Toward a Science of Qualities in Organizations

Lessons from Complexity Theory and Postmodern Biology*

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Abstract: *The development of complexity theory in the natural sciences is described, and summarized in six principles of complex emergent wholes. It is suggested that complexity theory is leading biology toward a science of qualities based on participation and intuition. It is argued on metaphorical and epistemological grounds that these principles which describe the emergence of complex wholes can be applied to social and organizational life. The six principles are then applied to qualitative and action research practice, with a particular reference to co-operative inquiry, in order to provide principles for good practice and theoretical support for the nature of valid inquiry processes.*

Key words: *complexity theory, postmodern biology, management science, quality.*

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Introduction

In this paper we outline the bases of complexity theory and review some of its applications in the natural sciences, particularly in biology. We suggest that this line of thinking, particularly as it has developed in postmodern biology, leads us toward a 'science of qualities' based on participation and intuition, and that there are remarkable similarities to the kinds of knowing which are seen as central in constructionist and participatory approaches to social and organizational life. We continue to argue that social life in general, and organizations in particular, can well be seen as complex self-organizing systems, and that drawing on complexity theory to explain them, while necessarily metaphorical, is epistemologically justifiable. We then apply the six principles to complexity theory to the practice of qualitative and participative forms of organizational research, and argue that these principles lead us toward new ways of thinking about the quality of a research endeavor.

Limitations of the control paradigm

Reductionist science is essentially a strategy of divide and conquer: dividing the world into constituent systems whose parts are simple enough to allow prediction of their behavior, and hence to exert control over their activity. This has worked remarkably well in many physical systems and even, to some extent, in biology. The approach exemplifies the principle that can be described metaphorically as linear thinking, which regards a whole as no more than the sum of its parts. Manipulation of the parts then results in control over the whole.

The limitations of this approach are becoming ever more apparent as we struggle to grasp the inherent complexities of organisms and ecosystems, organizations and societies, and patterns of global ecological change. Gregory Bateson was one of the first to point to the epistemological errors that arose when linear thinking is applied to the natural world, showing how conscious purpose creates errors since it abstracts small arcs of complex ecological circuits. He argued that "the most important task today … is to learn to think in the new way" (Bateson 1972: 462), and stressed the importance of appreciating the intricate networks of information and action "the circuits of mind" that characterize the living realm.

A systematic foundation of such an alternative method of studying complex systems has been developing for nearly a century. It started with the forays by Henri Poincaré, the great French mathematician and physicist, into the roots of chaos in something as apparently predictable as planetary motion. Towards the end of the last century, he applied the classical Newtonian theory of gravitational attraction to the movements of three bodies simultaneously, such as the Sun, Earth, and Moon, and observed that the equations gave rise to very strange dynamic behavior that seemed to carry a distinct, though obscure and unfamiliar, signature: it appeared that even a simple system of three bodies in space is not fully predictable in its behavior. It was not until the early 1960s that the details of this distinctive pattern were characterized. Edward Lorentz, a meteorologist at the Massachusetts Institute of Technology, working on equations that describe the dynamics of the weather, found the same behavior that Poincaré had. He had the advantage of a computer which showed him a picture of the dynamic behavior. Using Poincaré's method of studying nonlinear systems, he saw a new and beautiful mathematical object: a strange attractor (Figure 1) (Lorentz 1963, 1991).

Lorentz realized that he was dealing with a radically new type of behavior pattern whose properties led him to an immediately graspable metaphor: a butterfly flapping its wings in Iowa could lead, via the strange dynamics of the weather, to a typhoon in Indonesia. Stated in another way, very small changes in initial conditions in the weather system can lead to unpredictable consequences, even though everything in the system is causally connected in a perfectly deterministic way. The way this works in relation to the figure is as follows. Suppose you choose any point on the tangled curve in Figure 1 as the starting point, corresponding to some state of the weather. This will develop in a perfectly well-defined, though complex, manner, by following the curve from the (arbitrary) starting point in one direction, which is prescribed by the equations. Every successive state is clearly defined — i.e. everything is perfectly deterministic, since this is what dynamical equations describe. However, suppose there is a small disturbance that shifts the weather to a neighboring part of the system, to a point on a nearby part of the tangled curve. Then, comparing the state of the initial weather system with that of the disturbed system as they both develop along the curve, a basic property of the strange attractor is that they move away from each other exponentially fast. That is, knowing what the weather is now is no predictor of what it will be a couple of days hence, because tiny disturbances (the butterfly effect) can produce exponentially divergent behavior. This is the signature of deterministic chaos, now identified in a great diversity of mathematical equations whose dynamic properties are described by strange attractors.

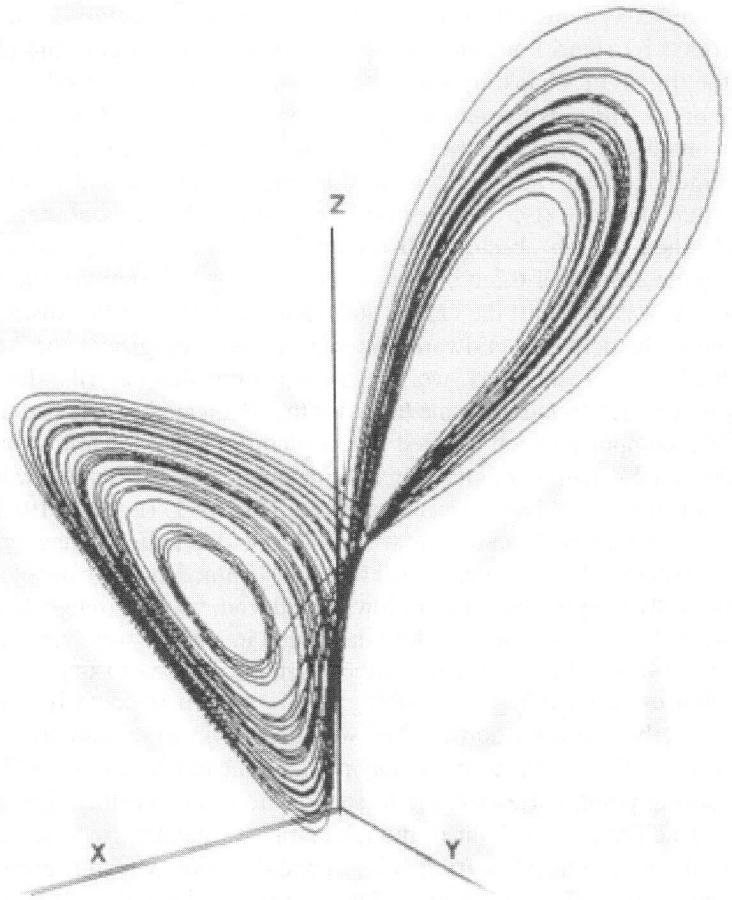

Figure 1.

The consequences of this mathematical discovery are enormous. Since most natural processes are at least as complex as the weather, the world is fundamentally unpredictable in the sense that small changes can lead to unforeseeable results. This means the end of scientific certainty, which is a property of 'simple' systems (the ones we use for most of our artefacts such as electric lights, motors, and electronic devices, including computers). More complex systems, and particularly living ones such as organisms, ecological systems and societies, are radically unpredictable in their behavior, as we all know from experience. But now we have a precise hypothesis about what may underlie this complexity: they may all live dynamically on strange attractors, or similar types of intelligible order governed by sensitivity to initial conditions, obeying dynamic rules that make it impossible to predict or control their behavior.

This is where another aspect of the complexity story enters. A typhoon may well be the unforeseen consequence of the butterfly innocently seeking nectar from the flowers growing in the fields of Iowa. But a typhoon is not itself a chaotic weather pattern: it has a highly organized dynamic structure with well understood behavior. Where does this order come from? It emerges from the intrinsic properties of the weather as a dynamic system (not included in Figure 1, which is a greatly simplified picture despite its own complexity). That is to say, a typhoon is one of the (relatively few) patterns that the weather system can generate. So there is something about the dynamics of the weather that combines both order and chaos. They live together. Although we cannot predict what will be the consequences of a small disturbance, we do know that one of a limited set of possibilities will follow — a typhoon, a high pressure region with sunny skies, a low pressure front with rain, and so on — a large but not indefinite set of possible patterns. The weather unfolds in irregular cycles of varying duration. This is a signature of complexity.

