Management Strategies for Complex Adaptive Systems

Sensemaking, Learning, and Improvisation

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Misspecification of the nature of organizations may be a major reason for difficulty in achieving performance improvement. Organizations are often viewed as machine-like, but complexity science suggests that organizations should be viewed as complex adaptive systems. I identify the characteristics of complex adaptive systems and give examples of management errors that may be made when these characteristics are ignored. Command, control and planning are presented as managerial tasks that come to the fore when a machine view of organizations dominates thinking. When we treat organizations as complex adaptive systems the focus of managerial activity changes, and sensemaking, learning and improvisation become appropriate strategies for performance improvement. Each of these is defined and described. A modest research agenda is presented.

Improving performance in organizations has always been difficult, and it may be true that a part of this difficulty is because we have often treated organizations as though they were machines. This assumption of organizations as "machine-like" systems may cause us to direct performance improvement efforts toward getting organizations to run more smoothly, more efficiently, and more effectively by applying management principles derived from successful efforts to improve machine performance. We say that we want organizations to work like clockwork. We want to be in control. Managers want workers to respond predictably to incentives and to accomplish goals defined by managers and to do this with little deviation from plans that management has developed for improved performance.

It is possible that these efforts have been less successful than we might wish, not because we have applied the principles incorrectly, but because we have mis-specified the nature of organizations. Many scholars as well as many practicing managers now understand that organizations are not really "machine like" but are complex adaptive systems (CAS) beset with uncertainty (Beinhocker, 2006). Recognizing that organizations are CAS helps you to see that employees are always learning and are not predictably responsive to interventions. Instead of perceiving systems as machines whose Newtonian-like dynamics need to be controlled, organizations are "self-organizing systems in which order emerges in a bottom-up fashion from the local relationships in which they are involved" (Ritter, Wilkinson, & Johnston, 2004, p. 175). Complex adaptive systems do not behave in the same way as Newtonian machines. Therefore, it is probable that organizational improvement strategies and tactics derived from knowledge that leads to improving machine performance may not work as well as we might like. This article is an effort to suggest some of the ways we might go about improving performance of organizations if we accept the idea that organizations are complex adaptive systems.

The article is organized as follows. First, I sketch the characteristics of complex adaptive systems and the dynamical properties of these systems.

Then I identify command, control, and planning as examples of standard approaches to performance improvement that are based on the notion that organizations are machine-like. Each of these approaches depends on the ability of managers and workers to forecast future system states, but it is difficult, if not impossible, to make accurate forecasts of the dynamics of CAS. Therefore command, control, and planning are not as effective as management tools as we once thought. I then focus on sensemaking, learning and improvisation as key managerial tasks for performance improvement when we recognize that organizations are CAS. This is the heart of the article. Some modest suggestions are identified for further research into organizational performance improvement given that organizations are CAS.

Complex Adaptive Systems

My purpose in this section of the article is to briefly describe complex adaptive systems (CAS). There are several definitions or descriptions of CAS, and while they differ in the detail and in the relative importance given to elements of CAS, they are very similar. Perhaps the best known is by Waldrop (1992) from his popular book chronicling the early development of complexity science with a particular emphasis on the development of the Santa Fe Institute, one of the pillars of the study of complex adaptive systems. Because complexity is often seen as related to the postmodern approach to the study of organizations, Cilliers' (1998) work is often referenced when looking for a description of complex adaptive systems. Cilliers has been a major contributor to both the philosophical and managerial views of CAS. A recent approach to economics and complexity has been articulated by Beinhocker (2006), and his definition of CAS is helpful in understanding how thinking in terms of complex adaptive systems reshapes our view of economics.

My own approach to describing the characteristics of CAS draws on the works noted above as well as other sources of understanding (Waldrop, 1992; Capra, 1996; Cilliers, 1998; Leventhal & Warglien, 1999; Chu, Strand & Fjelland 2003; Beinhocker, 2006; Maguire, McKelvey, Mirabeau & Oztas, 2006). This description, I believe, captures the essential elements of CAS and enables me to understand those characteristics of CAS that most illustrate the special considerations that CAS thinking brings to the management of organizations. The analysis below draws heavily on two previous works (McDaniel & Driebe, 2001; McDaniel & Driebe, 2005) that I wrote with the physicist Dean Driebe, who, at the time we did our work, was a senior research scientist at the Ilya Prigogine Institute at The University of Texas at Austin.

CAS are characterized by:

1. diverse agents that learn,
2. that interact with each other in nonlinear ways, and therefore,
3. self-organize,

4. have emergent properties, and
5. co-evolve with the environment.

Agents

Complex adaptive systems are made up of agents that are information processors with the capacity to modify their behavior based on information they receive (Casti, 1997; Holland, 1995). These agents are diverse from each other, and this diversity is the source of the creativity required for survival (Casti, 1997; Kauffman, 1995). No single agent knows what is happening in the system as a whole but each agent pays attention to its local environment, responding primarily to other agents in its locality (Holland, 1995). There is no "chief agent" who directs the behavior of all of the other agents because no agent (regardless of title) has the capacity to oversee the complexity in the whole system (Cilliers, 1998). Not even a network of computers can fully capture and interpret an organization's dynamic complexity because it is beyond a computer's capacity to discover and/or recognize the multiple informal relationships that emerge from social and task relatedness, and how these relationships might affect agents internal and external to these groups. It is also impossible for a computer system to capture the tacit knowledge that enables organizations to function (Brown & Duguid, 1991).

Non-Linear Interactions

The essence of CAS is captured in the non-linear interactions among agents rather than in agents themselves. There do not have to be a large number of connections among agents to accomplish orderly and meaningful functions (Kauffman, 1995; McKelvey, 1999). Understanding CAS requires the search for and understanding of patterns of non-linear relationships (Anderson & McDaniel, 1999; Ashmos & McDaniel, 1991) where inputs are not proportional to outputs and small efforts to change systems can lead to big effects, while large efforts may result in little or no change. This non-linearity is often the result of the positive and negative feedback systems that operate in CAS where one agent's activity can feed back on itself as well as influence other agents (Arthur, 1999; Eisenhardt & Brown, 1999; Kauffman, 1995; Morel & Ramanujam, 1999).

