make the transition to new context and new situation.

Implications

> We need to do memetics to demonstrate when, where and how memetics has a relative and relevant advantage over social science devoid of memetics. The future of memetics will not be decided by those talking about memetics, whether grand theorising or armchair philosophy about the evolution of culture, history, consciousness or how we think, but will be decided by those doing memetics and demonstrating its relevance. (Hales & Marsden, 2002)

A memetics that accepts memes as indexical catalysts and tools can demonstrate the advantage that Hales and Marsden seek. Such a memetics allows for study of the content of information and its use, with a focus on processes and mechanisms vastly different from what passes today as information science, knowledge management, or linguistics. This is not a memetics that studies the evolution of memes *per se*, for the ontological status of memes is changed within it. However, such a memetics can demonstrate relevance, advantage, and application.

For example, if this approach were adapted to an extension of Salingaros and Mikiten's (2002) exploration of modernism as an

architectural meme, the discussion would explore the environmental niche in which the qualities laid out for the success of the modernism thrive. This would be followed by an exploration of what potential risks for the success of the meme lie within and without that niche, and what factors of the meme and/or the niche contribute to its ongoing resilience. Once the risks and resilience factors have been so identified, they can be mapped to other domains and compared with the success/failures of other memes both within and without the architectural domain. This seems far more fruitful an approach to making social science advances than the mere mapping of modernism in architecture as a meme (a mapping that allows critics to reply "So what?").

Edmonds' (2002) three challenges can be answered by this revised form of memetics. For example, his first challenge argues that a "conclusive case study" would "clearly demonstrate that there is at least one cultural process that is of an evolutionary nature, where 'evolutionary' is taken in a narrow sense." If the requirement that it is the meme that must be of an evolutionary nature is dropped, then Edmonds' challenge is easily fulfilled. Anthropology and sociology can document hundreds of cultural processes that are evolutionary and many of these will have a history of successful memes associated with them. What is difficult for meme as replicator is much easier for meme as indexical catalyst.

Lissack and Letiche's forthcoming *Coherence Emerges: A Complexity Theory of Organization* (2004) is an example of work that meets Edmonds' second challenge. So too does much of the case-study work on organizational symbolism. Edmonds' third challenge is perhaps incommensurate with the revisions suggested above. Memetic processes of the catalytic indexical variety are easily found and documented in the "real" world and are not in need of "simulation." Such "real" examples should, in any case, be considered as a firmer foundation for an applied theory than simulations could provide. Memetic processes of the catalytic indexical variety also seem to address many of the concerns raised in Bloch (2000) and Kuper (2000).

This redefinition of memes recognizes that they are efficient tools for evoking particular affordances to be attended to in situ. Such a definition is consistent with theories of niche construction. This article suggests that Dawkins created an indexical (meme=gene) and it has exceeded its carrying capacity and thus lost its efficacy. Worse, that indexical is evoking images and affordances that stand in the way of the memetics field making true progress. It is time to recognize that ontic status has been misplaced. Memes need a new meme: meme as catalytic indexical.

For managers, memes defined as catalytic indexicals raise the potentialities offered by other catalysts—the provisioning of an environment with a catalyst can afford the possibility of a transformation that is much more difficult than without the catalyst's presence. Memes would be studied for their catalytic roles and managers would be taught sensitivity to the conditions that aid and hinder the evolution of such catalysts.

As catalytic indexicals, memes can be meaningfully assigned explanatory and causal roles—the very ingredients that Edmunds claims memetics needs, and the qualities that managers are often seeking.

NOTES

1 This notion does not conflict with the definition of meme in the *Oxford English Dictionary*: An element of a culture that may be considered to be passed on by non-genetic means.

2 An application of this argument is forthcoming in Lissack & Letiche (2004).

3 Cf. T. Kapitan's "Autonomy of indexical reference" and related works at http://www.soci.niu.edu/~phildept/ and G. Nunberg's "Indexicality and deixis" (1993) and related work at http://www-csli.stanford.edu/~nunberg/linguistics.html.

4 Much of the mechanism argument was first developed in Lissack & Roos (1999) and has been expanded in Lissack & Letiche (2004).

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The Dark Side of Organizations and a Method to Reveal It

David A. Bella, Jonathan B. King, & David Kailin

> The ability to see the larger context is precisely what we need to liberate ourselves. (Milgram, 1992: xxxii)

Few who have read Stanley Milgram's book, *Obedience to Authority* (1974), or have seen videos of these "shocking" experiments can forget them. In our view, Milgram's experiments offer important lessons about contexts, human behaviors, and the role of contexts in setting boundary conditions around such behaviors. This article takes these lessons seriously. But first, a succinct summary of the experiments.

A "teacher" is instructed by the "scientist-in-charge" to administer an electric shock to a "student" every time he gives a wrong answer—which is most of the time. The teacher is given a list of questions in advance. The electric shocks range from 15 to 435 volts and are visibly displayed on a panel facing the teacher: Slight 15+ … Intense 255+ … Danger 375+ … XXX 435. The student—a superb actor who is not actually shocked—starts to grunt at 75 volts. He follows a standard script.

> At 120 volts he complains verbally; at 150 he demands to be released from the experiment. His protests continue as the shocks escalate, growing increasingly vehement and emotional. At 285 volts his response can only be described as an agonized scream. (Milgram, 1974: 4)

And that's with 150 volts yet to go! At the high end, the student is dead silent. What happens if the teacher (repeatedly) objects? The scientist is

only allowed to "prompt" her or him with such comments as, "Please continue, please go on," "The experiment requires that you continue," "You have no other choice, you must continue." No threats, no demeaning remarks about the student; just calmly stated reasons why the teacher should continue.

So, at what point would you or I stop? The bad news is that over 60 percent of us go all the way even when we can hear the student screaming. The really bad news is the disparity between our actual behaviors and the predictions of "psychiatrists, graduate students and faculty in the behavioral sciences, college sophomores, and middle-class adults."

> They predict that virtually all subjects will refuse to obey the experimenter; only a pathological fringe, not exceeding one or two percent, was expected to proceed to the end of the shockboard. The psychiatrists… predicted that most subjects would not go beyond the 10th shock level (150 volts, when the victim makes his first explicit demand to be freed); about 4 percent would reach the 20th shock level, and about one subject in a thousand would administer the highest shock on the board. (Milgram, 1974: 31)

Why the stunning disparity? What are we overlooking? For starters, how did Milgram interpret the significance of such unexpected findings?

> I must conclude that Arendt's conception of the *banality of evil* comes closer to the truth than one might dare imagine… This is, perhaps, the most fundamental lesson of our study: ordinary people, simply doing their jobs, and without any particular hostility on their part, can become agents in a terrible destructive process… Men do become angry; they do act hatefully and explode in range against others. But not here. Something far more dangerous is revealed: the capacity for man to abandon his humanity—indeed, the inevitability that he does so—as he merges his unique personality into larger institutional structures. (Milgram, 1974: 6, 188)

"Larger institutional structures"? What are such things? And why are we apparently blind to the emergence of their dark side?

We propose that the first general lesson to be drawn from Milgram's experiments is that contexts are powerful determinants of human behavior. In his experiments, Milgram essentially constructed a context. And subjects found it extremely difficult to act out of context—to refuse to continue the testing. A second general lesson is that the power of context to shape human behavior has been vastly underestimated if not

overlooked entirely. For Milgram's work also demonstrates that when the experiments were described to people—including experts—virtually all failed to foresee anything remotely close to the compliance that actually occurred. A third lesson that we shall literally illustrate is that Milgram's experimental results not only extend to and pervade human existence, but that such contexts are typically neither the result of deliberate design nor otherwise intended. Instead, they emerge.

This article presents a method to see past the business that preoccupies us to expose the character of contexts that promote compliance no less disturbing than the compliance of Milgram's subjects. While disarmingly simple, this method is far from simplistic, for it allows us to illustrate the patterns that lie behind the countless tasks of ordinary people who are simply doing their jobs, getting by, and struggling to succeed. From such patterns, great harm can emerge. But within the context of such patterns, one finds individuals who are hard-working, competent, and well-adjusted. The key to understanding such claims is to take emergence very seriously.

Put bluntly, outcomes that we consider harmful, distorting, and even evil can and too often do emerge from behaviors that are seen as competent, normal, and even commendable. Not only cannot these emergent outcomes be reduced to the intentions of individuals, but, more disturbingly, dark outcomes can emerge from interactions among well-intended, hard-working, competent individuals. Such phenomena do not require the setting of Milgram's experiment—the "authority" of a laboratory complete with a "scientist" dressed in a white lab coat—quite the contrary. They are an everyday feature of our lives. Therefore, rather than focusing on the actions of irresponsible individuals, we must—most importantly—attend to the contexts within which normal, well-adjusted people find good reasons for behaving as they do.

