We're Not In Kansas Anymore, Toto: Mapping the Strange Landscape of Complexity Theory, and Its Relationship to Project Management

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ABSTRACT

Both practitioners and researchers in the field of project management have referred to problems caused by complexity or problems of particular significance to complex projects. In different scientific disciplines investigations into the behavior of complex dynamical systems are revealing insights that, taken together, amount to a challenge to the prevalent Cartesian/Newtonian/Enlightenment paradigm from which the practice of project management has emerged.

Concepts such as nonlinearity, emergence, self-organization, and radical unpredictability have major implications for the uncodified paradigm that underpins project management practice and research. Taken together, they amount to a complementary way of thinking and talking about projects and their management that might shed new light on intractable problems that appear to plague certain areas of project management practice.

One strand within complexity studies that holds particular promise is complex responsive processes of relating, a means of talking about how human beings interact and learn and how their interactions evolve over time and across space. A new program of research, of which this paper forms part, will apply this conceptual framework to the lived experience of project teams, including executive sponsors, project managers and project team members.

Keywords: project management theory; complexity theory; relationships; complex projects

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Introductory Comments

The Relevance of this Paper

During the past few years, there has been an increasing tendency to draw attention to the particular challenges posed by complex projects (Williams, 1999, Richardson, Tait, Roos, & Lissack, 2005) or by complexity in projects (Baccarini, 1996; Cicmil, 2003a, 2003b; Cicmil, 2005; Cicmil & Marshall 2005; Sommer & Loch, 2004). The discussion, however, has been somewhat hindered because the issue of theoretical foundations in project management research has been a central point of debate among both practitioner and scholarly communities for quite some time.

The discussion about complexity in projects is simply one strand to the growing concern about the dominance of various versions of control theory, operations research, or systems theory in the studies of projects and project management that are largely normative and prescriptive in character (e.g., Cicmil, 2006; Cooke-Davies, 2004a, 2004b, 2004c; Cooke-Davies & Wolstenholme, 1998; Hodgson & Cicmil, 2003, 2007; Melgrati & Damiani, 2002; Thomas, 2000; Williams, 2004).

It may be only one strand, but it is an important one. What is at stake is a comprehensive understanding of what it takes to deliver complex projects successfully in all fields of human endeavor, and not simply in the field comprising the traditional arena from which the disciplines of project management emerged.

This paper, then, seeks to make a significant contribution to the discussion about complexity by reviewing the major ideas that have emerged in the past few decades from the school of academic studies that can be characterized as complexity science and assessing their possible relevance to the disciplines of project management. Particular attention is paid to those ideas that are directly relevant to the social complexity created by and among disparate groups of people who together make up the team involved in delivering complex projects. After all, one of the 2006 Nobel Laureates for Physics said, "I'm convinced that over half the cost of a project is socially (contextually) determined."[1]

Before embarking on this review, however, it is helpful to undertake a couple of short excursions to clear the ground of two potential areas that could give rise to serious misunderstandings as the review progresses. The first of these areas is the realm of vocabulary, and how words are used to shape our understanding of the world we live in.

1 John Mather of NASA, quoted by Charlie Pellerin in private correspondence with Terry Cooke-Davies.

A Word About Vocabulary

Any discussion about a concept as broad as complexity or complex projects is bound to encounter risks inherent in the use of language. The term "complexity" itself is in widespread common usage, and all readers of this paper can be expected to have their own understanding of what the term means. Dictionary definitions are not particularly helpful, generally referring back to the Latin origins of the term (*complexus*, from *complecti*) in which *com* is combined with *plectari* meaning ply or braid. The picture that this suggests is generally one of the unavoidable result of a necessary combining, and does not imply a fault or a failure.

If the aim is to say something meaningful about the nature of the world we live in and, more particularly, about the management of projects, then we must be clear that we use two very different kinds of words in our conversation. These are *objects* and *ideas* (Hacking, 2000).

By *ideas*, Hacking means conceptions, concepts, beliefs, attitudes to, and theories about. They can be private or public, clear or vague but in any case they are discussed, accepted, worked out, shared or contested. Hacking would distinguish between, for example, the *idea* of complexity in projects and the *objects* such as the behavior of the people engaged in the planning and controlling activity on complex projects and the artifacts that they produce through this behavior.

At the same time, we need to accept that these two types are not independent from each other. The objects we deliberately create are strongly linked to the ideas we have about existing objects, and objects we'd like to see in the world. Moreover, new ideas are the result of interactions between ideas and objects. We could even go so far as to suggest that objects cannot exist (from the viewpoint of humans) without ideas about those same objects. We do not want to get into the relationship between ideas and objects too much in this paper other than to say that traditionally they have been seen as either totally separate (extreme relativism) or more or less one and the same (extreme realism). Complexity thinking tends to regard the relationship between ideas and objects as rather more "complex."

The short of it, however, is that research that takes ideas and treats them as if they were objects (in effect reifying them)—what philosophers would label a naïve realism—is built on shaky foundations.

Unfortunately in literature about the management of projects, there is a tendency in practitioner literature to reify processes, and in literature derived from organizational theory to reify social groupings and organizational units. This results in a blurring between objects and ideas, and a lack of methodological integrity to much quantitative research.

For the purposes of this paper, the issue is further complicated by the fact that the term "complexity theory" is becoming widely applied to research in a remarkable diversity of domains, each of which has specialized characteristics that distinguish it to some degree from the others, but from which a number of recurring deep themes have emerged that link each domain to the others (Axelrod & Cohen 2000). This paper proposes that these deep themes emerging from the research are of particular interest to the study of project management.