> In the world of linear equations we thought we knew that systems described by simple equations behaved in simple ways, while those described by complicated equations behaved in complicated ways. In the non-linear world—which includes most of the real world, as we begin to discover—simple deterministic equations may produce an unexpected richness and variety of behavior. On the other hand, complex and seemingly chaotic behavior can give rise to ordered structures, to subtle and beautiful patterns.... Another important property of non-linear equations that has been disturbing to scientists is that exact prediction is often impossible, even though the equations may be strictly deterministic. (Capra, 1996, p. 85)

Self-Organization

"Self-organization is the spontaneous emergence of new structures and new forms of behavior in open systems far from equilibrium, characterized by internal feedback loops and described mathematically by nonlinear equations" (Capra, 1996, p. 85). The structure of CAS is not simply structure imposed by hierarchical power constraints but is also the result of interactions among agents of the system. The capacity for self-organization is a function of (among other things) the number and intensity of these interactions. Too many interactions can lead to behavior that never settles into a recognizable pattern while too few interactions may lead to frozen behavior rather than dynamical self-organization. "The critical point of the complex systems approach is that from a macroscopic point of view the development of political, social or cultural order is not only the sum of individual intentions, but the collective result of nonlinear interactions" (Mainzer, 1996, p. 272). Complexity science teaches us that order in systems may well be the result of systems properties (Kauffman, 1993; Nicolis & Prigogine, 1989) and, therefore, the assertion that the order found in systems is the result of intentionality may well be erroneous. The idea that order requires careful construction or crafting is not correct. Order requires that extremely complex webs of interacting elements be sparsely connected (Kauffman, 1995).

Emergence

Emergence is the development of novel and coherent patterns and properties during the process of self-organization in a CAS (Goldstein, 1999). The global characteristics of CAS are the result of agent characteristics and nonlinear interactions of these agents. However, characteristics of CAS are not reducible to characteristics of agents and relationships. Rather systems have properties that go beyond a summation of subsystem properties (Casti, 1997; Holland, 1998). Examples of emergence in an organizational setting include both dishonesty intensifying within a work group even though each group member is deemed trustworthy, and improved product designs realized through the diverse contributions of several disparate employees.

The unpredictability of emergent systems is fundamental, and emergence is one key source of novelty and surprise in CAS. It must be recognized that emergence is not a provisional construct that will be conquered by some better analytical techniques or theory (Goldstein, 1999). Emergence is not the same as serendipitous novelty such as patterns of raindrops on a window pane, but it is the result of nonlinear dynamics generating new properties at the macro level of analysis (Goldstein, 1999; Holland, 1998).

Co-Evolution

CAS consists of agents interacting in a nonlinear fashion such that systems self-organize and emerge in a dynamic fashion. But CAS do not simply change; they change the world around them. CAS and their environments co-evolve such that each fundamentally influences the development of the other (Kauffman, 1995, 1993). There is a constant dance of change. Kauffman (1993, 1995) suggests that CAS exist on "fitness landscapes" and

act on local information (Cilliers, 1998), and they seek to continuously improve their position on their fitness landscape (Beinhocker, 1997; Rivkin & Siggelkow, 2002). They can only achieve some local optimum but in this process, CAS change the landscape for themselves as well as for any other CAS in the landscape. The dynamics of the situation mean that CAS can't achieve some "correct" position; the "goodness" of CAS adaptation to their environment is a moving target. Agents have conflicting constraints within themselves and among neighboring agents (Rivkin & Siggelkow, 2002) and, therefore, compromise and cooperation lead to workable solutions rather than to some grand superb solution (Kauffman, 1995). "Real organizations constantly circle and chase each other in an infinitely complex dance of co-evolution" (Waldrop, 1992, p. 259).

There are many management errors that can result from ignoring these five characteristics of complex adaptive systems. Table 1 is intended to give a modest sample of possible kinds of mistakes managers might make when they do not understand the nature of organizations as CAS.

Uncertainty, Unpredictability, and Surprise

When one examines the five basic characteristics of CAS it becomes clear that some uncertainty, unpredictability, and surprise are the result of bounded rationality (the limits of the human mind in formulating and solving complex problems; Simon, 1991), lack of information, tight coupling (strong linkages between agents of a system such that a change to one agent intensely affects other agents; Perrow, 1984) and interdependence of systems components (Perrow, 1984). However, much of the unknowability in organizations is a function of the fundamental nature of CAS. A major factor driving unknowability is the nonlinearity of interdependencies among agents, and another factor is the capacity of agents to learn, sometimes independently of managerial intentions. These factors lead to unpredictability in the dynamics of the system and also to unpredictability in the nature of the self-organization, emergence and co-evolution that take place. So managers are always being surprised (McDaniel, Jordan, & Fleeman, 2003).

It might be helpful to give some very specific examples of surprises that have been identified in the literature. While these examples may seem clear when stated and may seem like "common sense," at the time the research was done these findings were contrary to conventional wisdom and were often viewed as radical.

1. Participation of clinicians in hospital strategic decision making is more helpful in terms of bottom line performance than the participation of middle managers (Ashmos, Huonker, & McDaniel, 1998).
2. Organizations engaged in effective, fast decision making use just as much information as slow decision makers but information of a different kind (Eisenhardt, 1990).
3. Safety on aircraft carriers is a function of the development of collective mind rather than the development of well articulated procedures (Weick & Roberts, 1993).

TABLE 1
A SAMPLE OF POSSIBLE ERRORS THAT CAN RESULT FROM IGNORING COMPLEX ADAPTIVE SYSTEMS CHARACTERISTICS

Characteristic	Typical Errors
Diverse agents that learn	• Failing to account for employees' ability to learn unsafe machine operation methods by experimenting on their own with ways to speed up production and thereby reduce the effort they are required to use. • Putting all employees through the same orientation program regardless of differences in cultural interpretations of organizational hierarchies and thereby missing the potential for conflict among employees and between employees and management caused by different expectations of roles.
Nonlinear interdependencies	• Disciplining one employee, expecting a modest change in that employee's behavior but getting a massive union response. • Changing a work process without considering the role of communities of practice on work performance.
Self-organization	• Assuming that employees will not reallocate work assignments based on their perception of the best arrangement even after receiving work allocation assignments from management. • Ignoring the speed with which the informal organization can transmit messages and, therefore, failing to control rumors in a productive manner.
Emergence	• Failing to treat the organization's dominant logic as an emergent property of the system and, instead, treating it as something that can be imposed on the system. • Looking for one bad apple in a group as a strategy for improving work quality, when the quality of output may be an emergent property of the group.
Co-evolution	• Conducting careful market analysis to determine whether or not to release a new product but ignoring the fact that the release of the new product may change the market in such a way as to make the market analysis incorrect. • Offering a premium to internal workers for extra production without expecting the change in reward structure to affect relationships with suppliers.