Sketching context

Consider the normal behavior of well-adjusted students in a university library. At a football game, these students yell and cheer. At the library they do not. Why? The behavioral contexts are different and—this is a key claim—*contexts shape behavior*. To understand this claim, consider a sketch of the library context given in Figure 1. To read this sketch, begin with any statement of behavior. Read forward or backward along an arrow to the next statement. Say "therefore" when you move forward along an arrow and "because" when you move backward. Wander through the

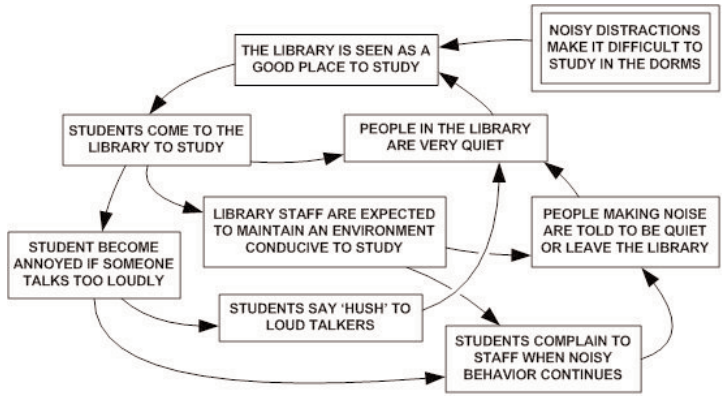

Figure 1 *A sketch of the university library context. Read forward (say "therefore") or backward (say "because")*

entire sketch, moving forward *and* backward along the many loops, until you grasp the character of the whole. Please note: If you do not work through the sketches in this manner, you will likely misperceive the fundamental claims of this article.

Yes, there are rules for proper behavior within the library, but very few read them. Instead, we find that amid the busy activities of students, general behaviors tend to settle into mutually reinforcing patterns. These emergent patterns constitute the context. Figure 1 therefore serves to explain not the specific behaviors of particular students, but rather the context that sustains normal behaviors as many students come and go.

Table 1 outlines the general method of sketching applied to Figure 1. Column A describes how human behaviors, in general, respond to any given context. Column B describes a disciplined approach to sketching that expresses the general behaviors given in Column A. Read these two parallel columns and note their relationships. Together they show that the way we behave within a context (Column A) can be sketched by the method given in Column B.

This method of disciplined sketching exposes behavioral patterns that are typically taken for granted. *Such patterns*, we claim, *constitute behavioral contexts*. Figure 1 is an example. Within this context, students find good reasons not to yell and cheer. This is what contexts do: They provide reasons for some kinds of behaviors and not others.

By using information relevant to the context of interest, this method can uncover the character of different contexts. Table 1 provides a discipline to such an inquiry. First, we are led to look for persistent behaviors

Table 1 *General observations of human behaviors (Column A) and related guidelines for sketching (Column B)*

A Within a given context	B To develop a sketch of a given context
Some behaviors and conditions tend to persist and reoccur	Place simple descriptive statements of behaviors (conditions) in boxes; statements should make sense to those involved
Persistent and reoccurring behaviors (conditions) are supported by reasons that make sense to those involved	Each boxed statement should have at least one *incoming* arrow from a boxed statement that provides a reason that makes sense to those involved*
Persistent and reoccurring behaviors (conditions) have *consequences* that are also persistent and reoccurring	Each boxed statement should have at least one *outgoing* arrow pointing to a boxed statement that is a consequence

*Occasionally a given statement can be employed without an incoming arrow, indicating that the reasons lie beyond the scope of the sketch

and to express them in general terms. Second, we are forced to seek reasons—not "causes" but "reasons"—for such behaviors, reasons that make sense from the perspectives of those acting out the behaviors. Having done this, we make a sketch under the guidance of Table 1. Figure 1 was sketched (after many revisions) in this manner. Notice that, with the exception of the "given" (double-lined box), all the behaviors must meet two commonsense guidelines:

1 Behaviors that tend to persist (keep coming up) do so because they have reasons that make sense to those acting out the behaviors.
2 Behaviors that tend to persist have consequences that tend to persist.

The first guideline is met when each behavior statement (except the "given") has at least one incoming arrow (a reason). The second guideline is met when each behavior has at least one outgoing arrow (a consequence). The patterns that emerge from these guidelines take the form of loops. Our method of sketching serves to uncover such patterns, exposing the fundamental character of a context that is often hidden in countless distracting details.

Notice some features of this simple sketch. The "elements" or "components" of the system, the boxed statements, do not refer to "agents" or

to groups of people. Neither do these boxes represent "storage tanks" as in stock-and-flow models. They are not "control volumes" as often employed in the derivation of differential equations. Instead, the boxes describe behaviors or behavioral conditions. In turn, the arrows do not represent transfers (inputs and outputs). Instead, when read backward an arrow gives a reason; when read forward it gives a consequence. Notice also that the figure reads in natural or ordinary language. This allows readers quickly to grasp the pattern as a whole without struggling with unfamiliar notations, jargon, or symbols. Such sketches involve only a few statements—usually fewer than 14—so that the reader is drawn not to details but to the pattern as a whole. Sketches gain validity when people who have been involved within the context recognize it within the sketch. Finally, notice the form of the pattern: multiple loops of mutually reinforcing behaviors.

In sum, we claim that emergent outcomes in human affairs appear in such forms and that such forms become apparent through the application of this method. We will now show how this sketching method serves to expose a whole class of problems that are commonly overlooked and misperceived.

Simple and complex problems

Imagine that a student does yell and cheer in the library; that is, that he or she acts out of context. This would constitute a problem—a condition that demands attention. "But," you might respond, "we don't need such sketches to notice, let alone understand, this kind of problem." We agree! The out-of-context (improper, maladjusted) behavior clearly stands out without the need of a method. So, when is this method of exposing context important? Why bother sketching loops if we don't need to? The answer becomes apparent when we recognize the difference between *simple* and *complex* human problems.

A problem arising from out-of-context behavior—a student shouting in the library—is a simple problem. Simple problems can be *reduced* to the improper behavior of the offending individuals. Thus, the problem lies in the part, not the whole. For complex problems, however, the condition that demands attention is the context as a whole. Unlike a maladjusted student yelling in the library, a complex problem arises from the well-adjusted behaviors of people acting within a context. Thus, the context itself demands our attention. However, unlike a shouting student, the context *does not stand out* in general, let alone as something abnormal in

particular. Quite the opposite! The context defines the norm and is usually taken for granted.

If all human problems were simple problems, then disciplined sketching would be of little use. But if complex problems are both common and significant, then the patterns of normal and well-adjusted behaviors should concern us. Such patterns constitute the contexts that normal and well-adjusted people take for granted. Context defines normal behaviors. There are few things that can hide and sustain a problem as well as normalcy. We will now apply this method to a complex problem that is serious, widespread, and sustained by the normal behaviors of well-adjusted people.

THE SYSTEMIC DISTORTION OF INFORMATION

Clearly, information can be distorted through the willful intent of individuals. Without denying such willful distortions, we claim that information distortion can also emerge as a complex problem that cannot be reduced to the intentions of individuals. Figure 2 illustrates such systemic distortions. This sketch was selected because it has been peer reviewed by practitioners from a wide range of disciplines and appears to describe a pervasive, complex problem (Bella, 1987, 1996).

Wander through the entire sketch, moving forward ("therefore") and backward ("because") along the many different loops, until you comprehend the whole picture. You can sense how information favored by "the system" serves to support, sustain, promote, and propagate the system. Such information is more readily sought, acknowledged, developed, and distributed, while unfavorable information has more difficulty coming up, going anywhere, or even surviving.

Such contexts and the information they sustain shape the premises and perceptions of those involved, instilling within them what are taken for granted as proper and acceptable behaviors. Those who raise troubling matters, questions that expose distortions, are out of context. As with simple problems, they become the problem "trouble-makers." They may face personal criticism, being charged with improper, even "unethical," behavior. In the private sector, the possibility of legal action—"You'll hear from our lawyer"—can be very threatening. However, the problem sketched herein is not a simple problem; the context itself is the problem.

