Complexity Science: A Bridge between Modernist and Postmodernist Perspectives on Organizations?

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Abstract

Competition between modernism and postmodernism seems ever present and has not been fruitful. Management researchers are divided in their preference for modernism vs. postmodernism, though modernism dominates American business schools. The legitimacy of truth-claims from management research remains an epistemological quagmire. Complexity science offers an epistemological bridge between the order-seeking regime of the modernists and the richness-seeking regime of the postmodernists. Gell-Mann's *effective complexity* principle defines the appropriate number of degrees of freedom relevant for studying efficacious social dynamics. Since the conjunction of tension and connectivity in social phenomena gives rise to Pareto rank/frequencies rather than normal distributions, we propose using scalable abduction, hermeneutics, and coherence theory to strengthen truth-claims based on isolated idiosyncratic outcomes of the kind that give rise to Pareto extremes. It turns out that the variety of research methods suitable for researching Pareto-distributed phenomena, can accommodate the Postmodernist agenda.

The study of social systems such as organizations has long been caught between two conflicting bases of legitimacy: On the one hand, we have *Positivism*—a set of procedures for creating valid knowledge that express a *Modernist* outlook that has its origins in the 18th century *Enlightenment* project. It presumes a real, relatively stable, and objectively-given world, manifested in phenomena that can be rationally known and rationally analyzed by independent observers. Such phenomena can be decomposed into observation protocols that rest on sense data and can be predictively related to each other through stable laws that are themselves integrated via a mathematical syntax (Benacerraf & Putnam, 1964; Lakatos, 1976). Positivism aims to promote the modernist agenda, namely, the understanding, manipulation and control of predominantly physical phenomena for beneficial social ends. In contemporary social sciences, neoclassical economics remains the foremost proponent of positivism as a research methodology (Friedman, 1953; Lawson, 1997; Mirowski, 1989).

On the other hand, the *Postmodernist* movement emerged the late 1960s to challenge the basic tenets of modernism and its epistemological ally, positivism. Whereas in modernism the focus is on a phenomenal world directly and unproblematically observed and described by a disinterested actor who remains external to what is being observed, the postmodernist strategy problematizes the relationship of the actor to the phenomena under observation by introducing language as a mediator in that relationship. Thus, whereas before we had an unproblematic relationship between an external world *W* and an observer *O*, we now have two relationships: (1) between an external world *W* and a language, *L*, for describing it; and (2) between the language *L* and an observer, *O*. A key point is that language is a *human* resource that places the relationship between W and O in a social context, S—one where divergent interests (Habermas, 1972) and social power (Foucault, 1969) come into play to shape language and linguistic usage, and by implication, the regions of the phenomenal world to which the language gives access. Therefore language, the postmodernists argue, is not a neutral observation tool. It is one that shapes observations in ways that reflect the ontological assumptions of a particular community of observers (Berger and Luckmann, 1966; Kuhn, 1962). Postmodernism emerged initially as a literary movement, a response to the so-called “linguistic turn” in philosophy. Its claim that “everything is text” (Derrida, 1978) reflects the interposition of language as a mediator between an observer and the world (Rorty, 1980; Lyotard, 1984).

Organization theory has been pulled in opposite directions by modernist and postmodernist ontologies. The American journal *Organization Science*, for example, started as a breakaway from *Management Science*, a journal devoted to mathematical modeling in operations research and decision science. Although the former is much less mathematical than the latter, it still reflects the early attempts to legitimize American organizational research along broadly positivist lines, attempts that date back to Lewin (1951), Hage (1965), and Starbuck (1965). In American business schools, the influence of disciplines such as neoclassical economics, financial economics, decision science, mathematical sociology, and math-based network theory and marketing science remain pervasive. By contrast, *Organization Studies* is a European journal more oriented towards poststructuralism, postmodernism, critical theory, and constructivism (Alvesson, 1985; Bouchikhi, 1993; Chia, 1995; Cooper & Burrell, 1988; Parker, 1995). Most of its emphasis is on qualitative case analyses.

Two problems result: (1) organizational researchers are caught between two conflicting bases of legitimacy with little overall consensus on what constitutes legitimate truth claims; and (2) consultants and managers have little reason to base their practical action on the research findings of academics who cannot achieve a stable consensus on the foundations of their discipline.

Absent any faith in what the positivists are attempting to measure with their quantitative emphasis on sample size, normal distributions, means, variance, probabilities, and statistical significance, and managers will draw mostly on gripping corporate yarns that gain their legitimacy by virtue of being vivid and compelling narratives—i.e., narratives concerning salient business outcomes that are readily remembered and retold. A good story loads on the dependent variable with gay abandon, leveraging "samples of one" (March, Sproull & Tamuz, 1991) into universal managerial truths. A good story is a plausible one rather than a probable one (Boisot & MacMillan, 2004), drawing its persuasiveness and appeal from its vividness, its internal coherence and its alignment with the experience of its intended audience rather than from any objective probability that it might, in fact, be true.

If, following the Chicago School Pragmatists (Dewey, 1925; James, 1907), we take knowledge to consist of beliefs that managers can act upon, we can think of modernism as attempting to substantiate these beliefs according to a rationally derived set of principles and rules. This modernist epistemology is now being challenged by postmodernism as being less than universal and of suppressing voices that fail to fit the rationalist straitjacket (Calas and Smirchich, 1999). Yet, to the extent that such beliefs are unconstrained, they can proliferate uncontrollably and become vulnerable to all kinds of biases. Which ones, then, should form a basis for legitimate action? Does the need to act suggest that we should accept the constraints imposed by modernism while recognizing them to be contingent? Or should we abandon these constraints as essentially arbitrary and follow Feyerabend (1975: 296) in arguing that "*anything goes*"? If the latter, what claim has organizational research to be a science-based *discipline*?