4. Nursing homes that want to improve quality care can use RN participation in strategic and tactical decision making to make performance improvements without significantly increasing costs (Anderson & McDaniel, 1999).

Surprises such as those noted above are viewed in a number of ways depending on the framework used (McDaniel, Jordan, & Fleeman, 2003). If we recognize that surprise is often the result of the fundamental unknowability of CAS, we open the door for creative approaches without the mark of blame or failure. The basic characteristics of CAS lead to

fundamental uncertainty, and when this is coupled with the uncertainties created by a lack of information then traditional approaches to management of organizations may well not be as useful as we once thought they were.

Traditional Managerial Tasks

Traditional management tasks are often summarized as command, control, and planning (Morgan, 1996, see esp. pp. 11-31). Command is an effort to give clear, unambiguous instructions to workers that will enable them to achieve organizational goals. Control can be seen as an effort to determine, through the use of feedback, if the system is doing what it is supposed to be doing—are goals being met. Planning is the process of making decisions, based on predictions of future system states, about what to do now to achieve desired goals in the future. Each of these tasks requires the ability to forecast future states of nature, but in CAS this is usually impossible. We give workers commands, they follow them, and results are sometimes very distant from anticipated results. A repairman is told to service X number of machines in a day in a certain prescribed manner, and he chooses to service those machines that require the least effort, thereby comfortably meeting expectations. We use feedback to control the organization only to find out that giving workers feedback causes the context of work to change in significant ways. People establish informal quotas or work at reduced speeds to ensure that their performance fits control parameters. We plan, get the plans implemented, and then discover that our forecasts about the state of nature have been made incorrect by the very implementation of our plans. Coca-Cola does market surveys, conducts focus groups, consults taste tests, and introduces New Coke only to discover that the very introduction of this product changes the entire soft drink landscape, and this helps to bring Classic Coke to the market. Commands are subject to the nonlinear interdependencies among agents. Control is sensitive to initial conditions and self-organization of work. Planning changes the world and by that very fact, can cause co-evolution that cannot be predicted. These traditional activities of command, control and planning may be less useful in organizations than previously thought because of CAS's inherent unpredictability.

New Managerial Tasks

What should managers do in the face of the difficulties in using traditional management strategies? Sensemaking, learning and improvisation should become central managerial tasks instead of command, control and planning when managers recognize the fact that organizations are complex adaptive systems. These are all management tasks that enable productive action in CAS despite the unknowability faced. They take advantage of the characteristics of CAS rather than trying to "overcome" them.

Sensemaking

"[Sensemaking] involves turning circumstances into a situation that is comprehended explicitly in words and serves as a springboard into action" (Taylor & Van Every, 2000, p. 40). "Sensemaking is a diagnostic process directed at constructing plausible interpretations of ambiguous cues that are sufficient to sustain action" (Weick, 2005, p. 57). Sensemaking is not just a response to bounded rationality but is fundamental because of the uncertainty of the dynamics of the world. "It is critical to note that meaning is assigned to surprise as an output of the sense-making process, rather than arising concurrently with the perception or detection of differences" (Louis, 1980, p. 241). "Whenever an expectation is disconfirmed, some kind of ongoing activity is interrupted. Thus to understand sensemaking is also to understand how people cope with interruptions" (Weick, 1995, p. 4) "Thus, sensemaking involves the ongoing retrospective development of plausible images that rationalize what people are doing" (Weick, 2001a, p. 460). Because CAS must cope with both fundamental unpredictability in their dynamics and unpredictability in their circumstances created by a lack of information, life in an organization is often confusing and disturbing. I don't have enough information to know with certainty what to do even when I invest heavily in systems to increase the amount of information available and to increase my information processing capacity. The issue is not simply bounded rationality of managers and workers. After the best of efforts there still remains uncertainty and ambiguity. If we want workers to be able to improve performance in the face of this unknowability we must invest in efforts to help them to make sense of the world in a way that enables the organization to take action and to learn about the world from the actions that are taken. Sensemaking is a social act (Weick & Sutcliff, 2001) and the quality of sensemaking is highly dependent on the nonlinear relationships among the agents in the system.

Sensemaking, learning and improvisation should become central managerial tasks instead of command, control and planning when managers recognize the fact that organizations are complex adaptive systems.

What can we do to facilitate sensemaking? "It is the job of the sensemaker to convert a world of experience into an intelligible world" (Weick & Sutcliff, 2001, p. 9). Weick (1995, pp. 61-62) has given us a seven element recipe for sensemaking. Below I have added to each element of Weick's recipe a single example of how we can help workers follow the recipe and, thereby, make sense of the world that they encounter.

"1. Identity: The recipe is a question about who I am as indicated by discovery of how and what I think." The manager can assist workers in this task by providing heedful reflection on workers' deeds and utterances.

"2. Retrospect: To learn what I think, I look back over what was said earlier." Managers can help workers with this task by helping workers remember and reflect on their deeds and utterances without getting them into excessive debates about what "really" happened.

"3. Enactment: I create the object to be seen and inspected when I say or do something." Managers can help workers with this task by taking

seriously the objects that workers create—by taking their sensemaking creations seriously.

"4. Social: What I say and signal out and conclude are determined by who socialized me and how I was socialized, as well as by the audience I anticipate will audit the conclusions that I reach." Managers can help workers with this task by recognizing the importance of both formal and informal socialization activities and the importance of self-organized structures, including communities of practice, in workers' socialization processes.

"5. Ongoing: My talking is spread across time, competes for attention with other ongoing projects, and is reflected on after it is finished, which means my interests may already have changed." Managers can help workers with this task by recognizing that sensemaking is dynamic and unfolds in a nonlinear fashion, involves continual updating, and requires continuous support from important others, including the manager.

"6. Extracted cues: The 'what' that I single out and embellish as the content of thought is only a small portion of the utterance that becomes salient because of context and personal dispositions." Managers can help workers with this task by making it possible for them to see the contextual nature of their sensemaking and the co-evolution of their sensemaking with changing contexts.