Life at the edge of chaos

These basic insights into the dynamics of complex, nonlinear processes have now been applied to a great diversity of phenomena, particularly in biological evolution. They raise doubts about Darwin's fundamental insight into the origins and extinctions of species, the processes of macroevolution (Goodwin 1994), though it is universally acknowledged that the Darwinian mechanisms of adaptive change are fundamental to micro-evolution, the small-scale modifications whereby organisms become better adapted to their habitats. In the Darwinian perspective, what drives evolution is competition for scarce resources between organisms that differ from one another in their 'fitness', their capacity to leave offspring. The survivors of this struggle are the better adapted, those that can function better in their environment. However, the evidence from studies of species emergence and extinction during past geological ages and from models that simulate these processes, is that species do not go extinct because of failure to adapt to changing circumstances, or because of cataclysmic events such a meteorite impacts or volcanic eruptions. Although these have undoubtedly contributed to the disappearance of the dinosaurs, for example, it appears that there is an intrinsic dynamic in complex systems, such as interacting species in ecosystems, which results in intermittent extinctions that vary from small to large, with a characteristic distribution, which occur independently of the sizes of external perturbations. Meteorite impacts and large volcanic eruptions can certainly trigger major extinctions so that, as David Raup (1991) put it, species go extinct not because of bad genes but because of bad luck. However, there seems to be a natural dynamic to creative processes such as evolution that involves inevitable extinction with a characteristic pattern of survival that is not due to individual success or failure but to the interactive structure of complex processes (Solé *et al.* 1998). The type of attractor involved may be similar to what Bak and Snepen (1993) have described as self-organized criticality. The game of life, we might say, is cycles of creative emergence and extinction in which the reward is not long-term survival but simply transient expression of a coherent form, a revelation of a possible state of life which we call a species, whose value is intrinsic to its being. Life, it seems, is not to be measured by quantity of success but by quality of creative living.

Clearly the metaphors are shifting here from competition and survival to creative emergence and expression of appropriate novelty. These are not necessarily in conflict. In fact, they are united in another fundamental insight of complexity theory. While studying the dynamic behavior of cellular automata, which are particularly useful for modelling complex systems, Norman Packard and Chris Langton (see Waldrop 1992) had the intuition that the 'best' place for these systems to be in order to respond appropriately to a constantly changing world is at 'the edge of chaos'. Here order and disorder are combined in such a way that the system can readily dissolve inappropriate order and discover patterns that are appropriate to changing circumstances (Kauffman 1993, 1995). This fertile suggestion has been subject to severe criticism, as should any proposal that attempts to capture a generic property of a whole new class of systems. However, the basic idea that creative, adaptive systems are most likely to function best near the edge of chaos is proving to be a robust insight, despite the difficulty of pinning it down precisely (i.e. mathematically and logically). One of the consequences of living on the edge is precisely the curious dynamics mentioned above: intermittent waves of extinction sweep through the system. Thus even though a player adopts a game plan of not holding on too tenaciously to any working strategy so that it can be dissolved when circumstances change and a more appropriate order allowed to emerge, there is no guarantee that the new order will result in survival. Clearly no-one can predict and control such systems. However, there are ways of maximizing creativity, providing us with a postmodern paradigm of learning to participate in an unpredictable, but nevertheless intelligible, world.

Six principles of complexity

After this discussion of the general characteristics of the science of complexity, we focus on six principles that capture what we believe to describe the essence of this approach to the dynamics of complex processes and their emergent properties. There is as yet no general consensus on how to axiomatize this subject (see, e.g., Holland 1998), so that our characterization is in no sense canonical.

1. *Rich interconnections*

Complex systems are defined in terms of rich patterns of interconnections between diverse components (Kauffman 1993). We can contrast this with simple systems which can have many components, but they themselves, and their interconnections are simple and uniform. A gas, for example, can be made of billions of molecules but they are all the same and act in the same way. Hence the order that gases express, such as is described by the gas laws and transition to the liquid state at particular temperature and pressure, is well defined and their behavior is predictable. However, in complex systems a knowledge of the properties of the components is not sufficient to allow one to predict the novel order that will emerge. There are two reasons for this. First, as mentioned above, knowing the present state does not allow one to predict future behavior, as in the weather; and second, the whole system has self-organizing properties that transcend the properties of its parts, a feature that arises from nonlinearity. This is why reductionism fails in complex systems (Cohen and Stewart 1995).

2. *Iteration*

Complexity theory describes novel, emergent form and behavior as arising through cycles of iteration in which a pattern of activity, defined by rules or regularities (constraints), is repeated over and over again, giving rise to coherent order. The order arises as a rich network of interacting elements is built up through the iterative process and the consequences of the process emerge.

A well-known example is the Mandelbrot set, a complex spatial pattern in which complex order emerges from an iteration procedure on a simple mathematical equation (Mandelbrot 1982). The iteration involves using the result of each calculation on a simple mathematical equation as the initial value for the next calculation. This gives rise to a sequence of points that define an unfolding spatial pattern. The complex potential of simple rules emerges through iteration. Instead of focussing on solutions which converge on a particular state, which are the classical attractors of dynamical systems, computers facilitate the exploration of convergent and divergent states at the same time and map them systematically in relation to each other. This results in the identification and characterization of fractal patterns and the visualization of strange attractors, such as the Lorentz attractor (Lorentz 1963), which simultaneously describe convergent and divergent motion.

3. *Emergence*

The order that emerges in a complex system is not predictable from the characteristics of the interconnected components and can be discovered only by operating the iterative cycle, despite the fact that the emergent whole is in some sense contained within the dynamic relationships of the generating parts. A simple example of this is the emergence of a rhythmic cycle of activity-inactivity in ant colonies from chaotic individuals. Experimental studies (Cole 1991) revealed that individual ants of the genus *Leptothorax* have a chaotic pattern in their transitions from activity (movement) to inactivity (no observed movement). However, when there are enough individuals within a confined space (i.e. a sufficiently high density), the whole group develops a rhythmic pattern with a cycling time of about 25 minutes from activity to inactivity and back, as is observed in the brood chambers of species of these ants (Franks and Bryant 1987). From the observation of individual behavior it is clearly not possible to predict that a colony could have a rhythmic pattern, even if one adds the observation that an active individual stimulates an inactive one into movement. To show that chaotic individuals plus excitation can generate a rhythm, it is necessary to model the process, as was done by Miramontes *et al.* (1993). The model colonies showed the same behavior as the real ants, with a rhythmic cycle of activity-inactivity emerging over the colony as a whole at a critical density of the population. The whole system was governed by simple rules defining the chaotic behavior of individuals and their interaction, and the process is iterated to find out what patterns emerge.

4. Holism

Emergent order is holistic in the sense that it is a consequence of the interactions between the component elements of the system and is not coded in or determined by the properties of a privileged set of components. A familiar example that comes from biology is the use of cuttings to propagate plants. These can be taken from shoots or roots — any part that is growing has the potential to develop into a whole plant. We see that there is no privileged part of the organism that has the instructions to make a whole from a part. What has this power is the dynamic relationships that characterize the living being, which has the potential for emergent order. This is a condition of dynamic organization; it is not a set of preordained instructions. The order that emerges can have different degrees of stability, or robustness. In biology there are certain patterns that are extremely stable and have persisted for many millions of years despite continuous extinctions of species that manifest these patterns. Plants again provide a striking example. Although there are currently some 250,000 species of flowering plant, there are only three ways in which the leaves are arranged up the stem. They either have a spiral pattern (the majority), as in ivy; or a whorl of two or more leaves at a node whose position rotates up the stem so that leaves at successive nodes are located over the gaps between leaves in the previous whorl, as in fuchsia; or, finally, single leaves that are located on opposite sides as they ascend the stem, as in maize. These are very robust patterns with some fascinating mathematical features describing them, and there are many other examples in biology (see Goodwin 1994). However, there are also less robust patterns, such as the forms of many fungi and lichens, which are very responsive to environmental conditions and so do not have any stable shapes, rather like clouds.