Now conduct the following exercise. Imagine that you have reviewed a recent report describing the consequences of an organization's activities (environmental impacts, as an example). You are upset to find that

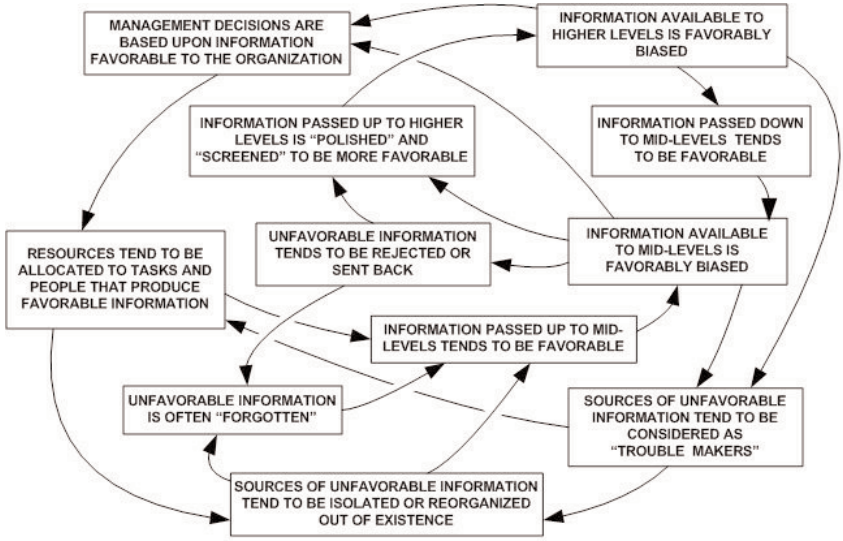

Figure 2 *The systemic distortion of information (Bella, 1987)*

information concerning adverse consequences was omitted. You question the individuals involved. Your questions and their answers are given in Table 2. As you read their answers, keep in mind the context sketched in Figure 2. Notice that the answers given in Table 2 make sense to those acting *within* this organizational context. In sum, the problem—systemic distortion—*emerges* from the context (pattern, system) as a whole and cannot be reduced to the dishonest behaviors of individual participants. Unlike the library context, systemic distortion of information is a complex problem where the context itself demands our attention.

The larger point is that complex problems are particularly dangerous because the individual behaviors that lead to them do not stand out as abnormal—as out of context. Quite the contrary, for as illustrated in Table 2, each individual finds good reasons for his or her behavior within the context. Indeed, distortions can become so pervasive and persistent that views contrary to—that don't fit within—the prevailing patterns are dismissed as misguided and uncalled for.

While such distortions can harm the organizations that produce them (Larson & King, 1996), they can also serve to propagate the systems that produce them, covering up adverse consequences and externalized risks. As a case in point, the model (Figure 2 and Table 2) was originally developed in 1979 to describe the frustrations of professionals involved in the assessments of *environmental* consequences. Here, the primary concern

Table 2 *Reasoning of participants within the context sketched in Figure 2 (Bella, 1987)*

Person in the system	Question	Assumed answer to question
Higher-level manager	Why didn't you consider the unfavorable information your own staff produced?	I am not familiar with the information that you are talking about. I can assure you that my decisions were based upon the best information available to me.
Midlevel manager	Why didn't you pass the information up to your superiors?	I can't pass everything up to them. Based upon the information available to me, it seemed appropriate to have this information reevaluated and checked over.
Professional technologist	Why wasn't the unfavorable information checked out and sent back up to your superiors?	That wasn't my job. I had other tasks to do and deadlines to meet.
Trouble-maker	Why didn't you follow up on the information that you presented?	I only worked on part of the project. I don't know how my particular information was used after I turned it in. I did my job. Even if I had all the information, which I didn't, there was no way that I could stop this project.
Higher-level manager	Why has the organization released such a biased report?	I resent your accusation! I have followed the development of this report. I have reviewed the drafts and the final copy. I know that the report can't please everybody, but based upon the information available to me, I can assure you that the report is not biased.
Midlevel manager	Why has the organization released such a biased report?	It is not just my report! My sections of the report were based upon the best information made available to me by both my superiors and subordinates.
Professional technologist	Why has the organization released such a biased report?	It is not my report! I was involved in a portion of the studies that went into the report. I completed my tasks in the best way possible given the resources available to me.
Trouble-maker	Why has the organization released such a biased report?	Don't ask me! I'm not on this project anymore and I really haven't kept up with the project. I turned in my report. It dealt with only a part of the project.
Higher-level manager	Why was the source of unfavorable information (the trouble-maker) removed from the project?	I hardly know the person. A lot of people have worked on this project. I must, of course, make decisions to keep this organization running, but there has been no plot to suppress people! On the contrary, my decisions have been objectively based upon the available information and the recommendations of my staff.
Midlevel manager	Why was the source of unfavorable information (the trouble-maker) removed from the project?	I don't like your implications! I've got tasks to complete and deadlines to meet with limited resources. I can't let everybody do their own thing; we'd never finish anything. I based my recommendations and assignments on the best available information.
Professional technologist	Why was the source of unfavorable information (the trouble-maker) removed from the project?	I'm not sure about the details because I don't work with him. I guess it had to do with a reorganization or a new assignment. He is a bright person, somewhat of an eccentric, but I've got nothing personal against him.
Trouble-maker	Why were you removed from the project?	My assignment was completed and I was assigned to another project. I don't think that anybody was deliberately out to get me. My new job is less of a hassle.

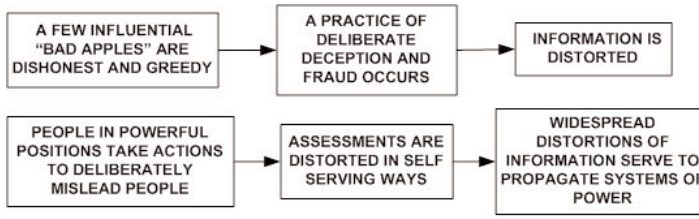

Figure 3 *Common and straightforward (linear) explanations of distortion*

was self-propagating distortions that *benefited* the organizational system that produced them while allowing harmful consequences to accrue in the larger environment and society.

If all systemic distortions were self-harming, we would expect this complex problem to be self-correcting. But where distortions benefit, sustain, and promote the systems that produce them, the presumption of self-correction does not apply. These are arguably the most serious forms of systemic distortion, propagating the systems that produce them.

DISTORTION AND EMERGENCE

We realize that much more is involved in organizational systems than shown in this sketch (Figure 2). But, of course, complex systems are "incompressible" (Richardson *et al*., 2001). Thus, all models (sketches) are simplifications. A test of any model is: Does the model describe *some* matters of importance *better than* its chief rivals?

In the case of information distortion, the dominant rivals involve lines of reasoning as sketched in Figure 3.

There is much appeal to such straightforward reasoning. We can blame others and it requires little effort on our part. However, this ease of reasoning arises from linear presumptions. In brief, one presumes that wholes, systemic distortions, can be reduced to the character of parts, individuals. *Ergo*, blame (Figure 3). If the world were linear, such reasoning would make sense. But of course, if the world were linear we could be great musicians. On a grand piano we could play grand notes. Alas, the world is nonlinear and the sum of our grand notes does not add up to grand music! Clearly, the character of wholes cannot be reduced to the character of parts. Blame, like the pounding of individual notes, is a linear misperception that fails to conceive emergent wholes. By sketching whole behavioral patterns in a disciplined way, rather than focusing on parts (individuals), we can expose emergent phenomena not reducible

to parts. However, to make such sketches, one must blame less and listen more.

Compare Figures 1 and 2 on the one hand with Figure 3 on the other. Notice the strikingly different form of thought. Instead of a "line" or "chain" of reasoning (Figure 3), we find that human behaviors tend to settle into mutually reinforcing patterns (Figures 1 and 2). Behaviors continue because they are sustained by such patterns. Emergent behaviors arise from the patterns as wholes.

Concerning "emergence," we are in agreement with the following general statements by John H. Holland (1998):

> Recognizable features and patterns are pivotal in this study of emergence... The crucial step is to extract the regularities from incidental and irrelevant details… This process is called *modeling*… Each model concentrates on describing a selected aspect of the world, setting aside other aspects as incidental (pp. 4–5)… emergence usually involves patterns of interaction that persist despite a continuing turnover in the constituents of the patterns (p. 7)… Emergence, in the sense used here, occurs only when the activities of the parts do *not* simply sum to give activity to the whole (p. 14).