"7. Plausibility: I need to know enough about what I think to get on with my projects, but no more, which means sufficiency and plausibility take precedence over accuracy." Managers can help workers with this task by helping them use the standard of sufficiency and plausibility when they are attempting to make sense of the nonlinear development of the CAS.

Sensemaking can be seen as the process of the development of collective mind (Weick & Roberts, 1993). This suggests that we must be sensitive to how organizations make sense and to the strategies they use for making sense. One sensemaking strategy that has been shown to be effective is participation by workers in organizational decision making. When they participate in decision making as opposed to simply being told what to do, their capacity for effective sensemaking improves leading to improved organizational performance (Ashmos, Duchon, McDaniel, & Huonker, 2002). Because sensemaking is a social act, attention to the system of communication in the organization will enhance sensemaking capabilities and, thereby, enhance organizational performance (Anderson, Issel, & McDaniel, 2003). Appropriate attention to interdependencies and interrelations, or organizational structures, enables effective distributed sensemaking and reduces typical errors in social systems such as normalizing or treating new events as though they were "normal" and the fallacy of centrality or assuming that because one is at the center of things one must know what is happening and if they do not know then it must not be happening (Weick, 2005). With the traditional focus in organizations on decision making and "getting it right," the important role of sensemaking may be lost. But, when the nature of organizations as CAS is recognized, then we are likely to pay more attention to important managerial roles in facilitating sensemaking processes.

Workers will continuously try to make sense of their worlds. Given the unknowability of their worlds, the sense that they make is critical to the success of the enterprise. We want workers to make sense of their worlds in ways that enhance, rather than inhibit, the organization's ability to take effective action and to learn from that action. For example, if workers make sense of an accident by deciding that it "was just fate" then the ability to learn from that action and thereby to modify future behavior in ways that reduce accident probabilities is weakened. If they make sense of an accident by deciding that improved machine design could have prevented the accident then attention is directed toward the machine designer. If they make sense of an accident by deciding that more training could have prevented the accident then attention is directed toward their supervisor. If they make sense of an accident by deciding that they need to be more careful then attention is directed toward their own behavior. Because of the nature of CAS the sense people make of their worlds is critically important to their ability to function effectively, and managers have a responsibility to help workers in this sensemaking activity.

Learning

Learning is important in CAS because of dynamic unfolding of events in unpredictable ways. It too is a social act, highly contingent on the nonlinear interdependencies in the system. Our task is not to know what is going on and then tell others what to do but to create an organizational environment in which learning is highly valued and in which people listen to and respect insights and understandings that are different than their own (McDaniel, Jordan, & Fleeman, 2003; McDaniel & Walls, 1997) People must learn as the world unfolds, and they must learn from meager scraps of information (March, Sproull, & Tasmuz, 1991). "The most important learning we do flows from the trial-and-error actions we take in real time and especially from the way we reflect on those actions as we take them" (Stacey, 1995, p. 17). This suggests that we attend to multiple interpretations of unfolding events and pay careful attention to various ways stakeholders might perceive the world (McDaniel, 2004; Thomas & McDaniel, 1990). "We must move away from the idea that we learn about the world (strategic planning) and then act rationally (implement an integrated delivery system). We must understand that learning is concurrent with action. We act in order to learn" (McDaniel, Jordan, & Fleeman, 2003, p. 273).

In the circumstances of unpredictable dynamics and sensitivity to initial conditions that exist in CAS, learning from samples of one or less is a critical skill (March, Sproull, & Tasmuz, 1991). People don't know what to do not because they are incompetent but because they have not seen the present situation before. They must continuously figure it out. Organizations are more likely to have the wide variety of perspectives necessary to learn from samples of one when they have diversity among the workers and when workers have developed the ability to leverage the creative tensions that diversity can bring (McDaniel & Walls, 1997). Diversity among agents that is a characteristic of CAS should be seen as strength, and care

must be taken not to try to stamp out diversity in the name of efficiency and reduced conflict. We need more different ways to pay attention to what is happening around us (Herriot & Pemberton, 1995). What looks to one person as a satisfactory adjustment to changing circumstances may look to another as an attempt to reallocate resources and thereby to reallocate power. When attention is paid to these potential multiple interpretations of the world, then it is more likely that learning about the situation will take place and a satisfactory resolution developed. In traditional views of organizational life, knowledge is the key but in a complexity view, learning is the key. Certainly the capacity to learn is built on what is known, but the focus shifts from learning to know, to knowing to learn.

Traditional management perspectives might suggest that failures to learn are because of a lack of information. But it is not information that we need. We have too much on our desks now. What we lack is the time to pay close attention to the world so that we can be thoughtful about what is going on (Argyris, 1992; Herriot & Pemberton, 1995; Senge, 1990). We need to be able to create hypothetical histories and near histories so that we can enrich the set of experiences that we have at our disposal for learning (March, Sproull, & Tasmuz, 1991).

Learning is very difficult, and organizational culture and style have a lot to do with organizations' efficiency and effectiveness in learning (Edmondson, 2003; Edmonson, Bohmer, & Pisano, 1996; Edmonson, Bohmer, & Pisano, 2001). People in organizations must feel a sense of psychological safety in order for learning to take place. Communication must be recursive in nature and not hierarchically constrained. Organizations are often more likely to learn if they focus on small wins instead of always trying to hit the home run (Weick, 1984). Small wins are not only more psychologically stable than big wins, but they enable more cumulative learning (Weick, 1984). We are beginning to understand the role of networks in organizational learning, especially the role of loose and tight couples in organizational learning (Buchanan, 2002). Often it is the combination of tight couples within a group and loose couples across groups that lead to the greatest learning. This suggests that we should facilitate gate keeping functions that enable a flow of information across systems (Liebeskind, Oliver, Zucker, & Brewer, 1996). We must learn to focus on both exploitation and exploration as learning strategies (Gupta, Smith, & Shalley, 2006) in order to cope with the depth of learning required in CAS for effective and efficient functioning.