The Importance of Paradigms

The second area in need of clarity is the paradigm that shapes both project management practice and project management research.

The term "paradigm" has become widespread in discussions of the philosophy of science since it was introduced by Kuhn in 1962 in the first edition of *The Structure of Scientific Revolutions* as a way of describing achievements that arise when a group of scientists adopt models from which spring "particular coherent traditions of scientific research" (Kuhn, 1996, p. 10). The term encompasses broad aspects of scientific practice, including law, theory, application, and instrumentation together.

As Kuhn explains, "the study of paradigms … is what mainly prepares the student for membership of the particular scientific community with which he (sic) will later practice. Because he there joins men who learned the bases of their field from the same concrete models, his subsequent practice will seldom evoke overt disagreement over fundamentals" (Kuhn, 1996, p. 11).

"Paradigms," asserts Kuhn, "may be prior to, more binding, and more complete than any set of rules … that could be unequivocally extracted from them" (Kuhn, 1996, p. 46).

It is Kuhn's assertion that scientific breakthroughs occur when a group of scientists starts to undertake scientific research employing a different paradigm than that which underpins "normal science." To paraphrase Kuhn: We do not learn to view the world differently because research provides us with new and different answers; rather we view the world in new and different ways, and so do different research.

What Kuhn says about the prevalence of paradigms in determining scientific achievements can also be applied to the prevalence of paradigms or world views in other fields of human endeavor. Wenger, for example, showed the importance of situated learning in shaping the development of practice through the absorption of a paradigm when expert practitioners operate as a community of practice. (Wenger, 1998).

Project management itself embodies a paradigm that is more coherent, more binding and more complete than the theory on which it is based, or than the achievements of the research that are increasingly being fed back to its growing number of practitioners. All attempts to describe the paradigm will inevitably rob it of some aspects of its richness, but it has been described as rational (Lundin & Soderholm, 1995), normative (Melgrati & Damiani, 2002; Packendorf, 1995), positivist (Smyth et al., 2006; Williams, 2004), and reductionist (Koskela & Howell, 2002). That is not to say, of course, that there are not practitioners who operate beyond these ideals, and it is the intent of the research program, of which this paper forms a part, to provide both language and conceptual tools to identify and facilitate this.

This paper is not concerned with a sociological explanation of the origins of the paradigm that underpins project management, but the tenor of all the works cited so far in this connection makes it clear that behind the paradigm lies a mechanistic world view deriving from Cartesian philosophy, a Newtonian understanding of the nature of reality, and an Enlightenment epistemology whereby the nature of the world we live in will be ultimately comprehensible through empirical research. This is an important assertion, because the nature of the deep themes that are emerging from complexity theory can be said to amount to nothing less than an expansion and enrichment of the Cartesian/Newtonian/Enlightenment paradigm from which the practice of project management has emerged. If it proves to be correct, then the emerging paradigm may well provide project management with the breakthroughs in practice that are being called for in the conduct of "complex" projects.

Complexity Theory—The New Landscape

Now that the ground has been cleared, so to speak, it is possible to embark on the promised review of the new landscape, not so as to present a historically rigorous account of the development of the emerging paradigm, but rather to provide practitioners and researchers in the field of project management a useful overview of the more significant components of the paradigm, including a brief account of when and how they arose.

Complexity theory can be defined broadly as the study of how order, structure, pattern, and novelty arise from extremely complicated, apparently chaotic systems and conversely, how complex behavior and structure emerges from simple underlying rules. As such, it includes those earlier fields of study that are collectively known as chaos theory. The component elements of the emerging paradigm have arisen from research conducted in academic fields that include life sciences, physical sciences, and mathematics. To refer to these component elements as features of a landscape is an appropriate metaphor, because it ties in directly with the concept of "fitness landscapes," which is one of the ways that the emerging paradigm has influenced evolutionary theory in biology.

The broad temporal and disciplinary relationships between the landmarks that will be discussed in this paper are shown as a diagram in Figure 1. The names associated with each landmark are frequently not the only people to undertake significant research into the particular field. They are, however, the names of people who have been closely associated with the landmark concept, and thus represent a starting point for any readers who are interested enough to want to pursue the topic in greater depth. Figure 1 is a map of a territory that encompasses about a half century of research in many disciplines carried out in different countries. As such, it is inevitably a gross simplification—and the actual landscape is far more interconnected that the diagram implies. What follows now is a brief explanation of the key landmarks on the map (Figure 1).

The "Butterfly" Effect

During the late 1960s and early 1970s, a group of scientists working in a wide range of disciplines became uneasy with the basic assumptions of linearity that were used as the basis for much science, especially in the physical sciences. Many researchers in mathematics and physics had concentrated their attention on discovering underlying patterns of cause and effect that could be expressed in terms of linear mathematics. For some three centuries, a view of the world as a kind of "clockwork masterpiece" (encapsulated in the mathematics of Newton and Leibnitz), had allowed scientists to unlock many of its mysteries.

The development of computers, however, with their ever-increasing computational power, opened the door not only to new technological achievements, but also to studies of much more challenging non-linear systems such as the weather (which had stubbornly refused to yield its secrets to the predominant mechanistic thinking), which are far more common in nature than linear ones are. Indeed, it was while using a computer to simulate weather systems in 1960 at Massachusetts Institute of Technology that meteorologist Edward Lorenz (1963) discovered one important aspect of how non-linearity affects the weather—the principle of "sensitive dependence on initial conditions." Using a computer model that went some way toward simulating the behavior of a weather system, Lorenz interrupted one such computer run, and entered the same starting data as he had done on an earlier run—only to find that after a few days the system started to diverge widely from that of the earlier run.