5. Fluctuations

Complex systems in their chaotic state have a distinctive pattern to the fluctuations in the variables. However, this pattern changes as order begins to emerge from chaos. Considering again the case of the ant colony, when there is a low density of ants and they are behaving chaotically, most of the fluctuations in activity involve few ants. However, as the critical density for the emergence of order is approached, transient patterns of activity arise that involve many ants and the fluctuations extend over the whole space of the colony. This is a sign that the collection of chaotic individuals is beginning to become a higher-order unit, a 'superorganism'. As the density increases further, these large-scale transient fluctuations become organized into rhythmic activity patterns with waves that propagate throughout the colony.

Of course the transition can equally well go the other way, from order to chaos, as density decreases in the colony. Then the pattern is from initial organization over the whole colony, which breaks down through large-scale fluctuations to chaotic patterns of individuals, with pockets of local order in small groups.

6. *Edge of chaos*

Emergent processes occur in a region of dynamic space described as the 'edge of chaos' at which there is a mixture of nascent order and chaos, as described above. This region of the dynamic spectrum has a rich and distinctive pattern of fluctuations which can be seen as transient manifestations of the pattern that emerges when parameters (such as the density of ants, above) change such that there is a transition to relatively stable expression of the order. If the system moves far into the ordered regime, particular dynamic patterns may become firmly established and there is a loss of capacity to respond flexibly to an unpredictably changing environment. Detailed studies of the behavior of the human heart as recorded in electrocardiograms have revealed that, within the stable mean heart rate of a healthy subject, there is a complex pattern of variability between heartbeats with a signature similar to that of chaos (Peng *et al.* 1995; Ivanov *et al.* 1996). Individuals with cardiac disorders such as arrhythmias often have an ordered pattern of variation between heartbeats. This somewhat paradoxical phenomenon of disease manifesting dynamically as 'too much order' is interpreted as a loss of capacity in the heart to respond flexibly to the unpredictable demands of the body. Senescence is also accompanied by reduced intrinsic variability or flexibility of physiological variables (Lipsitz 1995). It is recognised that too much chaos or disorder is equally malfunctional in complex systems.

These observations are generalized to mean that complex adaptive systems perform best when their order is not far from the transition to chaos so that their dynamic patterns are both robust and flexibly responsive to context. Furthermore, in evolving systems it is necessary for inappropriate order to be dissolved and replaced by more adaptive behavior as circumstances change. System behavior located not far from the transition to chaos is then seen as the 'best' place to be in an uncertain and unpredictably changing world (Kauffman 1995).

From quantity to quality: Intuition and a science of qualities

The science of complexity takes us to the threshold of a new relationship with the complex processes that define the context of our lives: the weather, the ecological systems on which we depend for clean air and food, and the social systems, organizations and economies within which we live and which we try to manage. These all appear to fall outside the realm of control and manipulation of the type that is possible with mechanical systems (clocks, cars, computers). However, these types of complex processes are not without their own subtle expressions of order. The collective patterns of ordered activity observed in ecosystems, in colonies of social insects and in human society, can be understood and described as emergent properties of complex systems, arising from the activities and interactions of the component individuals, though not reducible to these. The science of complexity has its focus on the study of these emergent properties, which are intelligible as consistent manifestations of principles of organization that characterize the systems, but are not reducible to the properties of their component parts.

The question that then arises is how we can best relate to these systems with their subtle emergent order. We cannot control them through manipulation of their parts to achieve predictable, desired results; but we do influence them, for better or for worse. One of the major constraints on conventional science that limits the ability to gain insight into the realm of complex phenomena is the restriction of data to quantifiable, measurable aspects of natural phenomena. These are the primary qualities of things, as described by Galileo, such as mass, position, velocity, momentum, and so on. The qualities are considered to be the only reliable source of scientific information about the world. Secondary qualities — the experience of color, odor, texture, aesthetic pleasure in beholding a deer or a landscape — are not taken to be reliable indicators of 'objective' nature. However, there is no intrinsic reason why this constraint should be accepted. What is required in a science is some methodology whereby practising subjects come to agreement on their observations and experiences. This is the basis of quantitative measurement: acceptance of a method whereby different practitioners can reach intersubjective consensus on their results. Where there is no consensus there is no 'objective' scientific truth.

Why should this not be extended to the observation and experience of 'secondary' qualities? In fact, this extension is practised in the healing professions, whether conventional Western medical practice or complementary therapeutic traditions. The presenting subject's experience of pain and its qualities are certainly used in diagnostic practice; and so are many other qualities such as color and texture of skin, posture, tone of voice, etc. Paying close attention to these, as well as to quantitative data such as temperature, pulse, and blood pressure, is a significant part of the art of diagnosis. Conventional wisdom accepts that these skills can only be acquired through practice and experience, which hones the intuitive faculty to perceive reliably the underlying condition that is the cause of change from health to disease. Health is in fact an emergent property that cannot be reduced to the sum of quantitative data about different aspects of the body. Its perception requires the healer to pay attention to qualities as well as quantities, and to make use of the intuition in coming to a holistic judgement about the condition presented.

Conventional scientists begin to get very nervous when this type of procedure is described as science. They are suspicious of the intuition, and they mistrust qualitative observation. As far as the intuition is concerned, they need have no anxieties: it is a universally recognised subjective component of scientific discovery. It is the intuitive faculty that makes sense of diverse data and brings them into a coherent pattern of meaning and intelligibility, though of course the analytical intellect is also involved in sorting out the logic of the intuitive insight. What is not practised in science is the systematic cultivation of the intuitive faculty, the capacity to recognize the coherent wholes that emerge from related parts. However, the study of emergent properties in the science of complexity clearly requires use of the intuition in high degree. It is what is required to perceive the subtle order that characterizes the holistic properties of complex systems — ecosystems, social systems, health. Furthermore, these emergent properties are closely associated with 'secondary' qualities. The health of an ecosystem is reflected in the quality of birdsong as well as in the (quantitative) diversity of species. However, scientists are trained to pay attention only to quantities. As people and as naturalists they are aware of qualities, which are often the primary indicators of change. But as scientists they factor them out of their consciousness. This restriction is based on a convention that has worked extremely well for 'simple' systems, but it has severe limitations in the face of complexity. It is time for the move into a science of qualities.

A science of qualities is not new in the Western tradition. This is the science that was practised by Johann Wolfgang von Goethe in the late 18th and early 19th century. Regarded for many years as an aberration because of an apparent conflict with Newtonian science, Goethe's studies have been largely ignored within mainstream science. However, it is now evident that Goethe's approach to natural processes is not so much in direct conflict with the dominant science of quantities as different from it (cf. Bortoft 1996). In Goethe's study of color, for example, which is where he ran into trouble for challenging Newton's color theory, an explicit goal is to understand not simply the conditions under which various colors emerge, but also to relate this to the experience we have of different colors, i.e., their qualia. The assumption is that our feelings in response to natural processes are not arbitrary but can be used as reliable indicators of the nature of the real processes in which we participate. Qualities include the realm of the normative, our assessment of the rightness or wrongness, appropriateness or inappropriateness, of particular actions in relation to our knowledge. A science of emergent qualities involves a break with the positivist tradition that separates facts and values and a re-establishment of a foundation for a naturalistic ethics (Collier 1994).

Participation now enters as a fundamental ingredient in the human experience of any phenomenon, which arises out of the encounter between two real processes that are distinct but not separable: the human process of becoming and that of the 'other', whatever this may be to which the human is attending. In this encounter wherein the phenomenon is generated, feelings and intuitions are not arbitrary, idiosyncratic accompaniments but direct indicators of the nature of the mutual process that occurs in the encounter. By paying attention to these, we gain insight into the emergent reality in which we participate. Of course there are idiosyncratic, personal components of the insight, just as there are idiosyncratic elements to the integrating theories that come with flashes of intuitive insight to individual scientists. These need to be distinguished from the more lasting and universal aspects of the insight, which is where the process of intersubjective testing comes in to find consensus amongst a group of practitioners. The same type of process is required to evaluate the insights gained from use of qualities of experience to understand the subtle order of complex systems.