This modeling approach (disciplined sketching) is different from (and we believe complementary to) the approaches of Holland and others. Nevertheless, Holland's statements do apply to our notion of systemic distortions as emergent phenomena. Furthermore, we find that these sketches are quickly grasped by participants within organizational systems. Indeed, Figure 2 was sketched in response to the stories of frustration of people within actual organizational systems (Bella, 1987). Rather than dismissing their frustrations as evidence of "poor attitude" (a form of blame), we took them seriously and sketched the context that (a) made sense of credible frustrations and (b) avoided blame. In brief, amid the busy activities of countless people involved in endless tasks, general behaviors tend to settle into mutually reinforcing patterns. These patterns constitute the contexts for the normal behaviors of well-adjusted people. In scale, duration, and complexity, the distortions that can emerge from such patterns far exceed the capabilities of deliberate designs. This has radical implications that are easily overlooked by a more straightforward (linear) understanding of distortion (Figure 3).

Implications for our emerging technological world

In the modern world, getting a drink of water is such a simple thing. Merely turn the faucet. But this simple act depends on a vast technosphere far beyond the capacity of any group to design deliberately. The components of our faucet may come from distant parts of the world. Following the faucet back through pipes, pumps, electrical grids, power plants, manufacturing facilities, and mining operations, one encounters vast and interconnecting complexities in all directions. The technological, informational, and financial interconnections are bewildering and vast. Yet, somehow it all comes together so that you can turn on your faucet and get water.

This global technosphere requires the busy and highly diverse activities of countless people involved in endless tasks. If we focus on only one project manager on one of seemingly countless projects, we find remarkable abilities that few of us appreciate. The real challenge is not scientific analysis of some physical entity or device. Rather, the challenge is getting the right materials, equipment, people, and information together at the right place and at the right time within a world that is constantly changing and ripe with the potential for countless conflicts and misunderstandings. If one is not impressed by the abilities of successful project managers, one simply does not understand what is going on.

However, the scale and complexity of such human accomplishments—the continuously changing technosphere on which we depend — extend far beyond the abilities of any conceivable project management team. Our drink of water, indeed our very lives, depend on vast, complex, adaptive, and nonlinear (CANL) systems. They are self-organizing and continually adapting. Through them, highly diverse activities are drawn together and outcomes emerge far beyond the abilities of individuals and groups. The activities of numerous people, including our successful project manager, occur within the contexts sustained by such CANL systems. Indeed, contexts are CANL systems emerging at multiple levels, shaping behaviors in coherent ways despite vast differences among individuals and the tasks they perform.

A growing body of literature, popular and academic, has been rightly fascinated by the remarkable behaviors of CANL systems, which are not subject to our traditional analytical habits of thought (Kauffman, 1995; Waldrop, 1992; Wheatley, 1992). Richardson *et al*. (2001) write:

> Complexity science has emerged from the field of possible candidates as a prime contender for the top spot in the next era of management science.

We agree. We are concerned, however, that too often the literature is silent on the dangers of emergent outcomes in human affairs. Indeed, some (Stock, 1993) treat emergent order in human affairs with a religious-like reverence. In our assessment, emergent outcomes cannot only be powerful but they can be dangerous, deceptive, and distorting.

We therefore face a worrying imbalance. Complexity science may well help managers expand the effectiveness, scale, and influence of organizational systems. But with respect to the distortion of information, a crude form of linear reductionism, blame, continues to prevail.

EMERGENCE AND THE DARK SIDE OF ORGANIZATIONAL SYSTEMS

There is a dark side to organizational systems that is widespread and well documented (Vaughan, 1999). Much of this involves the emergence of systemic distortions. After the first shuttle (*Challenger*) explosion in 1986 (see Vaughan, 1996), Figure 2 and Table 2 were sent to Nobel physicist Richard Feynman, who served on the commission to investigate the accident. Although the model was developed long before the accident without any study of NASA, Feynman (1986) wrote back:

> I read Table 2 and am amazed at the perfect prediction of the answers given at the public hearings. I didn't know that anybody understood these things so well and I hadn't realized that NASA was an example of a widespread phenomena.

We agree that general phenomena are involved, emergent phenomena that too often are distorting and destructive. Did the second and more recent shuttle (*Columbia*) tragedy involve such phenomena? Follow the investigation and judge for yourself.

The tobacco industry serves as an exemplar of our concerns. Here we find global systems that were among the most economically successful and powerful of the twentieth century. They produced addictive products that contributed to the deaths of 400,000 Americans every year. The method presented in this article has been applied to the tobacco industry, illustrating how its economic success was closely tied to systemic and self-propagating distortions that emerged over many decades (Bella, 1997).

The widespread distortions of information in recent years by huge businesses, including the formerly prestigious accounting firm of Arthur Andersen, provide evidence of much more than individual fraud (Toffler, 2003). "Favorable" information (hyping stock, inflating profits, etc.) gushed from these systems while "unfavorable" information (exposing risks, improper accounting, unethical behaviors, etc.) too often went nowhere. The transfers of wealth were enormous; some, who exploited the distortions, made fortunes; many lost savings (Gimein, 2002).

What, then, tends to limit the extent of systemic distortions and their consequences? Our answer reflects a growing understanding of CANL systems in general. The character of CANL systems emerges from the interplay of order (pattern) and disorder (disturbance) over time (Bella, 1997). As an example, forest ecologists tell us that the state of a forest ecosystem reflects its "disturbance regime," its history of events (fires, storms, etc.) that disturbed emerging patterns. In a similar manner, we claim that the extent of systemic distortion reflects the history of credible disturbances, those compelling events that disrupt more distorting patterns allowing less distorting patterns to emerge.

In human systems, credible disruptions arise in two forms. First, they arise through the independent inquiries, questions, objections, and challenges that people raise. Second, they arise from accidents, explosions, and collapses that the system cannot cover up. Both serve to disrupt distorting patterns, but, clearly, the former are preferable to the latter.

Credible disturbances of the first (human) kind emerge from independent checks and open deliberation. This view leads to a conjecture:

> The extent of systemic distortions and their consequences have been, are, and will be inversely proportional to the history of credible disturbances sustained by independent checks and public deliberation not shaped by the systems themselves.

If evidence supports such a conjecture, as we believe it will, then we must take far more seriously the crucial importance of independent checks, including public agencies, and what Eisenhower (1961) called the duties and responsibilities of an "alert and knowledgeable citizenry." The implications are significant: The market is insufficient, independent public agencies are vital, and higher education must involve far more than economic development and job preparation.

Responsibility: Beyond linear presumptions

Conventional notions of responsibility—and, more generally, notions of good and evil—reflect linear presumptions. This linear attitude can be simply stated: "I'm a responsible person if I act properly, don't lie, cheat, or steal, and do my job in a competent manner." The problem raised by such common understandings of responsibility is that we see no reason why the individuals of Table 2 would not fit this notion of responsible behavior. Likewise, people tend to reason that evil outcomes arise from evil people: "If the individuals are good (competent, well-intended), then the outcomes should be good." Such linear perceptions fail to grasp the importance of emergent outcomes. Distorting and even evil outcomes can and do emerge from the actions of individuals, in spite of the fact that each may believe that his or her own behaviors are proper and competently done—those in high positions might honestly say, "There was no attempt to mislead or deceive." And *within* their contexts, they may be correct. However, if the context is the problem, then emergence has radical implications for notions of responsibility.

We do not deny the importance of competency, involving actions that are credible, rightly done, and commendable within a given context (game, course, assignment, organizational system, market, etc.). Competency calls for the ability to respond in ways credible within the context. Yet, there is no reason to assume that greater competency would reduce systemic distortions; in fact, the reverse may be true! When the context is the problem, an additional and radically different form of responsibility is required, responsibility that transcends contexts.

The responsibility to transcend context is a universal historical theme in the search for Truth, the pursuit of Justice, and the service of the Sacred. Responding to a calling that transcends context serves to liberate us from our bondage to contexts. Such contexts give us reasons to say, "I just don't have the time," "It's not my job," "It won't make any difference."

The traditional name for a responsibility to transcend context—and which informs the essence of universal intent—is "faith." Wilfred Cantwell Smith (1977, 1979), who devoted a lifetime of study to the meaning of faith in other ages and cultures, found that faith never meant belief (and especially not belief in spite of evidence to the contrary). Rather, the very *meaning* of faith has been radically distorted—lost, given up—in our modern age. The point is that faith does not deny the reality of context; faith transcends context. To paraphrase Viktor Frankl (1978),

faith "pulls" or "calls" for responsible behaviors from beyond, above, or even "in spite of" the context.