Lorenz's discovery of how minute changes can have major and unpredictable consequences in non-linear systems became known as the "butterfly effect" from the title of a paper that he presented in December 1979 to the Annual Meeting of the American Association for the Advancement of Science, "Predictability: Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" Paradoxically, the fact that weather is not predictable in the long term does not mean that its behavior is impossible to understand or explain. Even though weather systems exhibit unstable behaviors, the systems themselves are not inherently unstable. The British weather, for example, is recognizably the British weather, and not that of the Arctic or of Texas. The reason for that is explained by the next landmark.

Strange Attractors

In his further work, Lorenz (1993) also contributed to the development of this second noteworthy landmark—Strange Attractors. To understand strange attractors, it is necessary to know that in any dynamical system (such as a simple pendulum) you can represent the state of the system using a diagram known as phase space. In the case of the pendulum, for example,

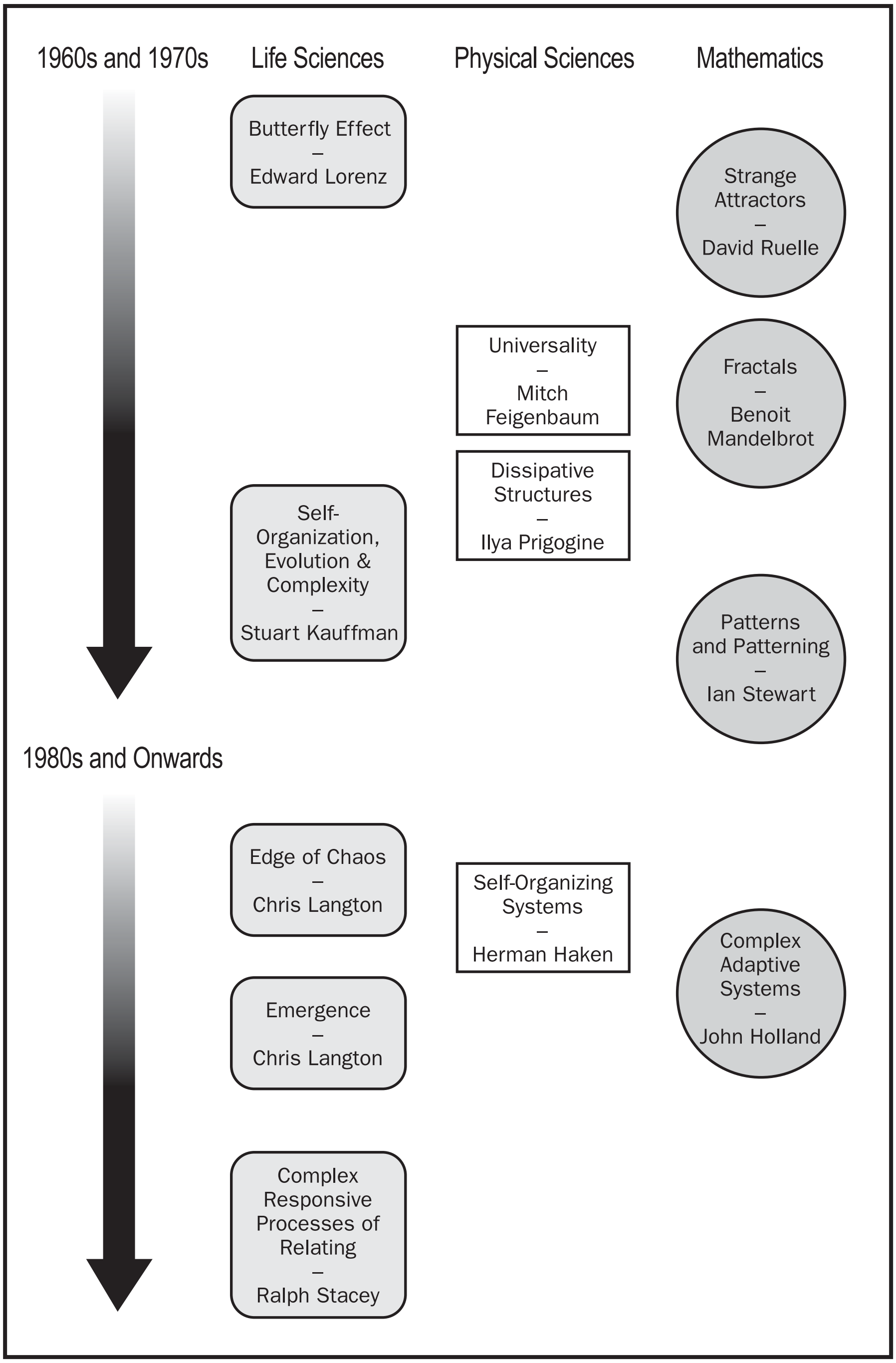

Figure 1: A diagram of "landmarks" on the landscape of the emerging paradigm

a simple diagram showing its position (on the X-axis) and its velocity (on the Y-axis) translates the behavior of the system into a simple spiral, finally settling down in a position of rest at the origin of the diagram. Although such a simple dynamical system as a pendulum requires only a simple two-dimensional phase space diagram, it is possible to represent more complex systems (such as the weather that was mentioned earlier) by more complex phase space diagrams.