The sensitivity of these systems to initial conditions means that we must be exquisitely careful and finely tuned to the process we seek to influence beneficially in order to monitor our effects, as in any healing process. This requires training that goes beyond what is cultivated in quantitative science. The additional components are the systematic cultivation of the intuition as a way of perceiving the integrity of healthy wholes and hence the capacity to see disturbances from health; and training in the ability to distinguish the idiosyncratic from the universal in the perception of qualities via intersubjective comparison. These are basic ingredients of a science of qualities. In a sense they are no more than a statement of what holistic practitioners have been engaged in. However, it is time to develop such a science systematically as an extension of quantitative science in a direction that is appropriate to the urgent needs of our age.

The social sciences have notoriously followed the physical sciences in attempts to identify and measure primary qualities, with arguably little success. In economics, for example, the focus on what can be measured, particularly Gross National Product, has led to what Daly and Cobb, drawing on Whitehead's philosophy, have called the "fallacy of misplaced concreteness" (Daly and Cobb 1990), so that we reify the constructs of our measurements as economic facts. Shotter makes a similar point, suggesting orthodox social sciences can lead to "misleading realism" (we explore Shotter's contribution below). In management science Mitroff has recently challenged the orthodox view by arguing that "truth is not solely a property of formal propositions", not, in our terms, based on the discovery of 'primary qualities', but is a "human activity that must be managed for human purposes": epistemology then becomes the "management of truth" (1998: 70). Writing about qualitative research, Lincoln and Guba (Lincoln and Guba 1985) have pointed out that all observations are theory laden, and so the search for such primary qualities is misguided.

Over recent years there have been many moves toward a science of qualities in social and management sciences, many of which can be seen as dimensions of an 'extended epistemology': there are ways of knowing other than the empirical and the rational which characterize traditional western science (Gergen 1994; Heron 1996, 1971). In particular, these various moves assert that knowing lies not so much in the mind of individual actors, but arises in relationship and through participation (Heron and Reason 1997): as Gergen asserts, not *cogito, ergo sum*, but *communicamus ergo sum* (Gergen 1994: viii).

Maybe most celebrated and acknowledged, although still not integrated with conventional research, is Polanyi (1962), who described clearly his concept of tacit knowledge, a type of embodied know-how that is the foundation of all cognitive action. He rejected the notion of the objective observer in science or any other area of inquiry, expressing his belief in engaged practice that necessarily joins facts and values in a participatory mode of understanding.

Writing more recently, Shotter argues that in addition to Gilbert Ryle's distinction between 'knowing that' and 'knowing how' there is a "kind of knowledge *one has only from within a social situation*, a group, or an institution, and thus takes into account "the *others* in the social situation" (Shotter 1993: 7, emphasis in original). It is significant that Shotter usually uses the verbal form '*knowing* of the third kind', to describe this, rather than the noun *knowledge*, emphasizing that such knowing is not a thing, to be discovered or created and stored up in journals, but rather arises in the process of living, in the voices of ordinary people in conversation.

Shotter draws on a social constructionist perspective, while Park (1999, forthcoming 2000), writing in the context of participatory research and drawing on the emancipatory traditions of Freire (1970), Habermas (1972) and others, has identified representational, relational and reflective forms of knowledge. Representational knowledge provides explanation through identifying the relationship between discreet variables; or understanding through interpretation of meaning. Relational knowledge is the foundation of community life and its development fosters community ties as well as helping create other forms of knowledge. Reflective knowledge has to do with normative states in social, economic and political realms, it concerns a vision of what ought to be, what is right and what is wrong, and arises, Park argues, through the process of consciousness raising, *conscientization*.

> Reflective knowledge ... instills conviction in the knower, and the courage to go with it, and commits him or her to action. (Park 1999)

Abram, drawing on the tradition of phenomenology, and in particular Merleau-Ponty's phenomenology of perception, shows how perception itself is based in relationship so that

> ... in so far as my hand knows hardness and softness, and my gaze knows the moon's light, it is as a certain way of linking up with the phenomena and communicating with it. Hardness and softness, roughness and smoothness, moonlight and sunlight, present themselves in our recollection not pre-eminently as sensory contents but as certain kinds of symbioses, certain ways the outside has of invading us and certain ways we have of meeting the invasion. (Merleau-Ponty 1962: 137)

We do not discover primary qualities but participate in relationship with qualia. As Abram has it, this means that there is

> underneath our literate abstractions, a deeply participatory relation to things and to the earth, a felt reciprocity .... (Abram 1996: 124)

From a feminist perspective, Belenky and her colleagues wrote of 'women's ways of knowing' (Belenky *et al.* 1986) which distinguished between connected and separated knowing: separated knowing adopting a more critical eye and playing a 'doubting game', while connected knowing starts with an empathic, receptive eye, entering the spirit of what is offered and seeking to understand from within. Feminist scholars generally have emphasized relational aspects of knowing (e.g. Bigwood 1993) and of the practice of management (Fletcher 1998; Marshall 1995).

Torbert — who builds on the foundations offered in Argyris' work (e.g. 1985), but has extended it considerably to draw on constructive developmental theory and the traditions of search for an integrative quality of awareness — describes the process of developmental action inquiry as addressing three questions: how to develop a quality of awareness that attends both to its origins and to action in the world; how to create communities of inquiry; and how to act in a timely manner (Torbert forthcoming 1999). Torbert's work has emphasized the importance of a quality of attention which moment to moment is able to interpenetrate four territories of attention: an intuitive knowing of purposes, an intellectual knowing of strategy, an embodied, sensuous knowing of one's behavior, and an empirical knowing of the outside world. Action inquiry is thus described as

> an attention that spans and integrates the four territories of human experience. This attention is what seems, embraces, and corrects incongruities among mission, strategy, operations and outcomes. It is the source of the 'true sanity of natural awareness of the whole'. (Torbert 1991: 219)

Finally, we have argued (Reason 1994; Heron and Reason 1997; Reason and Torbert, in preparation) for a participative paradigm for inquiry in the social sciences, in which it can be seen that a knower participates in the known, articulates a world, in at least four interdependent ways: *experiential knowing*, in which we resonate with the presence of other, *presentational knowing*, which draws on aesthetic imagery, *propositional knowing* which draws on concepts and ideas, and *practical knowing*, which consummates the other forms of knowing in action in the world. We have defined co-operative inquiry as a systematic process of action and reflection in which co-inquirers cycle through this extended epistemology (See Table 1).

While all these descriptions of extended epistemologies differ in detail, they all go beyond orthodox empirical and rational Western views of knowing, and assert, in their different ways, that knowing starts from a relationship between self and other, through participation and intuition. They assert the importance of sensitivity and attunement in the moment of relationship; they assert the importance of knowing not just as an academic pursuit but as the everyday process of acting in relationship and creating meaning in our lives. They thus echo the 'science of qualities' to which the postmodern biology points, and invite us to consider how to establish an organizational science of qualities. But before we can do this, we need to consider in more detail the relevance of complexity theory to organizational life and human knowing.

Table 1.

Experiential knowing means direct encounter, face-to-face meeting: feeling and imaging the presence of some energy, entity, person, place, process or thing. It is knowing through participative, empathic resonance with a being, so that as knower I feel both attuned with it and distinct from it. It is also the creative shaping of a world through imaging it, perceptually and in other ways. Experiential knowing thus articulates reality through inner resonance with what there is.

Presentational knowing emerges from and is grounded on experiential knowing, clothing our encounter with the world in the metaphors of aesthetic creation. Presentational knowing draws on expressive forms of imagery, using the symbols of graphic, plastic, musical, vocal and verbal art-forms. These forms symbolize both our felt attunement with the world and the primary meaning embedded in our enactment of its appearing.

Propositional knowing is knowing in conceptual terms that something is the case; knowledge by description of some energy, entity, person, place, process or thing. It is expressed in statements and theories that come with the mastery of concepts and classes that language bestows. Propositions themselves are carried by presentational forms — the sounds or visual shapes of the spoken or written word — and are ultimately grounded in our experiential articulation of a world.

Practical knowing is knowing how to do something, demonstrated in a skill or competence. It presupposes a conceptual grasp of principles and standards of practice, presentational elegance, and experiential grounding in the situation within which the action occurs. It fulfills the three prior forms of knowing, brings them to fruition in purposive deeds, and consummates them with its autonomous celebration of excellent accomplishment.