None of this, however, makes sense unless the dangers of contexts themselves become apparent. Distortions and, yes, evil, can and often are emergent outcomes not reducible to the "values" and "beliefs" of individuals. Without an appreciation of the dangers of emergence and the need for responsibility that transcends context, faith becomes reduced to individual beliefs and, more dangerously, the self-reinforcing behaviors of "true believers."

The method of disciplined sketching proposed herein seeks to expose the dangers of such reductionist thinking. This method, therefore, entails relational self-knowledge—know thy contexts. While such a challenge may be easily voiced, enacting it requires the system to be transcended. In our modern age of organizations, this constitutes a basic moral calling.

Epilogue

In 1982 John Naisbitt published a widely acclaimed book, *Megatrends*. In this book he declared:

> In the information society, we have systematized the production of knowledge and amplified our brainpower. To use an industrial metaphor, we now mass-produce knowledge and this knowledge is the driving force of our economy.

In the decades that followed, such declarations became so pervasive that objections to the idea might well be called a heresy of the age. Naisbitt's statement expresses the ideology of the age and, for many, its intellectual paradigm. Nevertheless, in this age we find evidence of information distortions arising from systems that selectively shape information in self-propagating ways. Such distortions, we claim, are emergent phenomena, emerging from patterns of behaviors that provide the contexts within which normal and well-adjusted people are busy at work. We provide a method to sketch such patterns.

To grasp the heretical implications of such claims, change one word in Naisbitt's declaration. Instead of "knowledge," insert the word "propaganda"—information selectively shaped to propagate the systems that produce it. The declaration now reads:

> In the information society, we have systematized the production of *propaganda* and amplified our brainpower. To use an industrial metaphor, we now mass-produce *propaganda* and this *propaganda* is the driving force of our economy.

Clearly, there is a moral difference. Judge for yourself. Has this "information age," our "knowledge" economy, provided evidence that this alteration of Naisbitt's declaration—and many others—should be taken seriously? We believe it does. But the evidence will not be understood if we persist in linear presumptions, reducing all distortions to individual fraud, a "few bad apples," or conspiracies deliberately to mislead or deceive. Emergence is real. Distortions emerge. This article presents a method to reveal how distortions emerge from contexts that well-adjusted people take for granted.

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Open Source as a Complex Adaptive System

Moreno Muffatto & Matteo Faldani

The concepts of complexity prevalent at various historical times have influenced the frames of mind with which organizations and the models of social planning and organizational design have been analyzed.

During the Industrial Revolution, the model of organizational design derived from the conceptual model of the machine. In this model, the concept of the hierarchical control of functions prevailed. The consequent approach was top-down thinking. Much of the organizational theory of the twentieth century was based on determinism, reductionism, and equilibrium as key principles. If an organization is conceived of as a machine, the control of the organization is obtained through a reduction in its complexity; that is, in the states of the machine or its variety.

The Information Revolution and the development of networks have produced phenomena such as the growing connection between elements that are often extremely different from one another (computers, people, even smart objects). This has led to phenomena that cannot be planned according to a top-down logic, but, on the contrary, "emerge" from interactions between elements and therefore "from the bottom." The approach most suitable for analyzing these phenomena is bottom-up thinking.

If in the past the world could be represented as a machine, today it is represented as a network and increasingly as an ecosystem. The internet, for example, can be considered not only as a technological infrastructure and a social practice, but also as a new way of thinking related to the concepts of freedom of access and diffusion of knowledge. Furthermore, the

internet is an organizational model without a center and without absolute control.

With the development of information networks, the internet in particular, it has been observed that not all phenomena that are developed can be designed and planned. In other words, networks involve social structures that make phenomena, to a certain degree, "emergent." Therefore, there has been growing interest in an approach that interprets phenomena from the bottom up; that is, from the network of relationships and the interactions between players.

The growth of the internet has led to the development of many types of online communities whose aims vary significantly. Only the creation of the Open Source community has offered the possibility of developing something concrete; that is, software products. Software lends itself to online development since it can be easily transferred via the internet itself. The many communities working together to produce Open Source software offer new stimuli for research in the context of complexity theory. The complexity of Open Source is due not only to technical aspects, relative to the complexity of software, but to the social complexity that characterizes the software development process.

In order to better understand this social complexity, some important studies have been carried out to interpret complex social phenomena (Axelrod & Cohen, 1999; Kauffman, 1995; McKelvey, 1999; Waldrop, 1992). In this analysis we will make reference to the theory of complex adaptive systems. A system can be considered complex and adaptive when the system's agents have the possibility of continually adapting their actions in response to the environment and the behavior of the other agents. Therefore, the agents have the ability to influence and be influenced by other agents. Consequently, the possibility of transferring information from one agent to another is extremely important in complex systems.

One of the most significant characteristics of complex systems is the presence of *emergence*; that is, the emergence of new states in the system that have new capabilities and offer new evolutionary possibilities. The very nature of this phenomenon makes it difficult to foresee what the new states of the system will be, since it is not always possible to extrapolate the new system properties from the existing system components.

The unpredictability of events and of the results makes understanding and interpreting a complex system that much more difficult. Nonetheless, one of the most interesting and significant aspects of the approach to complex systems is not the search for methods to limit their complexity,

but, on the contrary, the exploitation of the complexity itself (Axelrod & Cohen, 1999).

The Open Source community and its activities can be considered to have the characteristics of a complex adaptive system. The Open Source system is unique because it is neither controlled by a central authority, which defines strategy and organization, nor totally chaotic. It can be placed in a middle position between a designed system and a chaotic one (Lerner & Tirole, 2001). In this position, nonformal rules exist that allow the system to produce appreciable results.

The Open Source community

Software has not always been a commercial product. It was originally considered to be simply a tool for using computer hardware. Only hardware had a commercial value, whereas software was a complementary product needed to use and diffuse computers. Consequently, software was produced and distributed freely, just like other products based on knowledge and scientific research. The development of software was the fruit of the work of a small community of university researchers who collaborated closely with a few hardware manufacturers. Software was considered, just as academic research is, to be a common good (Di Bona *et al.*, 1999).

With the widespread diffusion of personal computers, software took on the characteristics of a commercial product. Since not all personal computer users had the technical skills to understand, develop, and configure software themselves, they were willing to buy it (Tzouris, 2002; Weber, 2000).

In 1985, Richard Stallman, a researcher at MIT, established the Free Software Foundation (FSF) with the aim of rebuilding a community for the free and independent development of software (Free Software Foundation, 2002). However, the word "free" was often wrongly interpreted as "free of charge." Therefore, it became necessary to substitute the word "free" with another word that described the characteristics of product accessibility, efficiency, reliability, and flexibility.

In 1998, another group of developers founded the Open Source Initiative (OSI) with the aim of making the concept of free software appealing to companies as well (Open Source Initiative, 2002). The term "free software" was thus substituted with "Open Source." In order to avoid further misinterpretations of the new term, an official definition was drawn up to specify the indispensable characteristics of Open Source

products. For a product to be considered Open Source, it must respect a series of rules summarized in the license that accompanies the product's source code. These rules regard the copying and distribution of the software, including the source code, and the products derived from it. Open Source licenses guarantee the freedom to distribute and use the software, study the source codes, and, if necessary, modify them according to specific needs. The licenses do not discriminate against any category of users, group or person, and they do not prohibit the use of the software in any particular field of application. Furthermore, according to the Open Source definition, the software developed and distributed cannot later be resold or appropriated by anyone. Open Source software is thus associated with the freedom that it concedes and not with the fact that it is free of charge, as a superficial analysis of the phenomenon might lead one to believe.

Open Source products are made within a community composed of a heterogeneous group of players or agents who interact but are driven by different interests and motivations (Bonnacorsi & Rossi, 2002; Lerner & Tirole, 2001; Tzouris, 2002; Weber, 2000). Some authors refer to the Open Source community using the metaphor of a bazaar, since it expresses the idea of the frenzy and chaos with which the activities in the community are carried out (Raymond, 1998). The Open Source community can also be seen as an immense "magic cauldron" of ideas to which volunteers contribute on a continuous basis (Raymond, 1999a). Anyone can draw from this cauldron to suit their needs without having to contribute money or knowledge.

It seems inconceivable that this type of system is able to continue to maintain itself. What seems even more improbable is that its apparent disorganization can produce concrete results. Nonetheless, the products developed in recent years (e.g., Linux, Apache) have made it possible to show that organizational criteria actually do exist within this community.

By observing numerous Open Source projects, it is possible to identify the following five categories of agents involved in the community.