It is easy when one sees organizations as machine-like to make very fundamental mistakes in thinking about the role of learning in organizational performance. For example, one can abstract processes such as service maintenance of office equipment and miss the role of communities of practice and of real-time, as-the-work-is-done conversations (Brown & Duguid, 1991). This makes the job of maintenance more difficult as the worker is cut off from previously developed relationship systems in the name of increased efficiency. Another example is the easy belief that medicine is practiced as a symptoms-diagnosis-treatment process when, in fact, much of the time

it is a symptom-treatment-diagnosis process where the diagnosis is made as a result of observing the patient's response to treatments. The physician often learns what is wrong with the patient after the treatment is undertaken. Ignoring this fact can lead to designs of electronic records systems that will not let you write a prescription or implement a treatment until you have made a diagnosis. The real time, as-you-go learning is missed in the assumption of linear cause-effect relationships that, in fact, are not the real relationships in the system.

Improvisation

Complex adaptive systems generate uncertainty and surprise, and dealing with this situation requires improvisational behavior. Improvisation as defined by Crossan and Sorrenti (1997, p. 156) is "intuition guiding action in a spontaneous way." Weick (1998, p. 544) uses the following, somewhat richer, definition of improvisation that he borrows from Berliner: "Improvisation involves reworking precomposed material and designs in relation to unanticipated ideas conceived, shaped, and transformed under the special conditions of performance, thereby adding unique features to every creation" (Berliner, 1994, p. 241). Barrett suggests that improvisation is the process of "fabricating and inventing novel responses without a prescripted plan and without certainty of outcomes; discovering the future that their action creates as it unfolds.... Improvisation involves exploring, continual experimenting, tinkering with possibilities without knowing where one's queries will lead or how action will unfold" (1998, pp. 605-606). As surprise emerges in organizations managers must encourage workers to respond to unanticipated events with a balance of structure and flexibility (Brown & Eisenhardt, 1998). What workers tend to do is to ask for a prescription; a right way for doing things. They want structure because it reduces their uncertainty and their risk. Organizations must strive to develop capacities for maintaining and managing loose ties as well as tight ties, for engaging in rich, focused information exchanges as well as broad environmental scanning and for enabling two-way relationships (McDaniel, 2004). Such activities will cultivate positive self-organization, constructive emergence and effective co-evolution, and, in turn, enable the organization to respond to operating environment changes.

In a world dominated by uncertainty and surprise, minimal structure (Barret, 1998), including loose-tight coupling and order-chaos-order enable the achievement of temporary advantage. While it is tempting to want to defeat uncertainty and surprise with control and planning, it is improvisation that will enable organizations to generate productive responses to changing conditions. Fortunately, the ability to improvise is not something that is rare but is a potential that is widely distributed in the population (Crossan & Sorrenti, 1997). However, conditions required for improvisation must be present, and these are often created by managers (Crossan & Sorrenti, 1997). Improvisation is a social act dependent of the nonlinear relationships in the system. We figure out where we are going by talking to others about where we have been and where we are. If we want to get per-

formance improvement through improvisation, then it is up to managers to facilitate conversations that can enable improvisational behavior.

Jazz players are an example of a group of workers who are used to living with surprise, and they are often seen as models of improvisational behavior. Jazz players do not simply "create music at random." They know the form of jazz, and they operate within that form to both create surprise and, at the same time, to improvise in response to the surprise created. There is constant surprise in every great jazz performance and some very complex stuff often comes out of a very simple standard form. The creation of jazz is a building process, and bad jazz occurs because one person played something that the others couldn't build on, not that someone played the wrong note. Note that both the player and the builders share the responsibility to create good jazz (Barret, 1998). The creation of effective improvisation is the responsibility of the whole system rather than just the responsibility of a single agent because of the importance of connections and relationships among agents. Good jazz players don't ask, what did you intend to do? Rather, they listen attentively to others and to themselves and build on what they hear to create the music; to create their jazz. It isn't a question of whether the previous segment was the right or the wrong one, but it is a question of what can I do with what is happening here and now (McDaniel & Driebe, 2001). In effective improvising organizations, people are more concerned with what they can do with the existing situation, how they can improvise on the situation, than they are with finding someone to blame for the way things are or finding a way to duck responsibility for what is happening (Simon, 1987). People must think while doing rather than look to a plan to guide their behavior (Weick, 1998).

In environments with uncertainty, managers will at times face surprises such as unanticipated changes to the operating or market environment. At these moments, managers must often improvise to adapt to the new environment. They often need to be able to improvise with or without new resources. Bricolage is a key strategy for improvising—for reconfiguring information and resources to create new opportunities. Bricolage (Levi-Strauss, 1966; Weick, 1993) is the ability to create what is needed to cope with a situation from the resources that are available rather than to seek new resources. Bricolage is a way that we can create order out of chaos by drawing together ideas and available materials in new ways to accomplish a task. A bricoleur knows existing situations intimately by paying close attention to the present and, thereby, can invent new ways for dealing with an emerging reality (McDaniel & Driebe, 2001; Weick, 1993). Bricolage requires creativity, an understanding of tools and materials and a willingness to experiment. You must learn while in the middle of action, and this means that you must think your way out of a situation while acting and act your way out of a situation while thinking (Weick, 1995).

In organizations, improvisation is hard, in part, because conversations about where we have been and where we are going are difficult and most organizations do not reward originality under the assumption that customers don't either (Weick, 1998). Also, because units are often tightly coupled

to other parts of organizations, improvisation can be disruptive. We find a creative solution to the problem we think we have, only to discover that our solution has created havoc for those in adjacent domains (Barret, 1998; Rivkin & Siggelkow, 2002). So while improvisation is one way to manage the surprises that confront us, we should be aware that one's improvisation can create surprise for others. We are always mixing intention with emergence and self organization as we improvise, and the appropriate mix is both situationally dependent and evolving over time. We build on emerging characteristics of CAS to develop patterns of social interaction among workers, and these social interactions give people confidence in each other that leads to small wins and that enhance the capacity to be improvisational in the face of uncertainty (McDaniel & Driebe, 2001). The system of interactions can be quite entangled. "Success [in improvisation] encourages simplification, more risk taking, less slack, and accelerated production, all of which shrink the time available for adaptive improvisation and force people back on older ideas and away from the very innovation that made them successful in the first place" (Weick, 1998, p. 553).