Thus in co-operative inquiry, people collaborate to define the questions they wish to explore and the methodology for that exploration (propositional knowing); together or separately they apply this methodology in the world of their practice (practical knowing); which leads to new forms of encounter with their world (experiential knowing); and they find ways to represent this experience in significant patterns (presentational knowing) which feeds into a revised propositional understanding of the originating questions. Thus co-researchers engage together in cycling several times through the four forms of knowing in order to enrich their congruence and complementarity.

Organizations as complex wholes

Is it reasonable to apply theories which have their origins in the natural and biological sciences to social life and to organizations? And if we do so, are we simply employing metaphors, rather than making a sound epistemological argument? These are questions with which reviewers of an early version of this paper challenged us. We will first argue that metaphor lies at the basis of all theorizing, and go on to argue that there are sound reasons for arguing that organizational and social life can be understood as a complex system and that such a perspective, metaphorical or not, can be seen as what Gergen describes as 'generative theory'.

As Lakoff and Johnson argue

> metaphor is pervasive in everyday life, not just in language, but in thought and action. Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature. (Lakoff and Johnson 1980: 3)

Morgan builds on Lakoff and Johnson, on Pepper (1942) and others, to show how

> our theories and explanations of organizational life are based on metaphors that lead us to see and understand organizations in distinctive yet partial ways … [M]etaphor exerts a formative influence on science, on our language, and on how we think, as well as on how we express ourselves on a day-to-day basis. (Morgan 1986: 12–13)

So it would seem there is a good basis for arguing that metaphor is at the basis of all theory. Shotter takes this further, arguing that

> … our disciplined ways of knowing are founded, or 'rooted' in, and relevant to, rhetorically organized, two sided, everyday traditions of argumentation. (Shotter 1993: 1)

Shotter later asserts that we must be wary of knowledge formulated as system, for talk of systems leads to a "misleading realism", which suggests that "everything of importance is already in existence" and fails to acknowledge the ways in which relationships are "self-constructed" and "essentially unsystematizable" (p. 59). We should rather seek a "poetics of relationships, a way of talking that leaves their precise nature open" (p. 59), that allow for what he (quoting Ingold) describes as "the generative possibilities of the relational field …." (p. 61).

The question, then, is not whether in applying complexity theory to organizational and social life we are being metaphorical — it would seem that metaphor is unavoidable. The first question, rather, is whether we can 'see through' our metaphor (Hillman 1975), to use the metaphor rather than having it use us, so to speak, and avoid the trap of reifying our metaphor and applying it indiscriminately. As Skolimowski has pointed out, one of the tragedies of Western civilization has been the indiscriminate use of the machine metaphor. And a major contribution of the deconstructionist movement has been to demonstrate the unconscious way in which we employ metaphors such as growth and progress to underpin our worldview (Gergen 1994; Harvey 1990). And the second question is whether we can use metaphor in a creative and transformative way, to open new up realities and new resources:

> Concepts of human conduct operate much like tools for carrying our relationships. In this sense, the possibility of social change may be derived from new forms of intelligibility … I [have] proposed the term *generative theory* to refer to theoretical views that are lodged against or contradict the commonly accepted assumptions of the culture and open new vistas of intelligibility. (Gergen 1994: 60; emphasis in original)

So we argue that, while of course complexity theory is a metaphorical construct, it is a construct which is in Gergen's sense *generative* when applied to social life and to organizations, and we will continue to show that it draws our attention to particular qualities of postmodern inquiry which provide support for emerging approaches to organizational inquiry.

So we now turn to show how it is helpful to see social and organizational life as a complex, self-organizing process. Indeed, we have already hinted at this in drawing on Shotter's argument that relationships are self-constructive and have generative possibilities. Shotter argues that relationships take the form of 'joint action', in a zone of uncertainty somewhere between individual action and natural event:

> The most obvious circumstance in which joint action occurs is in dialogue with others, when one must respond by formulating appropriate utterances in reply to their utterances. What they have already said constitutes 'the situation on hand', so to speak, in which one must direct one's own reply. It is thus clear why, in such circumstances, we as individuals do not quite know why it is that we act as we do: rather than speaking 'out of' an inner plan … we speak 'into' a context not of our own making, that is, not under our own immediate control. Thus the formative influences shaping our actions are not there wholly within us, prior to our actions, available to be brought out ahead of time. (Shotter 1993: 4)

This seems to us to be a description of a complex self-organizing process which cannot be understood in linear terms ("not under own immediate control"), nor in terms of the properties of the parts (individuals) but rather unfolds with emergent relational order. No wonder Shotter argues that we need a *poetic*, where "the word 'poet' is derived from the Greek *poietes* = one who makes, a maker, and artificer" (Shotter 1993: 64). Our view that

Shotter's perspective is congruent with complexity theory is supported by his own references to Prigogine's account of dynamic structures

> created and maintained (by being continually reproduced) within a continuous but turbulent structuring processes .... (Shotter 1993: 66)

He goes on to say that a relationship cannot be conceived as constructed out of elementary particles:

> Whatever its 'elementary components' we can be sure they are in some sense relational, that is to say, they only exist as sensibly distinct, novel moments within an otherwise flowing totality. In other words, there is no point in thinking of relational fields and the nature of their 'generative potentials' as systematically ordered 'things', they are loci of activity. Although they have no specifiable form, they can be specified by their formative powers. (Shotter 1993: 67)

More generally, the constructionist perspective argues that our world, and our knowing of it are best seen as created rather than given:

> knowledge and truth are created, not discovered by mind.
> (Schwandt 1994: 125)

> The terms and forms by which we achieve understanding of the world and ourselves are social artifacts, products of historically and culturally situated interchanges among people. (Gergen 1994: 49)

In arguing for a participative paradigm for inquiry, we argued that human presence meets given reality through participating in its being, "in its experiential participation in what is present, in what there is" (Heron and Reason 1997: 277). Thus human knowing is rooted in experiential encounter with the world, and, while sharing with the constructionist perspective the view that our world is a creation that arises from the interaction of an unknowable given world and the human mind, we argue that constructionist writing does not attend sufficiently to this experiential dimension of knowing:

> ... the point about experiential knowing is that the very process of perceiving is also a meeting, a transaction, with what there is. When I hold your hand, my tactual imaging both subjectively shapes you and objectively meets you. To encounter being or a being is both to image it in my way and to know that it is there. To experience anything is to participate in it, and to participate is both to mould and to encounter, hence experiential reality is always subjective-objective. (Heron and Reason 1997: 278)

So we argue that since our world, and our knowing of it, can be seen from constructionist and participatory perspectives to be emergent and self-organizing, then the principles of complexity theory may well help illuminate the process.

Turning specifically to the use of complexity theory to account for organization, we can best draw on the work of Stacey and his colleagues at the Complexity and Management Centre at the University of Hertfordshire (Stacey 1992, 1995, 1996; for a broad range of contributions to this debate see also Business Process Research Centre 1998). Stacey argues that we should pay attention to complexity theory because

> organizations are nonlinear, network feedback systems and it therefore follows logically that the fundamental properties of such systems should apply to organizations. (Stacey 1995: 481)

Organizations will therefore be characterized by bounded instability and spontaneous self-organization and emergent order. Stacey continues to demonstrate the significance of this perspective for the study of organization, drawing on the theoretical strands very similar to those in the first sections of the present paper. He goes on to argue that if organizations are best understood as complex systems this has major implications for the approaches to inquiry:

> The reductionist approach of testing hypotheses about causality independently of each other assumes that the systems being studied are linear, or can be approximated to linear systems. From a complexity perspective, however, organizations are essentially nonlinear systems which cannot be approximated to any linear form and to be creative have to operate far from equilibrium — reductionist approaches to researching them are likely to produce seriously misleading conclusions. (Stacey 1995: 493)

Thus we argue that it is quite appropriate to apply complexity theory to an understanding of social and organizational forms and turn to consider the nature of a science of qualities in organizational research.