User

This category is made up of all the people who use Open Source products but do not directly participate in their development because they do not have the ability, time, and/or resources to do so. Users are of fundamental importance, as they make it possible to carry out the timely and exhaustive process of observing and testing the product, and thus the code, which in turn produces feedback for the software developers.

PROSUMER (PRODUCER AND CONSUMER)

Prosumers are the software developers who actively participate in product development not only to meet their own needs but for the pure pleasure of developing products, and, in most cases, with the hope of improving their own professional prospects.

This group is the nucleus of Open Source code development. It is generally made up of people who come from different social classes and use their free time to work on the development of a code. They might be students or software developers/professionals with very different cultural backgrounds and professional needs.

LEADER TEAMS

This category is made up of software developers and is a sort of élite group chosen by the community based on merit. This group of people is given the authority and responsibility for managing development projects.

A leader team is made up of a tight circle of prosumers who have participated in the definition and production of Open Source products from the beginning.

Leaders dedicate much of their time to planning, managing, and checking the product development process and, therefore, often do not participate in programming. They have the important task of coordinating the development community and are responsible for helping integrate the contributions and feedback from the community. The leader team is, thus, a point of reference for all of the agents, companies, and institutions involved and interested in Open Source software.

COMPANIES

This category is made up of the companies that are interested in the Open Source community and its products. They interact with the Open Source community by using software and financing, and sometimes participating in, the development of software. Therefore, they either influence the development process and evolution of products or simply observe the community in order to improve their own organizational structure and business.

INSTITUTIONS

Institutions are nonprofit organizations and public bodies interested in using, and thus diffusing, Open Source products. Many public bodies, above all universities, have created the cultural environment in which

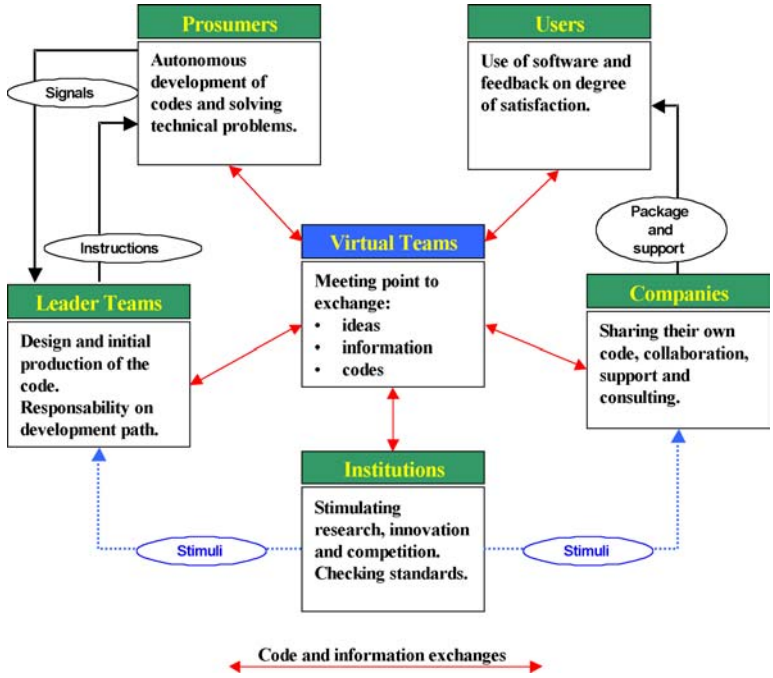

Figure 1 *Structure of an Open Source community*

many Open Source products have been developed. Some important products, such as Linux, were created thanks to the technical, and sometimes financial, support of universities. Recently, public bodies have also shown interest in the Open Source community and its products by carrying out studies and sometimes promoting the use of Open Source products in their own structures.

The community of agents meets online and creates a dynamic *virtual team*; that is, a team characterized by the continuous coming and going of agents belonging to the various categories mentioned above. A virtual team is created by agents who contact each other via virtual meetings such as forums and mailing lists. These meeting points make it possible to diffuse concepts, ideas, and strategies to the whole community and at the same time avoid dispersing or slowing down the flow of information and decisions.

Figure 1 shows the five categories of agents who make up the Open Source community and the relationships that exist between them.

CHARACTERISTICS OF THE ORGANIZATION AND PROCESSES OF OPEN SOURCE

Open Source products are, as has been explained above, the result of the collaboration, within a virtual community, of independent and heterogeneous players driven by different interests and motivations (Bonaccorsi & Rossi, 2002; Feller & Fitzgerald, 2002; Lerner & Tirole, 2001; Muffatto & Faldani, 2003; Tzouris, 2002; Weber, 2000). One might expect such a community to become an uncontrollable system. In fact, in order to avoid the generation of negative phenomena, the community has defined its own rules of behavior and functioning that guarantee quality results, stability, and continuity over time. The main characteristics defining how the community works deal with the organizational structure and development process (Bonaccorsi & Rossi, 2002; Dafermos, 2001). This analysis will focus on open participation and bottom-up organization (organizational structure) and the speed of development and parallelism of the process (development process).

Figure 2 overleaf summarizes these four main characteristics and the relationships that exist between them. As can be seen from the figure, open participation leads to both the other characteristic of organization—that is, bottom-up organization—and the two main characteristics of the development process—that is, the speed of development and parallel development.

Open participation generates decentralized decision-making power and thus the absence of rigid top-down planning. Projects can therefore be more flexible and have greater freedom to evolve. However, this can also lead to code forking, which is a situation that occurs when independent development paths of a code fork off in different directions (Raymond, 1999b). When code forking happens, the community tends to lose interest in the project. This loss of interest may provoke a gradual yet unstoppable distancing of software developers from the project, which is consequently destined to die. The end result could be the implosion of the community itself.

However, decentralized decision-making power does not mean a total lack of organization. In fact, in the Open Source community each project has a team of leaders whose appropriate management of consensus can limit the negative effects of code forking. The leader team is responsible for the development process and must answer to the whole community and all of the users. This small group of agents is also responsible for guaranteeing the compatibility and integration of the contributions. The

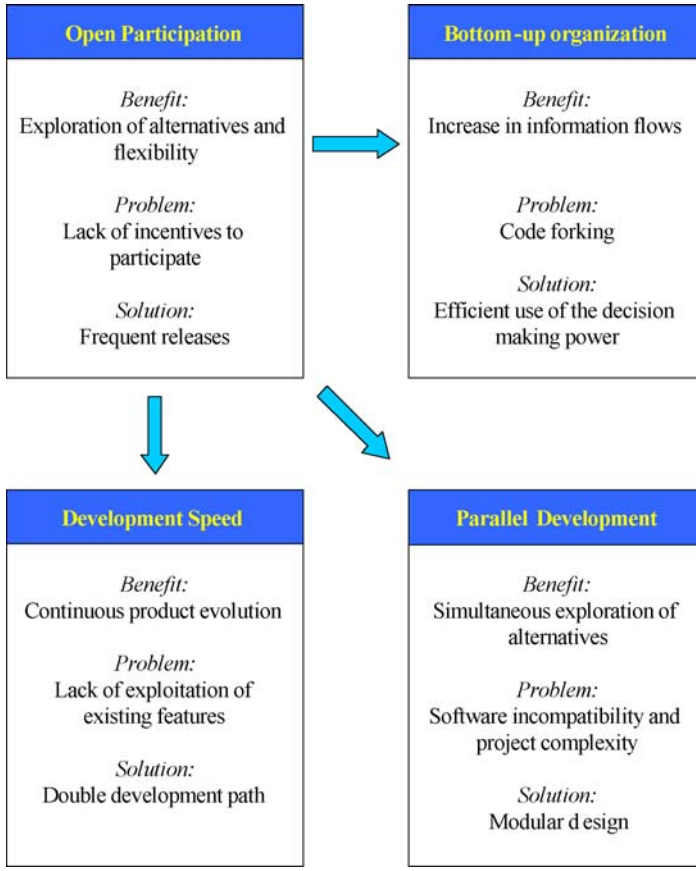

Figure 2 *Characteristics of the organization and development process of the Open Source community*

power of the leader team does not come from a privileged position or from property rights; rather, the position they occupy is legitimized by the development community itself. Their power is recognized according to the credibility and trust the community places in them. This credibility allows the leaders to exercise the power of dissuasion when there are actions that could lead to code forking.