Interesting examples of improvisation and bricolage occurred when organizations attempted to respond to the crisis created by the unexpected attacks on The World Trade Center on 9/11. Saint Vincent Catholic Medical Center (SVCMC) in Manhattan was the level one trauma center that was nearest to the disaster (Campbell, 2002). It was centrally involved in the immediate aftermath of the bombings and demonstrated a high level of capacity to improvise. As one example, when the phone system went down, computer technicians used the computer linkages to the other seven hospitals in the system to jerry-rig a telephone system and keep communications open despite the fact that other organizations in the area were cut off from the outside world by the effects of the blast. This is an excellent example of bricolage as workers used an existing system for new purposes. SVCMC's computer systems became the one consistent communications link. There was an overwhelming need for communication because of the horrors that had been witnessed, and the improvised telephone system became a way to provide critical linkages. When one examines the SVCMC's responses to the disaster, one can see that the key for much of their improvisation success was in the patterns of relationships that had previously been developed both within and outside of the organization (Campbell, 2002; McDaniel, 2004).

A Modest Research Agenda

When we take seriously the understanding that our organizations are complex adaptive systems, research in the area of performance improvement will take a different turn. We can see or notice different things using a complex adaptive systems perspective than we might see or notice from more traditional perspectives. There are puzzles that we will see differently from a complex adaptive systems perspective.

One puzzle that has been noted is that simply having the best workers may not always be a very clever strategy for improving performance. Com-

plex adaptive systems theory suggests that the quality of relationships may be more important to systems performance than the quality of the agents. This insight leads to the following research questions:

1. What patterns of relationships are the most likely to lead to improved performance?
2. What is the role of diversity in improving performance and what is the "correct" amount and kind of diversity.
3. What is the proper mix of tight and loose ties in a CAS?
4. What are the characteristics of agents that are likely to lead to productive patterns of relationships?
5. What are the characteristics of relationships (e.g., mindfulness, heedfulness, trust) that are most critical for performance improvement?

Another puzzle often noticed by those that practice performance improvement is that it is difficult to find performance enhancement solutions that work across a wide variety of situations and where the outcomes of improvement interventions will be "as predicted" in most cases. This insight leads to the following research questions:

1. How can we organize so that we can expect the unexpected?
2. What are the differences in context that are most significant in permitting the transfer of performance improvement strategies across settings?
3. Can we design information systems that will allow us to monitor performance improvement efforts when the nonlinearity of interdependencies can lead to such unpredictable behavior?
4. How can we include improvements in improvisational and creative abilities in our performance improvement efforts?
5. What are the boundaries of performance improvement efforts and how do we manage these boundaries?

Another puzzle often noted is that results of performance improvement efforts are sometimes better than expected and sometimes worse than expected. The nature of self organization, emergence and co-evolution in CAS suggests that strategies and tactics for leveraging these properties must be developed (Bettis & Prahalad, 1995). This insight leads to the following research questions:

1. How can we map the dynamics of performance improvement? What is its real trajectory as well as what is its expected trajectory? Is it a continuous function and, if so, what is the functional form of the trajectory?
2. Is performance improvement incremental in nature, and how can we anticipate or adjust for the differences in the size and timing of the incremental changes?

3. Is performance improvement a step function much like punctuated equilibrium?
4. How can we do a better job of anticipating environmental responses to performance improvement efforts so that co-evolution becomes our friend rather than our enemy?
5. Can we design the performance landscapes of our firms, or are we committed to a responsive mode of behavior?
6. How can we manage performance improvement when we acknowledge that improvement is an emergent property of CAS rather than something that is imposed on the organization?

It seems likely that successful interventions for performance improvement will be very modest. Many outstanding complexity scientists such as Stuart Kauffman and Brian Arthur have developed clear arguments about the importance of modest interventions when seeking systems improvements (Arthur, Durlauf, & Lane, 1997; Kauffman, 1995). Karl Weick has made a persuasive case for seeking small wins (1984), and Sim Sitkin has helped us to think about how we can use small failures to our advantage (1992). CAS theory suggests that we need research on performance improvement mechanisms that will help us use modest performance improvement approaches more effectively. Research questions include the following:

1. How can we learn from small wins and from small losses?
2. How can we manage the economics of modest improvement in a turbulent environment?
3. Can systems expectations be tuned to modest interventions?
4. What do we do so that we turn our understanding of CAS and the modest steps of performance improvement into a competitive advantage?

Not only do we see new research questions when we treat our organizations as CAS but our research methods are also affected. Research must be directed toward patterning and relationship (Fleener & Merritt, 2007). Computer simulation research has been one of the most widely used research strategies in studying CAS, and there has been a particular growth in the use of agent-based modeling to capture the interactive dynamics of CAS (Agar, 2003). Research with an ethnographic frame has been useful in seeing the dynamics in CAS (Agar, 1996). Case study research is particularly useful for detecting patterns in relationships (Eisenhardt, 1989). Longitudinal studies are often required to see emergent and self organizing characteristics of CAS (Allen & Varga, 2007). Most importantly, it must be recognized that the focus of research on CAS must be on understanding and not on prediction and that models used in the research effort must be driven by the research questions rather than attempts to map reality (Ashby, 1970; Giere, 1999). "If epistemology is about what we know and how we know what we know (what is inside) and ontology is about what there is to

know (what is outside) then the most fundamental challenge that complexity science makes is that these can no longer be considered as separable" (Allen & Varga, 2007, p. 19).

A Unifying Perspective

When one understands that organizations are complex adaptive systems and that they share the characteristics of these systems, then the managerial focus for improving performance shifts. It shifts from giving commands to enabling learning in real time. It shifts from controlling what is going on to making sense of a world characterized by an unpredictable dynamic. It shifts from planning based on forecasts of the future to making it possible for workers to engage in improvisational behavior, thereby taking advantage, in real time, of what unfolds. Instead of planning based around forecasts, which enables managers to feel that they should tell workers what to do, or otherwise control the actions of their staff, managers push decision-making authority down to their staff so that workers can improvise in real-time and leverage the unfolding events. We improve performance in CAS through sensemaking, learning and improvisation, rather than through command, control and planning. These new tasks are social acts and they are all dependent on patterns of relationships in the organization. Our role as managers becomes preparing organizations to meet an unknowable future and unleashing the potential of our organizations. Leadership has a different meaning in CAS and becomes the legitimization of doubt rather than knowing what to do and giving others directions for them to follow (Weick, 2001b).

Our role as managers becomes preparing organizations to meet an unknowable future and unleashing the potential of our organizations.