Toward a science of qualities in organizational research

In their magisterial introduction to the *Handbook of Qualitative Research*, Denzin and Lincoln (1994) identify a series of "moments" or "successive sets of new sensibilities" in the story of qualitative research, an account of the move from the clarity and unity of a positivist perspective rooted in a clear sense of northern world superiority, to current times of relativism, pluralism and constructivism. Their first moment is the 19th century colonial enterprise of understanding 'primitive people'; the second is the positivist mode which becomes the dominant approach to social science by the third quarter of the 20th century. After World War II, an 'interpretivist' mode emerges which is pluralistic, interpretive, and open ended, taking cultural representations and their *meanings* as being appropriate points of departure in the social sciences. Denzin and Lincoln suggest that in the present moment, a time of enormous ferment, scholar/practitioners committed to qualitative inquiry face the twin crises of *representation* and *legitimation*: "Is it possible to represent what our experience was in some way that we can characterize as having integrity and fidelity?" "If we cannot claim to create texts which are objective and wholly true, from where do we derive our authority and our legitimation as social scientists?" (Lincoln 1997: 7)

If this is true for qualitative research, it is even more true for participative forms of action research, for here scholar/practitioners are not primarily interested in producing texts, but in opening the possibility of transformative action through first-, second- and third-person research/practice (Gergen 1994; Reason and Torbert in preparation). The scientific merits of action research have been a contentious issue, debated for at least three decades since the celebrated Susman and Evered paper in *Administrative Science Quarterly* (1978), which we are addressing elsewhere (Reason and Torbert, in preparation). Here we wish to argue that the principles of complexity theory lead us toward a science of qualities in organizational and social research, just as it is beginning to do in the natural sciences. We will do this by drawing on the six dimensions of complexity theory discussed above and illustrate our argument by drawing in particular on our experience with the process of co-operative inquiry (Heron 1996; Reason 1998; Reason forthcoming; Reason and Heron 1995; Reason and Heron 1996).

Rich interconnections

The touchstone of a science of qualities is experiential, participative knowing, Shotter's 'knowing of the third kind' which arises through relational engagement: a deep and intimate sense of connection is sought with the phenomena being studied. While this can be approached through observation, interviews and other forms of qualitative data gathering, rich interconnections are most fully developed through participative inquiry in which the object of inquiry is experience and action within one's own life world in collaboration with one's peers. For example, in co-operative inquiry all those engaged in the inquiry venture work together as co-researchers, contributing both to the ideas that form the basis of the inquiry, and to the action which is its focus; they explore their own and each others' experience and action through a sustained process of inquiry, typically meeting over several months, allowing experiential contact to develop at many different levels (see Heron (1996) for a full description of co-operative inquiry). This inquiry process brings about an intimate and critical encounter with the phenomena being explored, producing a rich sense of experiential knowing: what gestalt practitioners would describe as good contact (Herman and Korenich 1977), opening to the presence of the experience.

High quality research/practice also requires rich interconnections among those involved in the inquiry, whether they be the co-researchers of a co-operative or appreciative inquiry (Cooperrider and Srivastva 1987), the community engaged in participatory research (Fals-Borda and Rahman 1991), insider/outsider relationship (Louis and Bartunek 1992). Co-researchers can provide each other with support and encouragement; they can challenge blind spots and defensiveness both in individuals and in the culture of the group. Beyond this the group can provide a living container for the emergence of new order, new ideas and new practice. For a dynamic culture of inquiry, with diversity of viewpoint and complex internal communication, can be seen as having the qualities of an 'excitable medium', a term complexity theorists (Goodwin 1994) use to describe the capacity of a system to generate pattern spontaneously. Complex, nonlinear interactions result in a dynamic field which is self-organizing. An inquiry group exhibiting the qualities of an excitable medium will find new patterns emerging from its own dynamics, which will involve a mixture of order and chaos of the type which is described above as 'living at the edge of chaos'.

This argument for high quality connections is of course in contrast to some forms of qualitative research, in which contact is made only through interview or relatively distant observation, and certainly in contrast to those forms of quantitative research in which contact is made only through pre-determined measurements. In our view, it is not possible to conduct a science of qualities except from a place of rich mutual engagement, a place which opens the inquiry community to experiential, tacit knowing. This invites imaginative representation, if possible through multiple media, so that the richness of experiential contact is articulated and its potential meanings explored. It invites creative and challenging use of ideas and theories, with speculative theory building which nevertheless remains close to the experience. And it leads toward bold and original practice, taking novel experimental action into the field of practice with courage and commitment. Complexity theory suggests to us that these rich interconnections are not simply a way of logically saturating our data in order to confirm that data represent the phenomena being studied, as theorists of qualitative research would argue (Glaser and Strauss 1967; Lincoln and Guba 1985); they are the very ground from which new order may emerge.

Iteration

As Shotter argues, the form of relationship emerges over time through the process of action and interaction; and as we described above, complexity theory describes how novel form arises through cycles of iteration in which a pattern of activity is repeated, giving rise to coherent order.

Applying these ideas to the process of group development shows how unique and complex form emerges from very simple principles. Many theories of group development trace a series of phases of development in the life of a group. Early concerns are for inclusion and membership. When and if these needs are adequately satisfied the group focuses on concerns for power and influence. And if these are successfully negotiated they give way to concerns for intimacy and diversity in which flexible and tolerant relationships enable individuals to realize their own identity and the group to be effective in relation to its task (see for example Srivastva *et al.* 1997). This phase progression model of group behavior — in which the group's primary concern moves from issues of inclusion to control to intimacy (which the Srivastva paper bases on Schutz' (1958) original formulation), or from forming to norming to storming to performing (Tuckman 1965); or from nurturing to energizing to relaxing (Randall and Southgate 1980) — is easy to express in propositional terms. But however accurate this may be as a statement of the parameters within which group life unfolds, each actual group unfolds these processes in its own particular fashion. Every group becomes a unique product of human interaction which is impossible to fully describe, not simply because the map is not the territory, but because the territory is in a continual process of emergence. Each group evolves a rich originality while conforming in principle to the same pattern, analogous to a Mandelbrot set (although far more complex).

Many descriptions of qualitative and action-oriented research methods describe an iterative cycle of data-gathering and sense-making, or of action and reflection. Lewin first described the process of action research in the 1940s as a cycle of planning, action, and evaluating. Glaser and Strauss' (1967) articulation of grounded theory describes a constant comparative method of moving between data gathering and theory generation, and Lincoln and Guba (1985) place a cycle of purposive sampling, inductive data analysis, grounded theory, and emergent design at the center of their description of naturalistic inquiry. Recently, Greenwood and Levin (1998) have taken the argument forward, pointing out that the physical and natural sciences take the form of a highly iterative and dynamic activity involving repeated action–reflection–action cycles in which thought and action cycle around each other repeatedly.

The iterative process is also central to the work of a co-operative inquiry group: the inquiry process cycles through phases of action and reflection — or more accurately between phases of experiential, presentational, propositional and practical forms of knowing — in which the same realm of experience is visited on several occasions. The group may choose convergent cycling, in which one aspect of experience is explored in increasing depth over several cycles; or divergent cycling so that different aspects of experience are explored and the group can see particular experience in a wider context; or both. Through convergent cycling the co-researchers are checking and rechecking their discoveries with more and closer attention to detail. Through divergent cycling they affirm the values of heterogeneity and creativity that come with taking many different perspectives, and they acquire a systemic view of the phenomena.

As we learn from complexity theory, convergence and divergence together contribute to the building of a fractal structure, which is a mathematical description of the rich complex wholes we see both in the natural world and, as we suggest above, in social processes such as groups. The iterative process of research cycling moves people away from linear cause-and-effect thinking into a cyclical, ecological mode, which in some sense in which this reconnects people with what Bateson (1972) would describe as the circuits of Mind rather than the arcs of conscious purpose. Our understanding of the world becomes more complex, interconnected and holistic: poetic, as Shotter (1993) might describe it, rather than systematic.

In this way, a science of qualities elaborates the pattern in both its uniqueness and its generality. The orthodox distinction between emic and etic research is superseded in that the single case contains the general as iteration proceeds. Complexity theory provides some support for Carl Rogers' intuition, of many years ago, that when you travel to the unique heart of a person you find yourself in the presence of eternal truth. As you peel off layer after layer, every aspect of the uniqueness is expressing the core, and one can learn both to appreciate the principle while honoring its unique manifestation. From this perspective, a reductionist approach to inquiry which starts from establishing linear causal propositions is clearly inadequate. In particular, we need to move away from prediction, and move to an exploration of emergence.