Working in this medium, David Ruelle, a Belgian-born mathematical physicist, working with Floris Takens, a Dutch mathematician, began to develop the notion of strange attractors to describe and explain the patterns of behavior that they detected while studying turbulence in fluids. Their findings were first published in 1971 (Ruelle and Takens, 1971), and over the succeeding years their work gained increasing recognition. As they did so, these recurring patterns (for that is what strange attractors, in effect, are) began to provide an explanation for why apparently chaotic systems (such as the weather that has already been discussed) display recurring and quasi-predictable features. This insight opened new possibilities for scientists studying the behavior of dynamical systems in nature, enabling the surprising discovery that complex systems can follow a number of qualitatively different attractors, depending upon initial conditions and external perturbations—this is very different from simple deterministic chaos.

Fractals

The term fractal, the next feature of this proposed landscape, was coined by the French mathematician Benoit Mandelbrot (1982) to describe irregular shapes that repeat themselves in nature. It is a form of algebra dealing with features of self-similarity (the property of certain natural objects to repeat themselves on different scales of size), and it helps to explain how complex patterns from simple guidelines. Although rooted in algebra, it is fractal geometry that has found the greatest popularity, with many books, magazines, and posters featuring spectacular pictures of such patterns as the Mandelbrot set. Fractal geometry is about the whole system, not its component parts, and explains mathematically how it is possible to see the same pattern recurring at both a small scale (such as an individual fern leaf) and at a larger scale (such as the plant as a whole). It also offers insights into the mathematical nature of strange attractors.

Edge of Chaos

Perhaps the feature of the new landscape that has become the most familiar to project managers has emerged from the life sciences, and is generally known as the *edge of chaos*, a term featured prominently in a best-selling book on the whole emerging field of complexity theory (Lewin, 1993). Studies of the evolution and behavior of living dynamical systems suggest that these systems manage to demonstrate elements of both chaotic and orderly behavior, and both computer scientists (through cellular automata—more popularly known as *artificial life*) and evolutionary biologists have carried out pioneering work to understand why this might be.

Stuart Kauffman, one of the foremost biologists working in this field (e.g., Kauffman, 1993), likes to use the analogy of the different states of water to illustrate the concept. Water can exist in a completely orderly state (ice) or a chaotic one (steam), but it is in the intermediate form (liquid) that it offers the best opportunities for the development of complex activities. The fact that these simple molecules can organize into three such qualitatively different structures is itself significant, but it is from Kauffman's primary area of study (evolutionary biology) that the concept of "fitness landscapes" has emerged, offering explanations for the success or failure of different species as their environment changes.

Scientists working at the Santa Fe Institute, who did much of the early work in this field starting in the early 1980s, found that both observations and computer simulations of ant colonies provide some evidence for this balance between order and chaos, and for the "real" existence of a way of existence at "the edge of chaos." Ants as individuals exhibit chaotic tendencies, continually switching between frantic activity and static inactivity. The colony as a whole, however, exhibits a pattern of behavior that is both rhythmic and orderly. Experimental studies have revealed that the pattern is also affected by population density, with the nature of activity in the nest changing from more chaotic to more stable, depending upon how many ants are in the nest at the particular time.

Kauffman does not claim undisputed title to have originated the term; co-claimants include Chris Langton and Norman Packard (Lewin, 1993). He does, however, elevate it to primary place as one of the four laws he proposes as candidates for an explanation of how evolutionary activity of competition between species coupled with their evident interdependence can lead to the co-construction of a biosphere, such as the one we live in (Kauffman, 2000).

Universality—Patterns and Patterning in the World

Order and chaos are not confined to the life sciences. Anyone who has ever been kept awake at night by a dripping faucet will recognize that the time between drips can vary both in the volume and frequency of the noise. If the faucet is tightened slightly, the pattern slows down, and if it is loosened, the pattern accelerates. The amount by which a faucet has to be tightened in order to double the time between drips is known as the *period doubling factor*. Mitch Feigenbaum (1979) is a physicist who, in the 1970s, was working to understand this "period doubling" effect (which, incidentally, is a common mechanism to move from simplicity to chaos), and in 1975 discovered that a particular number (approximately 4.669) is associated with period doubling in every field—not just dripping faucets.

Ian Stewart (1996), a mathematician, cites this as simply one example of the mathematical regularities such as π or ? (the golden number), which seem to crop up time and time again as constants in various laws of geometry or of nature. He also draws attention to the fact that in nearly all flowers the number of petals is one of numbers that makes up the Fibonacci series of numbers 3,5,8,13,21,34,55,89. Lilies, for example, have three petals, buttercups have five, many delphiniums have eight, marigolds have 13, asters have 21, and most daisies have 34, 55, or 89.

Why a man-made construct (mathematics) should be so useful in explaining so many aspects of the natural world remains one of the great mysteries of life. The observation that repetitive patterns occur in the most diverse and unlikely fields, however, has become elevated to the principle of *universality*—one element in the emerging paradigm.

Dissipative Structures

If the edge of chaos lies close to the heart of evolutionary biology, a similar revolution has taken place in the realm of physics, perhaps exemplified most dramatically in the work of Ilya Prigogine for which he was honored with the 1978 Nobel prize. In awarding the prize, the Nobel Committee observed that Prigogine's work had "fundamentally transformed and revised the science of thermodynamics."