Great companies get remarkable performance from ordinary people while not-so-great companies take talented people and manage to lose the benefits of their talent, insight and motivation (Pfeffer & Sutton, 2000). When we mis-specify the nature of organizations and act as though they were machine-like in their unfolding, then we fail ourselves, our organizations and the ordinary people as well as the talented people, both of whom are capable of remarkable performance. As managers, if we attend more carefully to sensemaking, learning and improvisation and to the relationship systems that enable these functions, then we will manage in ways that are more consistent with the complex adaptive nature of our systems and we will make a positive contribution to improvement of organizational performance.

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References

Agar, M. H. (1996). *The professional stranger: An informal introduction to ethnography* (2nd ed.). San Diego: Academic Press.

Agar, M. H. (2003). My kingdom for a function: Modeling misadventures of the Innumerate. *Journal of Artificial Societies and Social Simulation, 6*(3). Retrieved June 1, 2003, from http://jasss.soc.surrey.ac.uk/6/3/8.html

Allen, P. M., & Varga, L. (2007). Complexity: The co-evolution of epistemology, axiology and ontology. *Nonlinear Dynamics, Psychology, and Life Sciences, 11*(1), 19-50.

Anderson, R., & McDaniel, R. R. Jr. (1999). RN participation in organizational decision making and improvements in resident outcomes. *Health Care Management Review, 24*(1), 7-16.

Anderson, R. A., Issel, I. M., & McDaniel, R. R. Jr. (2003). Nursing homes as complex adaptive systems: Relationship between management practice and resident outcomes. *Nursing Research, 52*(1), 12-21.

Argyris, C. (1992). *On organizational learning*. Cambridge, MA: Blackwell Publishers.

Arthur, W. B. (1999). Complexity and the economy. *Science, 284*(5411), 107-109.

Arthur, W. B., Durlauf, S. N., & Lane, D. A. (1997). *The economy as an evolving complex system II*. New York: Addison-Wesley.

Ashby, W. R. (1970). Analysis of the system to be modeled. In R. M. Stogdill (Ed.), *The process of model-building in the behavioral sciences* (pp. 94-114). Columbus, OH: Ohio State University Press.

Ashmos, D. P., Duchon, D., McDaniel, R. R. Jr., & Huonker, J. W. (2002). What a mess! Participation as a simple managerial rule to "complexify" organizations. *Journal of Management Studies, 39*(2), 189-206.

Ashmos, D. P., Huonker, J. W., & McDaniel, R. R. Jr. (1998). Participation as a complicating mechanism: The effect of clinical professional and middle manager participation on hospital performance. *Health Care Management Review, 23*(4), 7-20.

Ashmos, D. P., & McDaniel, R. R. Jr. (1991). Physician participation in hospital strategic decision making: The effect of hospital strategy and decision content. *Health Services Research, 26*(3), 375-401.

Barret, F. J. (1998). Creativity and improvisation in jazz and organizations: Implications for organizational learning. *Organizational Science, 9*(5), 605-622.

Beinhocker, E. D. (1997). Strategy at the edge of chaos. *The McKinsey Quarterly, 1*, 24-39.

Beinhocker, E. D. (2006). *The origin of wealth: Evolution, complexity, and the radical remaking of economics*. Boston, MA: Harvard Business School Press.

Berliner, P. F. (1994). *Thinking in jazz*. Chicago: University of Chicago Press.

Bettis, R. A., & Prahalad, C. K. (1995). The dominant logic: Retrospective and extension. *Strategic Management Journal, 16*(1), 5-14.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities of practice: Toward a unified view of working, learning and innovation. *Organization Science, 2*(1), 40-57.

Brown, S. L., & Eisenhardt, K. M. (1998). *Competing on the edge*. Boston, MA: Harvard Business School Press.

Buchanan, M. (2002). *Nexus*. New York: W.W. Norton & Company, Inc. (See Ch. 3 Small worlds, pp. 48-60)

Campbell, D. (2002). 9/11: A healthcare provider's response. *Frontiers of Health Services Management, 19*(1), 3-13.

Capra, F. (1996). *The web of life: A new scientific understanding of living systems*. New York: Anchor Books Doubleday.

Casti, J. L. (1997). *Would-be worlds: How simulation is changing the frontiers of science*. New York: John Wiley & Sons, Inc.

Chu, D., Strand, R., & Fjelland, R. (2003). Theories of complexity: Common denominators of complex systems. *Complexity, 8*(3), 19-30.

Cilliers, P. (1998). *Complexity and postmodernism: Understanding complex systems*. New York: Routledge.

Crossan, M., & Sorrenti, M. (1997). Making sense of improvisation. *Advances in Strategic Management, 14*, 155-180.

Edmondson, A. C. (2003). Speaking up in the operating room: How team leaders promote learning in interdisciplinary action teams. *Journal of Management Studies, 40*(6), 1419-1452.

Edmonson, A. C., Bohmer, R. M., & Pisano, G. P. (1996). Learning from mistakes is easier said than done: Group and organizational influences on the detection and correction of human error. *Journal of Applied Behavioral Science, 2*(1), 5-28.

Edmonson, A. C., Bohmer, R. M., & Pisano, G. P. (2001). Disrupted routines: Team learning and new technology implementation in hospitals. *Administrative Science Quarterly, 46*, 685-716.

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532-550.

Eisenhardt, K. M. (1990). Speed and strategic choice: How managers accelerate decision making. *California Management Review, 2*, 39-54.

Eisenhardt, K. M., & Brown, S. L. (1999). Patching-restitching, business portfolios in dynamic markets. *Harvard Business Review, 77*(3), 72-82.

Fleener, M. J., & Merritt, M. M. (2007). Paradigms lost? *Nonlinear Dynamics, Psychology, and Life Sciences, 11*(1), 1-18.

Giere, R. N. (1999). *Science without laws*. Chicago: University of Chicago Press.

Goldstein, J. (1999). Emergence as a construct: History and issues. *Emergence-Journal of Complexity Issues, in Organizations and Management, 1*(1), 49-72.

Gupta, A. K., Smith, K. G., & Shalley, C. (2006). The interplay between exploration and exploitation. *Academy of Management Journal, 49*(4), 693-706.

Herriot, P., & Pemberton, C. (1995). *Competitive advantage through diversity: Organizational learning from difference*. London: SAGE Publications.

Holland, J. H. (1995). *Hidden order: How adaptation builds complexity*. New York: Addison-Wesley.

Holland, J. H. (1998). *Emergence: From chaos to order*. Reading, MA: Addison-Wesley.