Emergence

The order of a complex system is not predictable from the characteristics of the interconnected components nor from any design blueprint, but can be discovered only by operating the iterative cycle, despite the fact that the emergent whole is in some sense contained within the dynamic relationships of the generating parts. In a science of qualities, the interactive process, given rich interconnections and deep engagement, will lead to emergent order. A science of qualities, as a form of bounded instability, is radically unpredictable. As Lincoln and Guba put it

> … within the naturalistic paradigm, designs must be emergent rather that preordiate: because meaning is determined by context to such a great extent; because the existence of multiple realities constrains the development of a design based on only one (the investigator's) construction; because what will be learned at a site is always dependent on the interaction between investigator and context, and the interaction is not fully predictable; and because the nature of mutual shapings cannot be known until they are witnessed. All these factors underscore the indeterminacy under which the naturalistic inquirer function. The design must therefore … unfold, cascade, roll, emerge. (Lincoln and Guba 1985: 208–209)

The principle of emergence is similarly central to co-operative inquiry. It is not possible to 'set up' a co-operative inquiry and expect it to work in a particular way; rather the form of the inquiry process emerges in response to the particular people involved and focus of inquiry, the context, and so on. Just as the rhythm of the ant colony emerges through the interaction of its members, and the pattern of a Madelbrot set emerges through iteration with divergence and converge, so the process of co-operative inquiry emerges over time. The knowing is in the active, iterative process of co-creating a world through aware action, not in a goal or outside purpose.

It also appears from experience that the precise focus of inquiry can only emerge through the process of iterative inquiry cycles. An inquiry may be launched with a particular set of concerns and interests that the participants wish to explore. They may think they know exactly what they want to find out, or they may know that their interests lie within a general area. But the actual outcome arises from the unpredictable emergent process of the group and of the inquiry cycles. It is not possible to *set up* a co-operative inquiry group with a specified goal; it is only possible to *facilitate its emergence*. This means establishing an iterative process, nurturing a deep experiential engagement with the issues to be explored and allowing the pattern of inquiry activity to emerge. This is so very different from the experimental method in which the whole point is to keep experimenter control of the whole experimental activity, isolated from influences of the wider environment. To put it more prosaically, in co-operative inquiry you throw the issues of concern into the pot of human being, making sure that there is an iterative process with rich interconnections, and the particular unique inquiry will emerge (for better or for worse, we might add, for it is in principle impossible to predict whether any particular inquiry process will be 'successful' or not).

Holism

The principle of holism argues that there are no privileged parts, no primary causes, no blueprint which defines the emergent order. A significant outcome of a science of qualities can be seen as 'living theory' (Reason 1996; Whitehead 1989; for examples see Bravette 1997; Laidlaw 1996) which guides and illuminates action. Such theory provides understanding in terms of a dynamic pattern of relationships which connects aspects of practice, rather than a hierarchical cause and effect explanation. Toulmin makes this point very clearly when he writes of the difficulties of squaring the results of action research with traditional academic theories in social science:

> [The action approach,] particular not universal, local not general, timely not eternal … concrete not abstract … undermines the founding dream of social scientists — that they can do for human society what Newton did for Nature. It might be better for the philosophes to set their sights on less ambitious targets: for them (say) to have competed to be the Linnaeus, rather than the Newton of human society. It would have been even better if they had recognized that local and timely studies of concrete, particular situations … represent a practical (even clinical) activity; and has set the original dram of a universal, timeless social theory aside, as an overambitious delusion. (In Toulmin and Gustavsen 1996: 3–4)

Thus the holistic medicine inquiry group (Heron and Reason 1985; Reason 1988) started its work by outlining a five-part model which described aspects of holistic medical practice. This model was developed and elaborated over the course of the inquiry, with some aspects receiving more attention than others. After the inquiry was finished one of the members of the group wrote a piece in contribution to the group report elaborating on the model, and showing how its component parts could be seen in different kinds of relationship in different situations, and how from this different choices about medical practice might be made. Almost all theories of practice have this kind of quality: they draw attention and elaborate key issues of practice and show some of the ways these may be related. But the models are not reductionist: none of the parts determine the whole. They provide a window through which each unique situation may be seen rather than predetermined templates; and of course the experience of each situation, novel in its own right, further elaborates the model.

It is tempting to speculate whether there are persistent robust forms which emerge in human interaction, taking as metaphor the robust forms in the biological world mentioned above — indeed we have already suggested that one such may be seen in the development pattern of human groups. Bateson (1972) has suggested that human interaction can be seen as taking complementary and symmetrical forms. In complementary interaction a stable pattern is formed from contrasting forms of behavior (if I am dominant, you must be submissive; if you win, I must lose; patriarchy in agricultural and industrial societies is a good example); in symmetrical interaction the pattern is formed from similar behavior (I threaten you, so you threaten me, so I increase the stakes …; as for example in the arms race between superpowers). Bateson showed that complementary relations tended toward stagnant stability while symmetrical forms to runaway inflation, and that stability in cultures arose with appropriate integration of complementary and symmetrical forms of organization. Similarly one might follow Wilhelm Reich (1961) in wondering if the orgasmic response cycle — foreplay, excitement, discharge, relaxation — is a stable pattern of energy stimulation and release which applies not only to sexual activity but to all cycles of creativity (see also Randall and Southgate 1980).

Fluctuations

We have argued that relational form in social and organizational life emerges through iterative, nonlinear processes; from this we have argued that the kind of science of qualities needed for research/practice within them should be similarly nonlinear. However, we have also seen from complexity theory that iterative processes are rarely regular, but are more usually characterized by fluctuations. And while this is clearly in contrast to the orderly, rational and linear images of orthodox research, it is also a relatively novel notion for qualitative inquiry and action research. To take just two examples, Lewin's plan-act-evaluate cycle, and Lincoln and Guba's cycle of purposive sampling-inductive data analysis-grounded theory-emergent design: both can be taken to suggest a certain regularity in the iterative process which is far from the experience of practice; if taken literally both could be seen as advocating an almost mechanical approach to qualitative research. Of course, neither description is intended to be taken literally, although researchers schooled in linear positivist research methods are likely to take them as such. But the insights of complexity theory show us that fluctuations are not simply an aberration of practice but are significant in their own right, especially those which presage a novel, emergent order.

Heron (1996) probably gets the closest to an understanding of the importance of fluctuations in his proposal that inquiry groups need to draw on both Apollonian and Dionysian qualities in their research cycling. Apollonian inquiry is planned, ordered and rational, seeking quality through systematic search: models are developed and put in to practice; experiences are systematically recorded; different forms of presentation are regularly used. Dionysian inquiry is passionate and spontaneous, seeking quality through imagination and synchronicity: the group engages in the activity that emerges in the moment; rather than planning action; space is cleared for the unexpected to emerge; more attention is paid to dreams and imagery than to careful theory building; and so on. Apollonian inquiry carries the benefits of systematic order, while Dionysian the possibility of stretching the limits through play. To the extent that co-inquirers can embrace both Apollo and Dionysus in their inquiry cycling they are able to develop diverse and rich connections with each other and with their experience. But while Apollonian inquiry is relatively safe — indeed, one can imagine an inquiry so ordered and tram-like in its travelling the circuits of the inquiry cycle that no risks of new discovery were possible — in contrast the Dionysian mode hovers continually on the edge of catastrophe.

The potential catastrophe is twofold. The logic of the research cycling may break down or become so inordinately complex that it cannot be followed. But more frightening, the diversity of needs and loss of clarity of purpose may tip the group into a destructive dynamic in which primitive emotions, primal grief, fear, rage and hatred are aroused and amplified so that they overwhelm the creative purpose of the group, as in Bion's (1959) 'basic assumption' group and Randall and Southgates' (1980) 'destructive' group.

So while we cannot describe the fluctuations of co-operative inquiry as systematically as complexity theory, it is clear from experience that as an inquiry progresses and the complexity rises, the rational Apollonian process of research cycling will often become mixed with Dionysian passion. Conflict may arise as some inquirers attempt to bring the group back to greater order while others rejoice in the potential creativity of spontaneity. The group process may fluctuate between the poles of order and chaos, and the fluctuations may increase in amplitude. These are exciting and dangerous times.