Prigogine's primary interest was in a particular kind of complex dynamical systems, which he called *dissipative structures* because they are continually both receiving and transmitting energy—thus dissipating it. In order to enable experimental science to be applied to simply one aspect of these systems Prigogine chose to study Bénard instability, which is concerned with the patterns of convection in fluids. Through encasing a thin film of liquid between two sheets of glass, injecting it with a dye, and then observing the ensuing patterns of convection when the lower part of the film was heated, Prigogine was able to demonstrate that even systems composed of inanimate fluids, reached points of irreversible change (known as bifurcations) where the state of the system changed in ways that were impossible to predict from microscopic considerations alone—not because of any inadequacies of information, but simply because the outcome was inherently unpredictable.

This early work led on to more general studies of dissipative structures (or *complex dynamical systems* as they are now more generally known) and to a recognition of the potential that these systems have for producing unpredictable behavior. Ultimately, it led Prigogine to ask the question, "Is the future given, or is it under perpetual construction?" (Prigogine, 1997).

Self-Organizing Systems

Prigogine's work in this field made him a Nobel Laureate, but the work that he started has been taken forward enthusiastically in the study of spontaneous self-organization. Examples of complex dynamical systems that seem capable of self-organization and exercising choice in a manner that makes them inherently unpredictable include hurricanes, living cells, and human self-organization. What all these systems have in common is that they exchange matter and energy, and remain far from equilibrium. The feedback loops that are contained within the systems ensure that rich patterns are produced, and that the system itself behaves in its own unique way. This production of complex behavior from relatively simple rule-based behavior and feedback loops allows such systems to be simulated on modern high-powered computers. It makes possible the lifelike behavior of computer-generated images of fish, birds, or bats for the purposes of either entertainment (as in films such as *Batman Returns*) or for serious study (see Reynolds, 1987).

Emergence

If universality is one of the observed characteristics of complex dynamical systems in many fields of study, a second characteristic that flows from the study of these systems is that of *emergence*. As self-organizing systems go about their daily business, they are constantly exchanging matter and energy with their environment, and this allows them to remain in a state that is far from equilibrium. That allows spontaneous behavior to give rise to new patterns. Such characteristics allow shoals to respond effectively to predators, for example, of organisms to adapt to life in different climatic conditions from those within which they evolved. In doing so, characteristics and patterns emerge that are different in kind as well as in degree from the characteristics and patterns of the constituent components of the system.

It is these emergent properties of living systems that allows novelty and innovation and provides a credible account of how diversity and variety arise in order to allow evolution to happen. It also suggests that when dealing with complex dynamic systems, there is an element of unpredictability about the future that is pregnant with as-yet undreamt of possibilities. As Kauffman (2000, p. 139) so elegantly puts it, "The universe in its persistent becoming is richer than all our dreamings."

Complex Adaptive Systems

The last landmark shown in Figure 1 arises quite naturally from the preceding two—self-organizing systems and emergence. The difference between complex adaptive systems and self-organizing systems is that the former have the capacity to *learn* from their experience, and thus to embody successful patterns into their repertoire, although there is actually quite a deep relationship between self-organizing systems and complex adaptive systems. Adaptive entities can emerge at high levels of description in simple self-organizing systems, i.e., adaptive systems are not necessarily self-organizing systems with something extra thrown in. McMillan (2004, pp. 30 & 31) distinguished between a laser beam, which is a self-organizing system, and a human brain, which is a complex adaptive system.

One specific strand of the study of complex adaptive systems—complex responsive processes of relating, is dealt with in more detail later in the paper. But before examining how this particular strand of complexity theory relates to the study of projects and their management, there is one final concept that occupies a significant place in the emerging paradigm. It is one that cannot be located in any of the other landmarks, but is itself an emergent property of the new fields of study.

Indeterminacy

In fields of study as varied as physics, biology, mathematics, and even philosophy, a characteristic is emerging that challenges the fundamental tenets of the Cartesian/Newtonian/Enlightenment paradigm. That characteristic is the recognition of the inherent indeterminacy of the future of complex dynamical systems, and thus of the physical universe itself.

To the annoyance of Einstein who famously rejected the idea with the statement, "God does not play dice," (see Stewart, 1997 page xi) Heisenberg, Schrödinger, and other pioneers of quantum theory demonstrated that in the subatomic world, even physical matter contains inherent uncertainty. As was previously shown, Prigogine arrived at similar conclusions in thermodynamics, and Kauffman in biology. In mathematics, Gödel's theorem demonstrates that it is impossible to formulate any theorem in mathematics that does not contain at least one unprovable assertion. And by no means least, Wittgenstein (1953), as he reflected on and rejected the conclusions he reached in *Tractatus* (Wittgenstein, 1921), concluded that it was impossible to define the conditions that are necessary and sufficient in any lower-order characteristic to fully account for the higher-level definition. For example, one cannot precisely predict the next number in even the best-defined mathematical series of numbers, until the series is complete. This will, of course, never happen if the series is infinite. The implications of this emerging paradigm for both science, and for the study of project management, are fundamental, and it is appropriate to spell them out before turning in detail to complex adaptive systems.

Implications of the New Landscape for Science and for Scientific Research

In a plea for an end to what he refers to as a "post-critical philosophy" Polanyi (1958, p. 74) wrote:

> "Backed by a science which sternly professes that ultimately all things in the world—including all the achievements of man from the Homeric poems to the *Critique of Pure Reason*—will somehow be explained in terms of physics and chemistry, these theories assume that the path to reality lies invariably in representing higher things in terms of their baser particulars. This is indeed almost universally regarded today as the supremely critical method, which resists the flattering illusions cherished by men in their nobler faculties."