Another positive effect of open participation is the possibility it offers to explore different alternatives and keep strategies flexible. However, flexibility makes it difficult to define precise deadlines for development. This uncertainty could lead to a lack of incentives for software developers and limit their commitment to a project, which could, in turn, slow

down the development process. However, the software developers try to avoid these problems by producing many frequent releases of the code in order to motivate themselves and others to contribute actively (Jørgensen, 2001).

The speed of development and frequency of releases create a continuous evolution of the products. At the same time, the codes are relatively instable due to their incessant evolution, making it difficult for users to use the products. Even though on the one hand continuous modifications and new releases help keep the products technologically advanced and innovative, on the other hand this could discourage their being used. Innovation does not always guarantee product reliability and stability; at least not until products have undergone sufficient checks, trials, and modifications. In other words, users are not willing or inclined to use recent versions of a product whose quality the community is still not able to guarantee.

In order to reach a satisfactory compromise between the *exploration* of new solutions and the *exploitation* of existing ones, a project's development process is usually split into two development paths. The first one, called the *stable path*, is made up of products that have been proved to be stable and whose compatibility over time with future versions of the same products has been guaranteed. The second one, called the *development path*, is made up of the most recent versions of products that have not been sufficiently checked and tested, and are therefore still merely the fruit of research and innovation. The subdivision of development into two paths, product exploitation and exploration, makes it possible to improve the distribution of responsibilities and the organization of activities, while maintaining a relatively fast speed of development and high degree of innovation.

The last effect of open participation is the parallel development of projects. When there are many different possible solutions, it is not always easy immediately to identify the best one. Parallelism allows many different players to explore different alternatives contemporaneously without forcing them to follow one particular evolutionary path. However, a disadvantage of parallelism is that any overlap and/or interference between the various contributions could lead to incompatability, thus making it difficult to manage development projects.

When software is produced in the traditional way, excessive parallelism is considered to be a waste of resources and a factor that increases the complexity of the development process. Brooks' Law states that as the number of software developers increases, there is a proportional increase

in the amount of code produced, but also an increase in the complexity of the project proportional to the square of the number of software developers (Brooks, 1975). This complexity leads to higher communication and management costs and a greater probability of making errors. In order to avoid these problems, the Open Source model suggests subdividing relatively large products into more simple modules. In this way, resources are used more efficiently and any interferences between single contributions are more easily solved.

The leader team is responsible for the modularity of Open Source products. The leaders plan products and the interface protocols to be used for communication between the various modules. Modularity also means that additions, modifications, and imperfections present in one module do not have negative effects on the whole code, but rather are limited to that one module.

We will now interpret these characteristics of the Open Source community in the context of complex adaptive systems theory, but before doing so will briefly define some key aspects of this theory.

COMPLEX ADAPTIVE SYSTEMS

A *system* is made up of a heterogenous group of interrelated elements. Some of these elements can be defined as *agents*. Agents can interact with each other and with their environment. Each agent has its own *strategy*. A strategy is the way in which an agent pursues its own goals, interacts with the other agents, and reacts to stimuli from the environment. Strategies are selected using certain *measures of success* (Axelrod, 1984; Axelrod & Cohen, 1999). An efficient strategy tends to be followed by many agents. This leads to a *population of agents*; that is, a group of agents that imitate one another's way of acting. The evolution of a system heads in a given direction according to the strategy identified by its population of agents.

A system is said to be complex and adaptive when the agents have the possibility of continually adapting their actions in response to the environment and the behavior of the other agents. For this reason, the possibility of transferring information from one agent to another, which depends on connectivity, is particularly important in complex systems. The high level of connectivity that characterizes complex adaptive systems allows for the creation of a dynamic network of agents that are constantly communicating and interacting (Coleman, 1999; Kelly, 1994; Lissack, 1999; McKelvey, 1999; McKelvey & Maguire, 1999; Waldrop, 1992).

The interaction between the agents leads the system to take on some *emergent properties* that characterize the system but are not present in any single agent. The word "emergent" means that the properties of a system "emerge" from the interaction between agents and are not dictated by a central authority. The emergent properties can lead a system toward new evolutions that cannot be foreseen. Therefore, a structured and predefined organizational control system cannot work. Nonetheless, the fact that the evolution of a complex system is difficult to foresee does not mean that there is no organization. In fact, a complex adaptive system is characterized by self-organization.

Three fundamental processes can be identified in complex adaptive systems: variation, interaction, and selection (Axelrod & Cohen, 1999).

VARIATION

In any system, at any time, it is possible to find a certain degree of variety, which is defined as the set of differences and alternatives that characterize both the agents and their strategies. Variety is the result of a process of variation; that is, changes in the set of alternatives. Variation determines the number of possible alternatives in a system.

INTERACTION

Interaction is defined by the ties that exist between agents and the ways in which the agents and their strategies influence each other. Interactions are neither random nor completely predictable. The quantity and quality of the interactions determine the dynamics of the system.

SELECTION

Selection is the process of choosing and diffusing or eliminating properties that characterize agents and their strategies. Therefore, it deals with the ability a system has developed to identify which agents and strategies are to be chosen and thus diffused, and which, on the other hand, are to be eliminated. Consequently, selection determines the evolution of a system.

All of these characteristics of complex adaptive systems can be found in the Open Source community.

OPEN SOURCE AS A COMPLEX ADAPTIVE SYSTEM

The Open Source community can be considered an example of a complex adaptive system. It is made up of a population of heterogenous players,

each having its own role and self-defined strategies (Axelrod & Cohen, 1999; Kuwabara, 2000). In the Open Source community, the various roles are not rigidly assigned by a higher authority; on the contrary, each player has the freedom to act and interact with the other players in the system. Therefore, the players in the Open Source community have the characteristics to be defined as agents. They can influence the system by interacting with the rest of the community and are able to use their experience and memory to model their behavior in the present.

The definition of agent proposed by complex adaptive systems theory makes it possible to include users in this category as well. In fact, users can stimulate the system—that is, the community—through explicit and implicit feedback. Users are an integral part of the Open Source system since they participate in the processes of variation, interaction, and selection and, by doing so, can influence the evolution of the system.

According to Axelrod and Cohen, the concept of complex adaptive systems can be most easily related to problems that are long term or diffused, require continuous innovation, need a great deal of feedback in a short period of time, or have a low risk of catastrophe. All of these characteristics can be found in Open Source products.

Long-term or diffused applications offer many opportunities for agents to come together. This leads to a critical mass that can activate significant processes of variation and interaction. In the case of software, examples of this type of application are operating systems, network platforms, web servers, programming languages, and all of the components and protocols that have created the standards of the Internet. Some Open Source products are part of this category of long-term applications. They are usually platforms or common standards; for example, Linux, Apache, and PHP.

In the case of applications that require continuous innovation—that is, those in particularly dynamic industries—there is a signifcant need to explore new solutions. This is the case for software applications related to the internet, such as web servers, protocols, browsers, and so on. Since Open Source products are technologically advanced and innovative, they stimulate the creativity of the community and the continuous exploration of alternatives.

As far as applications that require a great deal of feedback over a short period of time are concerned, significant advantages can be gained from the interaction between the agents in a development community. In the Open Source community, the users are considered to be the main source of inspiration for and evaluation of the quality of the products. The fact

that products are available at a low cost makes it possible to obtain a significant quantity of information and to have the software undergo an extensive process of observation and checking based on daily use. The fact that the code is open and available to all makes it easier to carry out better measurements of product performance. This in turn gives agents a precise series of parameters that they can use to evaluate product performance objectively and, consequently, base their choices on.

Applications with a low risk of catastrophe are those for which the efforts committed to exploring alternatives should not put the survival of the entire system at risk. A system that manages to do this is dynamic and at the same time stable and, therefore, not at risk of implosion. The modular structure of Open Source products limits the effects that each activity can have on the entire product and makes it possible to avoid the diffusion of any imperfections. Furthermore, the failure of one or more exploratory actions does not lead to the failure of the entire system, which nevertheless continues to survive since there are other players involved in the development process. In fact, in Open Source nobody has total control over or responsibility for products and each activity is usually shared by a group of autonomous agents. Should any agent decide to stop carrying out its activities, it can easily and quickly be substituted regardless of the position that it occupied.

Axelrod and Cohen consider Open Source mainly as an example of the variation mechanism, since it very much exploits the advantages gained from conserving diversity within a system. One of the main dangers for a complex system is the extinction of a type of agent or strategy that reduces a system's diversity. Since the creation of a type requires resources and effort, its premature extinction should be avoided. A type that is not very successful in the present might have characteristics that could prove to be very important in the future. The Open Source community manages to conserve diversity by keeping track of the whole evolutionary process in order to be able easily to find anything that might be needed.