Kauffman, S. (1993). *The origins of order: Self-organization and selection in evolution*. New York: Oxford University Press, Inc.

Kauffman, S. (1995). *At home in the universe: The search for laws of self-organization and complexity*. New York: Oxford University Press.

Levinthal, D. A., & Warglien, M. (1999). Landscape design: Designing for local action in complex worlds. *Organization Science, 10*(3), 342-357.

Levi-Strauss, C. (1966). *The savage mind*: The University of Chicago Press.

Liebeskind, J. P., Oliver, A. L., Zucker, L., & Brewer, M. (1996). Social networks, learning and flexibility: Sourcing scientific knowledge in new biotechnology firms. *Organization Science, 7*(4), 428-443.

Louis, M. R. (1980). Surprise and sensemaking: What newcomers experience in entering unfamiliar organizational settings. *Administrative Science Quarterly 25*, 226-251.

Maguire, S., McKelvey, B., Mirabeau, L., & Oztas, N. (2006). Complexity science and organization studies. In S. R. Clegg, C. Hardy, T. B. Lawrence, & W. R. Nord (Eds.), *The SAGE handbook of organization studies* (2nd ed., pp. 165-214), Thousand Oaks, CA: SAGE Publications Inc.

Mainzer, K. (1996). *Thinking in complexity* (2nd ed.). New York: Springer-Verlag.

March, J. G., Sproull, L. S., & Tasmuz, M. (1991). Learning from samples of one or fewer. *Organization Science, 2*(1), 1-13.

McDaniel, R. R. Jr. (2004). Chaos and complexity in a bioterrorism future. In M. D. Fottler, J. D. Blair, & A. C. Zapantam (Eds.), *Advances in health care management* (Vol. 4, pp. 119-139). Oxford, UK: Elsevier, Ltd.

McDaniel, R. R. Jr., & Driebe, D. J. (2001). Complexity science and health care management. In J. D. Blair, M. D. Fottler, & G. T. Savage (Eds.), *Advances in health care management* (Vol. 2, pp. 11-36). Stamford, CN: JAI Press.

McDaniel, R. R. Jr., & Driebe, D. J. (2005). Uncertainty and surprise: An introduction. In *Uncertainty and Surprise in Complex Systems* (pp. 3-11). Heidelberg: Springer Verlag.

McDaniel, R. R. Jr., Jordan, M. E., & Fleeman, B. F. (2003). Surprise, surprise, surprise! A complexity science view of the unexpected. *Health Care Management Review, 28*(3), 266-278.

McDaniel, R. R. Jr., & Walls, M. E. (1997). Diversity as a management strategy for organizations: A view through the lenses of chaos and quantum theories. *Journal of Management Inquiry, 6*(4), 371-383.

McKelvey, B. (1999). Avoiding complexity catastrophe in co-evolutionary pockets: Strategies for rugged landscapes. *Organization Science, 10*(3), 294-321.
Morel, B., & Ramanujam, R. (1999). Through the looking glass of complexity: The dynamics of organizations as adaptive and evolving systems. *Organization Science, 10*(3), 278-293.
Morgan, G. (1996). *Images of organization*. Thousand Oaks, CA: Sage.
Nicolis, G., & Prigogine, I. (1989). *Exploring complexity*. San Francisco: Freeman.
Perrow, C. (1984). *Normal accidents: Living with high-risk technologies*. New York: Basic Books.
Pfeffer, J., & Sutton, R. I. (2000). *The knowing-doing gap: How smart companies turn knowledge into action*. Boston: Harvard Business School Press.
Ritter, T., Wilkinson, I. F., & Johnston, W. J. (2004). Managing in complex business networks. *Industrial Marketing Management*, 33, 175-183.
Rivkin, J. W., & Siggelkow, N. (2002). Organizational sticking points on NK landscapes. *Complexity, 7*(5), 31-43.
Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday.
Simon, H. A. (1987, February). Making management decisions: The role of intuition and emotion. *Academy of Management Executive*, 57-64.
Simon, H. A. (1991). *Information, technology and computers in management*. Lecture at the Graduate School of Business, The University of Texas at Austin.
Sitkin, S. B. (1992). Learning through failure: The strategy of small losses. In B. Staw & L. Cummings (Eds.), *Research in Organizational Behavior* (Vol. 14, pp. 231-266). Greenwich, CT: JAI Press.
Stacey, R. D. (1995). The science of complexity: An alternative perspective for strategic change processes. *Strategic Management Journal, 16*(6), 477-495.
Taylor, J. R., & Van Every, E. J. (2000). *The emergent organization: Communication as its site and surface*. Mahwah, NJ: Erlbaum.
Thomas, J. B., & McDaniel, R. R. Jr. (1990). Interpreting strategic issues: Effects of strategy and the information-processing structure of top management teams. *Academy of Management Journal, 33*(2), 286-306.
Waldrop, M. M. (1992). *Complexity: The emerging science at the edge of order and chaos*. New York: Touchstone by Simon and Schuster Inc.
Weick, K. E. (1984). Small wins: Redefining the scale of social problems. *American Psychologist, 39*, 40-49.
Weick, K. E. (1993). The collapse of sense making in organizations: The Mann Gulch disaster. *Administrative Science Quarterly, 38*(4), 628-652.
Weick, K. E. (1995). *Sense-making in organizations* (Vol. 3). Thousand Oaks, CA: Sage Publications.
Weick, K. E. (1998). Improvisation as a mindset for organizational analysis. *Organizational Science, 9*(5), 543-555.
Weick, K. E. (2001a). *Making sense of the organization*. Malden, MA: Blackwell Publishers.
Weick, K. E. (2001b). Leadership as the legitimation of doubt. In W. Bennis, G. M. Spreitzer, & T. G. Cummings (Eds.), *The future of leadership* (pp. 91-102). San Francisco: Jossey-Bass.
Weick, K. E. (2005). Managing the unexpected: Complexity as distributed sensemaking. In R. R. McDaniel Jr. & D. J. Driebe (Eds.), *Uncertainty and Surprise in Complex Systems* (pp. 51-65). Berlin: Springer-Verlag.
Weick, K. E., & Roberts, K. H. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly, 38*(9), 357-381.
Weick, K. E., & Sutcliff, K. M. (2001). *Managing the unexpected: Assuring high performance in an age of complexity*. San Francisco: Jossey-Bass.

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