The developments described would seem to answer Polanyi's reservations, in part at least. Summarizing the foundations to the scientific complexity-systems theories, Auyang (1999, p. 341) writes:

> "Science reveals complexity unfolding in all dimensions and novel features emerging at all scales and organizational levels of the universe. The more we know the more we

become aware of how much we do not know. Gone is the image of a clockwork universe. Equally untenable are the image of a clockwork science that claims to comprehend all the diversity by a single method and a single set of laws and the clockwork scientists who are absorbed in deducing the consequences of the laws by applying given algorithms. Scientific research is a highly creative activity. Scientific creativity, however, is not an anything-goes arbitrariness. There are general guiding principles, which are discernable across diverse disciplines."

By no means would all scientists working in the field of complexity theory agree with the implication that determinism (the clockwork universe) and indeterminism (scientific creativity) are mutually exclusive. The game-of-life is probably the best example of a clockwork universe that contains (at higher levels of reality) seemingly creative entities. It is not a question of replacing one simplistic philosophy with another—rather it is a recognition of paradox underpinning the very nature of reality.

For Project Management and Project Management Research

If even pure science is finding the need to become more flexible in its research methods while not relapsing into "anything goes," is it perhaps too much to hope that research into projects and their management will take account of these developments and incorporate methods that investigate both the objects (human beings) who work together in ways that are labeled "projects," and the ideas that they find useful in doing so?

If this provides the basis to a research method that is compatible with both critical realism (human beings working together and learning together as complex adaptive systems) and constructivism (human beings generating ideas about their work together), then it will represent a major step forward for project management research.

Such a method will incorporate several of the ideas that have been briefly portrayed.

- *Nonlinearity*—The Butterfly effect, sensitive dependence on initial conditions, strange or multiple attractors, self-organization, adaptive systems and self-transformation. As has been previously seen a complex dynamical system is any system that has within itself a capacity to respond to its environment in more than one way. It introduces the idea of *choice*—and it cannot be simply a mechanical system. You can do the same thing several times over and get completely different results; small variations can lead to big changes, while big variations can result in minimal change; the paradox of detailed programming of a system's path in advance.
- *Emergence*—Processual rather than structural systems paradigm (not only goal-oriented but driven by broader, multiple, heterogeneous and frequently conflicting agendas, aspirations and values). It is at the heart of the process of evolving, adapting and transforming; E. O. Wilson (1971, p. 224) at Harvard considers it as a core feature of life shared by humans and insects alike; by working collectively, something novel emerges; the role of cooperation and self-organization is seen as essential for evolution; (see next the notion of joint action proposed by Stacey (2001) as one of the key premises of human living).
- Explanation of *states of stability and instability*; chaos and equilibrium, order within chaos/fractals/complex patterns; *self-organization*, adaptation and self-transformation. Although the *potential for chaos* resides in every system, chaos, when it emerges, frequently stays within the bounds of its attractor(s): No point or pattern of points is ever repeated, but some form of patterning emerges, rather than randomness.

  Life scientists in different areas have noticed that life seems able to *balance order and chaos at a place of balance known as the edge of chaos.* Observations from both nature and artificial life suggest that the edge of chaos favors *evolutionary adaptation.* Individual ants behave in a chaotic fashion, but the colony does not (this is the result of the emergence of robust high-level structures). In biology this is quite a fashionable theory (but not without its opponents).
- Stability is achieved at the level of patterned behavior influencing and simultaneously being influenced by the patterns at a higher level of interaction and governance (the boundary of strange attractor).

  A single complex mathematical formula describes a *pattern that keeps on repeating itself up and down the scale.* One formula describes lots of things. It is the kind of thing that keeps mathematicians happy. It is used to describe, rather than to predict. It applies to coastlines, weather systems, clouds, and so on. *Fractal patterns, even though they exist as a mathematical ideal, DO approximate* certain features of the natural world.

  Prigogine (1980) developed the theory of dissipative structures, which was his early name for self-organizing systems, by extending the work of thermodynamics from closed to open systems. Instead of a world where entropy rules and systems are subject to ongoing deterioration, he showed that open systems are essentially nonlinear, dynamic, and *able to transform themselves* into new states of being. It has been argued that dissipative structures are the basis to all living systems, including human beings.
- *Radical unpredictability* related to time flux and outcomes of complex interaction among agents over time, i.e., change at the micro-level of the phenomenon. "Paradoxically, weather systems as a whole are not unstable, although they exhibit unstable behaviors." Prigogine expressed the fundamental question "Is the future given, or is it under perpetual construction?"

Complex Responsive Processes of Relating

Complex responsive processes of relating (CRPR) is a theoretical concept within the conceptual palette of complexity thinking in general and complex adaptive systems in particular, which has been introduced and argued for by Stacey (2001, 2003) and his co-researchers (Stacey, Griffin, & Shaw, 2000; Fonseca, 2002; Griffin, 2002; Shaw, 2002; Streatfield, 2001) on the basis of the problematic capacity of other theoretical approaches to address complexity and paradox in contemporary organizations. It suggests a particular way of speaking about complexity of organizations, organizing, managing, and knowing. It emphasizes self-referential, reflexive nature of humans, the essentially responsive and participative nature of human processes of relating, and the radical unpredictability of their evolution and outcomes over time. From a methodological point of view, this concept puts *emphasis on the interaction among people* in organizations and is concerned with the question of how *the patterned themes of conversations* in local situations constitute and are simultaneously constituted by power relations in organizations, and how the *potential transformation* of these conversational patterns can induce change, trigger learning, and create new knowledge.