It is also possible to identify the interaction and selection mechanisms in the Open Source community. Above all, it is possible to understand how the close relationship that exists between these mechanisms allows the Open Source community efficiently and effectively to exploit its own complexity.

Axelrod and Cohen identify a sequence in the mechanisms of variation, interaction, and selection. They consider variation to be a premise for the activation of different forms of interaction, which, in turn, produce effects of selection within a system. However, it is possible to hypothesize

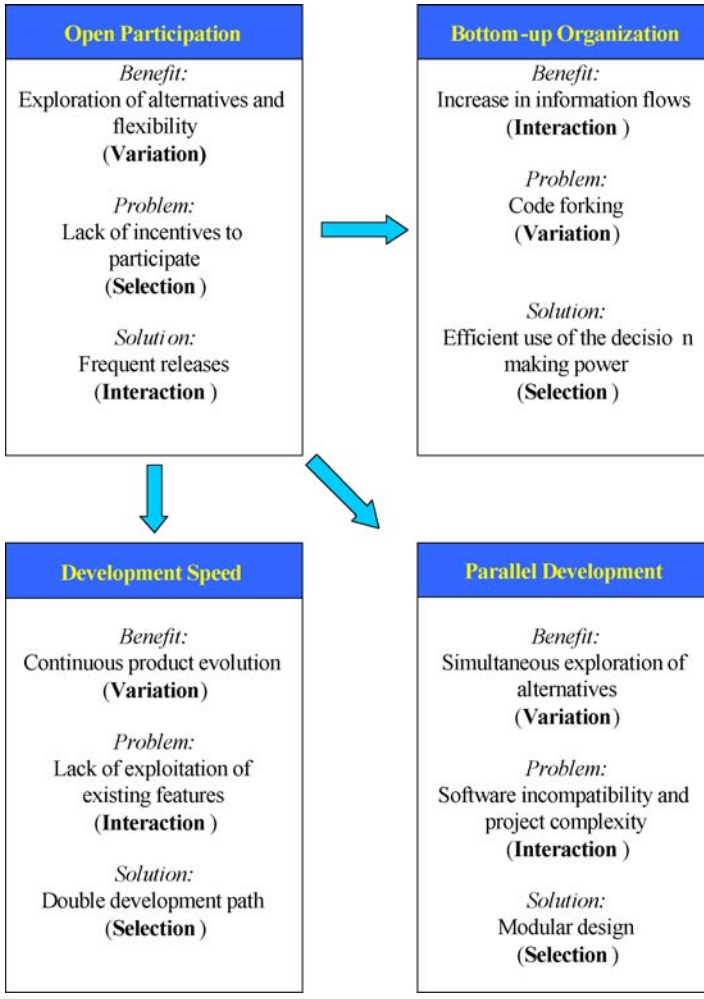

Figure 3 *Characteristics of a complex adaptive system in the Open Source community*

that there are other sequences of variation, interaction, and selection in the characteristics of the Open Source organization and development process mentioned above; that is, open participation, bottom-up organization, speed of development, and parallel development. The benefit of each characteristic can be interpreted as one of the mechanisms, but it is also possible to identify a negative effect, which can be interpreted as another mechanism, and the actions taken to solve the problem can be interpreted as the remaining mechanism (Figure 3).

The advantage of open participation—that is, the free exploration of alternatives and flexibility of strategies—can be interpreted in terms of *variation*. In the Open Source community, however, agents tend to work on development for long periods of time without making their solutions available. In this way, they do not stimulate the other agents in the community. This can be interpreted as a phenomenon of premature and highly subjective *selection*. In other words, this selection remains within the subjective evaluation of individual agents and does not benefit from the contribution of many different agents in terms of peer review. Furthermore, the agents are not solicited enough to offer new contributions to the development process. The result of this excess is that the exploration process slows down, limiting the variety in the system. One solution to this problem is to increase the frequency with which software is released. Basically, the community makes a release each time there is a new feature, even if it is relatively insignificant, in order to motivate and involve the agents in the community. This action, seen from the point of view of complexity theory, has the effect of increasing the *interaction* between agents.

Another characteristic of the organizational structure of the Open Source community is decentralized decision-making power; that is, the implementation of a bottom-up organization. As has often been noted, the advantage of decentralized power is an increase in the flow of information within an organization. If the organization of the Open Source community is interpreted as a complex system, this effect can be interpreted as an increase in the possibilities for *interaction* between the agents in the system. This increase in horizontal interaction can, however, lead to a negative effect, code forking. Code forking can be interpreted as a negative aspect of *variation* that can damage the development of Open Source projects. The solution, in this case, is to create elements of organizational structure in the Open Source community as well; that is, leader teams. The leaders' efforts to maintain consensus help the community not to lose its connectivity, as is the case with code forking where agents work on the same objects without exploiting the positive effects of interaction. In this way, leaders carry out *selection* by deciding what direction product evolution will take.

As we have seen, the Open Source development process is characterized by frequent releases in order to motivate the community to participate. The advantage of frequent releases is the continuous evolution of the products; that is, their dynamic variation, which leads to significant *variation* in the system itself. Nonetheless, if new versions of a product

are released too rapidly, there could be an excess of exploration, to the disadvantage of the exploitation of the results already obtained. This effect could lead to a lack of focus and scarce and ineffective *interaction* between agents. The Open Source community attempts to avoid this problem by separating the development process into a dual path. In the stable path, which corresponds to the exploitation of results already obtained, variation is very slow. In the development path, which corresponds to the exploration of new alternatives, there is a great deal of variation in the system. The two different development paths are managed through a process of *selection*, in which contributions must be separated into two groups: on the stable path there are those that only need to be consolidated, while on the development path there are those that need to be developed further.

Finally, there is the parallel development of products. The advantage of this is the possibility of exploring a greater number of different alternatives at the same time. In other words, parallelism has the positive effect of *variation* regarding both the type of agents involved in the system and the strategies they pursue. Nonetheless, the parallel development of one product can also lead to excessive complexity and even incompatibility between components and alternative product solutions. In fact, one single modification can have a significant impact on other parts of the product and the effect of the impact is unpredictable. This could be seen as a negative effect of the *interaction* between the elements in the system. The solution to the possible negative consequences is parallel development organized according to modular product planning. A precise definition of the modularity forces agents to make a *selection* of the objects on which they want to work, and at the same time limits possible interference with the activities of other agents.

In conclusion, in each of the functioning characteristics of the Open Source community it is possible to highlight the three fundamental mechanisms of complex adaptive systems. Whereas in the variation–interaction–selection sequence all the mechanisms have positive effects on the system, we have considered the possibility of other sequences characterized by the presence of a mechanism having negative effects on the system. Finally, we have shown that the solution to the problems caused by the negative effects of one of the mechanisms can be interpreted as the effect of another one.

IMPLICATIONS

The observations made in this article can lead us to reflect on how the interpretation of the phenomena analyzed here can be extended within this context as well as to other contexts. Similar contexts could be those dealing with knowledge products whose characteristics are similar to those of software. This analysis could therefore also be extended to involve the processes of scientific research in general, and those of highly innovative fields such as bioinformatics or pharmaceutical research in particular. Furthermore, since Open Source tends to diffuse and impose itself as a standard, it would be worthwhile studying the problem of strategies for setting and diffusing technological standards. Finally, since the concept of complexity can be used to interpret social characteristics as well, the complex adaptive systems theory would certainly be suitable for interpreting networks and clusters. Given the flexibility of the complex adaptive systems theory, it would certainly be worth dedicating significant analysis to the applicability of this theory to various contexts.

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Submission information

Emergence is interested in receiving work from a wide range of perspectives: theoretical and practitioner based; both conventional and unconventional methodologies; case study work; approaches to teaching management or leadership; work covering a variety of organizational types, size and ownership; cross-cultural studies and work from Australasia and the Far East as well as the USA and Europe.

We ask that authors set their paper clearly within the context of the notion of complexity and complex systems, however they chose to define such, and that the practical implications and transferable lessons from their work be clearly described.

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All submissions are electronic. Suggested length is 4000 to 5000 words. Review pieces and essays should be 2000 to 3000 words. Note: additional material considered relevant and/or related by the author(s) can be posted on the website, which will be associated with each accepted article. The author(s) will be responsible for securing all necessary permissions for material to be posted on the website.

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There is detailed information on the format for submissions on the website, www.emergence.org.

Submissions should be sent to: editor@emergence.org with one hard copy to:

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