A recent, as yet unreported, inquiry group established by one of the authors may exemplify this. While attempting to get to grips with the inquiry process and with the questions group members wished to address, members engaged each other in an energetic and very confused fashion, with no clear direction, lots of overtalk and interruption, and a sense of disorder. At a certain point, however, a way forward emerged which was crystallized in a proposal from one group member, swiftly amended and developed by others and then followed with a remarkable discipline over a period of several hours of close attention. This period of order was followed by another period of chaotic interchange and a further emergent period of order. The following edited extract from a transcript reflects some of this playful quality of order and chaos:

> *John*: I think we have evolved a group process mainly of having turns, which is interesting and unusual for me. We started off by having a round and have been having rounds ever since ....
>
> *Dave*: You're wrong! [Much laughter] ... I think that this is one of the things I've most delighted in hasn't been a democracy of turns, it's been this wonderful tumbling which has moved us ... 'forward' is probably not quite right — this wonderful tumbling that's moved us, and we've gone sideways a bit. ... Something somebody says triggers something else, triggers something else, and we go back then and go off that way. ... People look for what is agreeable, what is exciting, what is a lead ...
>
> *Sara*: There seems to me that with the tumbling ... [there is] quite a high degree of sophisticated editing that goes on within individuals in the group in order that the contributions ... resonate with what's gone before. ... There is an eye to the purpose of why we are gathered... held with a lot of attention, high quality attention ...

This group appears to exhibit a sophisticated capacity not only to move between periods of chaotic and ordered interaction, but to have become aware of this process. This proposal that creative groups move consciously between Apollonian and Dionysian phases requires further observation and exploration.

Edge of chaos

We have already introduced the notion of living systems being most adaptive when the settling down at the edge of chaos, at which there is a mixture of nascent order and chaos. Emergent order arises only under conditions in which large fluctuations occur. The Dionysian mode of inquiry can be compared with Goodwin's (1994) emphasis on play as a crucial way in which the possibility of emergent new order is created in living beings — and it is interesting to connect this notion of play in the natural world with the playful postmodern pastiche of different styles, the 'invitation to the carnival' (Gergen 1991). Play is by nature spontaneous and purposeless; it is simply for its own sake; it is dangerous to living creatures in not attending to the harsh realities of existence; yet it is helpful because it contains the possibility of novelty.

We find it interesting that ten years ago, before they had heard of complexity theory, Peter Reason and John Heron wrote:

> From our early inquiries we came to the conclusion that a descent into chaos would often facilitate the emergence of new creative order. There is an element of arbitrariness, randomness, chaos, indeterminism, in the scheme of things. If the group is really going to be open, adventurous, exploratory, creative, innovative, to put all at risk to reach out for the truth beyond fear and collusion, then once the inquiry is well under way, divergence of thought and expression is likely to descend into confusion, uncertainty, ambiguity, disorder, and even chaos, with most if not all co-researchers feeling lost to a greater or lesser degree.
>
> There can be no guarantee that chaos will occur; certainly one cannot plan it. The key validity issue is to be prepared for it, to be able to tolerate it, to go with the confusions and uncertainty; not to pull out of it anxiously, but to wait until there's a real sense of creative resolution. We make this argument for openness to extreme uncertainty to counterbalance the human being's enormous capacity for creating and sustaining order, even when such order is no longer appropriate. (Reason and Heron 1986: 470)

One of the journal reviewers (in 1986) wrote that they could not see how chaos could be an aspect of valid inquiry. We now see from complexity theory a substantial support for our intuition. Living inquiry is continually questioning its own premises and assumptions; the inquiry group, if it wishes to be creative, needs to learn to tolerate the kind of fluctuations described above and to be open to periods of deep confusion, which the creative group will approach in a playful, rather than an anxious, attitude.

We would suggest that there are 'zones of organization' around the edge of chaos which describe different qualities of order. There is a zone which we might describe as a frozen regime, highly, rigidly and sometimes pathologically ordered with little or no spontaneous activity. This is the place of repetitive, ritual interaction, rigid bureaucracy, highly scripted conversation (Mangham and Overington 1987), here-we-go-again argument. Then there is a zone, on the ordered side of the edge of chaos, which we can see as a zone of healthy and bounded interaction. Here we will find those everyday conversations and relationships which are lively and interesting, unpredictable within a certain framework — just like the conversation one of us had with a research colleague when trying to explain these ideas over lunch. On the other side of the edge of chaos is a highly disordered zone in which all taken-for-granted patterns are lost in a tangle of confusion and spontaneity and there is an active seeking for new order. Finally, there is a zone so far into chaos that all sight of order is lost, the social system explodes or implodes.

Highly creative research will from time to time enter the third zone of considerable disorder out of which creativity can emerge. We would not argue that all research needs to enter this zone, but clearly any inquiry aimed at real novelty and creativity is likely to touch this area: we would describe this as the zone of healing. The danger of course, in research as in all social organization, that in entering the third zone we approach the fourth, which may be one explanation for the dynamic conservatism (Schon 1971) of human organization generally and 'normal science' (Kuhn 1962) in particular.

Reflections on complexity theory

In this paper we have argued that the principles of complexity theory and a science of qualities in biology lead us toward a form of research/practice in organizations which is intimate, systematic, and also emergent and playful. We suggest that the six principles identified about might be used as design principles to create the conditions for high quality creative inquiry, and as criteria to assess the quality of the emergent understanding and practice. Thus a PhD dissertation or other research project drawing on a science of qualities would actively and intentionally employ the six principles in the conduct of inquiry; and examiners or reviewers would similarly use them to explore and assess the qualities exhibited in the inquiry process.

Complexity theory suggests that we live in an unpredictable but nevertheless intelligible world. It raises fascinating questions about the inquiry process that must remain beyond the scope of this paper. John Heron, on reading an early draft, pointed out that complexity theory has primarily been articulated in terms of non-living and biological systems which do not exhibit reflexivity and intentionality and asked us to consider what happens to the dynamics of complex systems if you add these human qualities? For example, if a persons are aware that complex systems are most innovative when at the edge of chaos, when chaotic times arise in the life of the sophisticated group these will be seen as reassuring signs that new order is about to emerge. In consequence, group members no longer experience the situation as chaotic, and thus maybe new order does not emerge? Alternatively, when chaotic times arise a sophisticated group is able to recognize these as positive signs and are able to tolerate the resulting ambiguity and lack of certainty and await the emergence of new order; while a less sophisticated group will respond with anxiety and either retreat back to order, shutting down the chaotic dynamics, or in its anxiety amplify the chaotic signals in a move into uncreative chaos. As a riposte to this suggestion another colleague, Paul Roberts, suggested that the argument here begins to hint that these processes may be able to be managed, made easier, less problematic etc. — all of which can imply the reassertion of control, whereas the greatest value in complexity may be in its radical challenge to control.

A further question concerns the implications for human consciousness of engaging with these ideas. What kind of worldview may emerge based on the metaphors of complexity, which are so different from the mechanical metaphors of the Newtonian worldview that most of us have been brought up with (although our feeling from observing our children as young adults is that they are much more comfortable with the unpredictability of the postmodern world than we may ever be). On the one hand, we might see complexity theory principles in a passive sense, simply accepting them as more accurate descriptions of the world than the mechanical metaphors. This approach is fatalistic: we used to live in a mechanical world in which we could to some extent predict and control; now we see that our ability to do this is circumscribed by the dynamics of complexity. Alternatively, we can accept the principles of complexity theory in an active sense, working with them as offering the possibility of creating the conditions in which creative order can emerge. This offers a particular challenge to leadership and facilitation to find ways to create the conditions in which creative order can emerge in inquiry projects. Is it possible, for example, to develop an understanding of how to help a group move to and hold the point of chaos without erring on the side of stability or pushing too far into the chaotic realm?

All these questions are beyond the scope of this present paper but emphasize the fruitfulness of the contribution of complexity theory and the lessons of the emergent postmodern biology to the practice of organizational inquiry. As Gergen might put it, thinking in terms of complexity leads to generative, rather than predictive theory, and is all the more fruitful for it.

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