With these assumptions and propositions, CRPR implies an alternative view on management of organizational arrangements, the methodology of inquiry, the possibility of control, and the role of the individual and the group in these processes. The way in which organizing, managing, strategic change, and complexity are approached from this perspective resonates with the theoretical traditions of Mead's (1934) relational psychology, Elias's (1939) concept of the relational character of human nature, and the experiences with applications of chaos and complex systems theory to studying organizations (Stacey, 2003, Stacey et al., 2001), including bounded instability, self-organizing properties of complex systems, and non-linear behavior over time. It goes a step further by acknowledging the advantages of a processual approach over a systemic perspective in understanding complex and chaotic patterns of relating among individuals and groups, over time, which simultaneously constitute and are constituted by a wider organizational system. This is where the main difference between the concept of complex adaptive systems (see earlier reference to McMillan, 2004) and the one of complex responsive processes of relating becomes visible.

From the perspective of complex responsive processes of relating, social structures, and individual personalities largely emerge without overall intention of an agent in the interaction through symbols and gestures. The argument is that the individual and the social structures are emerging at the same time (Stacey, 2003, p. 319).

Under this theory, organization is an emergent property of many individual human beings *interacting together through their complex responsive processes of relating* centered on the use of language simultaneously for conversation and to negotiate social status and power relationships. Communication by means of evolved language is a defining characteristic of human beings, distinguishing them from all other species of animal (Kauffman, 1993). Central to the theory is the recognition that communication is a complex process involving both the words that are spoken and the response that they elicit—indeed *the chain of responses* that provide the context for an individual conversation or an element of it. The CRPR concept rejects the distinction between the individual and the group as unhelpful and argues that it is more useful to think of individuals relating to each other through the complex processes of vocalized and non-vocalized communication.

The concept of the complex responsive process of relating understands "human intentions, choices, and actions as essential to, as operating within, the dynamic of daily interactions between people." It argues that "organizing is human experience as the living present, that is, continual interactions between humans who are all forming intentions, choosing and acting in relation to each other as they go about their daily work together" (Stacey et al., 2000, p. 187). The joint action has therefore a spatial and temporal dimension of the process of organizing—it *is located in a specific context* and is oriented toward an *unknown future*—the future that is seen from this perspective as being under perpetual construction by the movement of human action itself.

Interaction is both communicative and power-relating, which is responsive but the *outcomes of which are unpredictable* at the fine level of detail. Thus, in the process of responding in the medium of symbols, artifacts, feelings and the unconscious, novelty (e.g., change of power relations, new knowledge, complex collaborative and individual learning, innovation) can be created or can emerge. It draws attention to *self-organizing capacity* of the processes of communicative relating in the medium of (sophisticated) tools, technologies, and artifacts, and the way people make sense of their being together through *self-reflection* on conflict, power and the "ordinary" (Stacey, 2003). The concept of CRPR refocuses attention on the *reflexive* monitoring of interaction by agents/actors, and the radical *unpredictability* and uncontrollability of the outcomes of action and intersubjective relating. As was demonstrated earlier, learning is what distinguishes complex adaptive systems from self organizing systems: separation, alignment, cohesion; programmed with only the simplest of rules. As flocking is an emergent property of essential bird behavior …. So organization and knowledge are emergent properties of the essential human behavior of communicating—of complex responsive processes of relating.

And out of this web of complex responsive processes arise both the emergent properties of organization and self-identity. Furthermore, human *action* is seen from this perspective as the process of perpetual reproduction of *identity* (individual and collective at the same time) with the potential for transformation. It is *accomplished* with the use of tools, artifacts, technologies, design systems, and other symbols where *identities* form and are simultaneously being formed by narrative and propositional themes. There is thus no distinction of kind, or of logical level, between the individual and the social. The phenomenon being studied is human relating, and the individual is the singular element of this, while the social is the plural. *Transformation* and novelty are possible because of the intrinsic *diversity* of the people interacting, which makes reproduction (memory) of past habitual interaction imperfect and people's choice of responses spontaneous to some extent. This draws attention to the issue of radical unpredictability and the future as being perpetually constructed in the process of human interaction, as the known-unknown, and implies what Stacey (2003, p. 390) calls a "fundamentally paradoxical theory of causality".

The proponents of this concept acknowledge *anxiety* that people experience in these processes of communicative interaction by which existing power relations and knowledge are being sustained or new forms constructed, and are interested in how that anxiety is lived with when the outcomes are not predictable to the finest level of detail and *complexity is unavoidable.*

The CRPR concept views *managerial practice, skills and competencies* in a particular way. As opposed to normative/rational perspectives and majority of processual, strategic choice, learning organizations, and knowledge management theories, which take the methodological position of "the objective observer where the manager stands outside the organization understood as a system and thinks in terms of controlling it" (Stacey, 2003, p. 414), the complex responsive processes perspective takes the following position: The manager is assumed to him/herself be a participant in these processes of relating, continuously engaged in "emergent enquiry into what they are doing and what steps they should take next" (Stacey), and reflexive in thinking about the nature of their own complex processes of relating in their local situation. What Stacey has proposed within the concept of complex responsive processes is that the agency lies simultaneously with individuals and the group because they form and they are formed by each other through self-organizing experiences of relating. Even the most powerful individual, Stacey claims, is a participant in human interaction.

New Directions for Research

The implications of this different "lens" through which to examine what happens when people work together on a project team, are that new insights could appear in particular in connection with three aspects of project management, namely human action, radical unpredictability, anxiety, and inseparability of thinking and action; organizing, power, identity, and structure/agency relationship; and managerial practice, skills and competencies (Cicmil, Cooke-Davies, Crawford, & Richardson, 2006).

Human Action, Radical Unpredictability, Anxiety, and Inseparability of Thinking and Action

If we adopt the perspective of complex responsive processes of relating, then project arrangements and settings can be seen as a particular kind of pattern of interaction between people. Two qualities of such interaction are emphasized as follows: (1) interaction is always communication and communication always takes place in the medium of symbols, where symbols, including vocal symbols of language, are tools created, reproduced, and transformed in that interaction; and (2) patterns of interaction between human bodies is always power-relating because, in relating to each other people, are always simultaneously constraining and enabling each other's actions. Therefore, project structures and forms of work, including any kind of design tools and plans for project-based organizing, must be seen as forming and simultaneously being formed in the process of interaction between people, through a thematic patterning of conversational themes.

This approach sheds new light on how we might understand what goes on in the context of projects, which are conventionally seen in systemic terms, where there is a dual relationship between, on the one hand, formative unfolding of the envisaged design toward some pre-given motivation such as a project goal, and on the other hand, rationalist individual choice of action. If organizations are continually iterated, self-organizing processes of relating, and if strategic direction and future goals are continually emerging, reflecting evolving collective and individual identities, the question becomes what happens to project control and what the role of project manager/leader is. This is also relevant to the debate about project failure/success outlined earlier. The implication of this perspective to understanding project arrangements is that projects are not structures but social arrangements that have structural properties that actors draw upon in their social interaction. The concept of CRPR refocuses attention on the reflexive monitoring of interaction by agents/actors, and the radical unpredictability and uncontrollability of the outcomes of action and intersubjective relating (Cicmil, 2006; Cicmil, Williams, Thomas, & Hodgson, 2006).

On Organizing, Power, Identity, and Structure/Agency Relationship

From this perspective, projects are seen as processes of continuous reproduction and transformation in the ongoing communicative interaction between people in the present, both their former members and people in other organizations. Themes and conversational patterns of relating form, and are simultaneously being formed by, power relations in project settings. Power is therefore located in the processes of conversation that are the processes of relating, rather than in one individual (project manager, line manager, senior manager) or a group of stakeholders (the parent organization, executive board, suppliers, the client) who somehow manipulate or dominate others. As a consequence of differentiating between those who are "in" from those who are "out," certain frameworks of talking are often legitimized and prevail (Cicmil & Marshall, 2005).

Conceptually, it is possible to explain how actors create the arrangements labeled "project" as both the medium and the outcome of their social practices. The concept of CRPR acknowledges the role of *power relations, artifacts,* and *feelings* in the process of construction and reproduction of social structures and action. Project working then can be viewed as an evolving pattern of individual and collective identities emerging in the ordinary, everyday local interaction and conversations between people. In comparison with more mainstream approaches to projects and project-based organizing (discussed earlier), attention here is refocused on the importance of local communicative interaction in the present, "particularly its thematic patterning, its gesture-response structure and its reflection in ideologies and power relations" (Stacey, 2003, p. 404).

On Managerial Practice, Skills, and Competencies

Resonating Baets's (2006, p. xxiv) view, the concept of CRPR refocuses attention from *management* of *project complexity to management in complexity.* The authors' study and argument for CRPR as a theoretical lens and interpretative framework in project management research has an important mission: to inform and influence practice by encouraging practicing project managers to pay attention to quality of the patterns of conversations and relating and their own participation in these processes; to learn how to live with anxiety (their own and that of others); to cope reflectively with the paradox of being and not being in control of the project and still enabling joint action to move the things on and accomplish a cooperative sophisticated activity labeled "project" (Cicmil, 2006; Cicmil et al., 2006).

In contrast to the two pervasive assumptions within the project management mainstream (plannable content and disciplined control), Stacey (2001, 2003) argued for a view that organizations exist in order to enable people to accomplish the *joint action* required for human living.

> … and it is in such responsive processes of relating that human beings accomplish joint action of any kind. The key feature of all human groups, organisations, institutions and societies is this joint action. Joint action is only possible because complex responsive processes of relating are patterned in coherent, that is, meaningful, ways (Stacey, 2003, p. 389).

Intentional goal-oriented actions emerge in the conversations of practitioners, managers and non-managers alike, at a local level, and those conversations function as patterning, meaning making processes. One of the key management skills can therefore be seen as "courage to carry on creatively despite not knowing and not being in control, with all the anxiety that this brings" (Stacey, 2003, p. 393).

This concept provides some important propositions related to management knowledge and competencies, which refocus attention away from managerial intervention "from outside" promoted by the conventional body of project management knowledge toward the following (Cooke-Davies & Cicmil, 2005):

- The ability of practitioners to engage in these processes of conversational and power relating, and reflexivity in thinking about one's own complex processes of relating with others in project situations
- Sensitivity to qualities of conversational life—to themes that form, and are simultaneously being formed by, power-relating; the ability to enable "free-flowing conversation" (breaking the stuck patterns of intersubjective relating in the local context) in order to create a scope for novelty and change to emerge
- Adequate holding of anxiety in coping with unpredictability and paradox of outcomes of individual and group complex conversational relating
- Ethical and moral concerns about actions, both intuitive and logical, taken while "thinking on one's feet" and simultaneously "knowing" and "not knowing," "being" and "not being" in control.

The authors of this paper are currently engaged in just such a program of research, and look forward to being able to report their findings in this journal at a future date.

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