We offer a third alternative based on complexity science. We draw on several well-known complexity principles to bridge between the ordered world of modernists and the chaotic world of the postmodernists: Prigogine's *tension* (1980), Ashby's *requisite variety* (1956), Haken's *slaving principle* (1983a,b), Gell-Mann's *effective complexity* (2002), and Bak's *self-organized criticality* (1996). Given these principles, we posit that the conjunction of tension and connectivity in social phenomena generates Pareto rank/frequency and power-law distributions instead of the "normal" ones studied via Gaussian statistics. Numerous complexity researchers (Andriani & McKelvey, 2007, forthcoming; Newman, 2005; West & Deering, 1995) find Pareto and power-law distributions to be ubiquitous in both natural and social systems.

Pareto rank/frequency distributions provide a way of tracking social phenomena from the N=1 extreme outcomes best studied by hermeneutics in one tail of the distribution to the large samples of highly ordered phenomena in the opposite tail. Pareto distributions, then, call for self-organizing and socially-constructed epistemological positions ranging between the "ordered" regime that is the primary focus of the modernists and the "chaotic" regime identified by the postmodernists. An appreciation of the different ways in which social phenomena can be distributed allows us to build an epistemological bridge between the seemingly opposed modernist and postmodernist epistemologies, thus enhancing the epistemic legitimacy of each in the eyes of the other.

The structure of our paper is as follows. In Section 1 we briefly provide a working definition of the modernist and postmodernist positions. We set forth five key complexity principles in Section 2 that will help us to locate effective complexity between order and chaos, to identify new order creation, and to adapt efficaciously. Next, in Section 3 we argue that these principles illuminate the modernist/postmodernist debate. Finally, in Section 4, we explore the implications of our analysis for 21st century organizational research. A conclusion follows.

1 MODERNISM VS. POSTMODERNISM

1.1 DEFINING MODERNISM

Modern science is one of the fruits of the Enlightenment, from which evolved the Eighteenth century Modernist project that posits the epistemological and moral unity of mankind (Hollinger, 1994). Bacon and Descartes are considered to be the philosophical founders of this project (Hollinger, 1994). Insofar as the social sciences seek to promote the understanding and use of science to improve modern society, they pursue the modernist agenda.[1]

Modernism attempted to build reliable knowledge on an alternative basis to that of religious revelation. Baconian science argued for the empirical justification of truth claims rather than for the acceptance of revealed truths on faith. Truth arose from a correspondence between a claim and empirically observed facts rather than with divinely sanctioned revelations transmitted through sacred—and hence un-modifiable—texts. This required the repeatability or replicability of empirical phenomena and the rejection of one-shot events such as miracles. The objectivity that was sought, however, could only be achieved by a totally impartial observer abstracted away from the context of observation, effectively providing him/her with a god's eye view—a view from nowhere (Nagel, 1986; Shapin and Schaffer, 1985).

If modernism constituted a world view, the rise of positivism at the end of the nineteenth century provided it with a methodology. Ernst Mach's rebellion against Hegelian idealism gave rise to the Vienna Circle in 1907—a group of physicists and mathematicians (Suppe, 1977). Their dream was the attainment of absolute verified Truth ("verificationism") based on a rigid correspondence ("correspondence theory") between operational measures and theory terms. Modernism, and its methodological handmaiden, positivism, have long provided the natural

[1] Israel (2001) distinguishes between a *moderate* and a *radical* Enlightenment, associating modernism with the latter

sciences with their basis of scientific legitimacy. Being essentially concerned with what Reichenbach (1938) called "the context of justification"—justification being one of Plato's prerequisites for genuine knowledge—they showed little interest in what he called "the context of discovery." If for Bacon, genuine knowledge yielded prediction and control—a recipe for *action*, and an alternative to the passive acceptance fostered by the culture of revelation—these also amounted to forms of justifications that would separate science from superstition, alchemy, and revealed truth. Into this world of apodictic certainties, Reichenbach introduced the idea that probabilistic thinking offered a more realistic basis for justification (Reichenbach, 1938). From Brown's "Brownian Motion" in 1827, Boltzmann's statistical mechanics of 1877, to Gibbs' statistical actuarial tables for the insurance industry in 1902, and Fisher's statistics of 1916, we gradually see a shift taking place from exact to probabilistic representations, a shift legitimated by Reichenbach's 1938 treatise.

In a noisy world, the structures underpinning the replicability of events are captured by the mean. In the case of normal distributions, the variance could be treated as mere noise—something to be got rid of rather than something to be explored. Over time, the normality of a distribution became the default assumption—the taken for granted signature of universal reality that yielded stable, manipulable objects. Gaussian statistics, the statistics of the normal distribution that is now universally applied in the social sciences (e.g., Greene, 2002), focuses on stable means, finite variances and independent data points (Andriani and McKelvey, 2007; Taleb, 2007). The social sciences, epitomized by neoclassical economics, thus created for themselves the stable and (mostly) computationally tractable objects that were the focus of Newtonian physics (Freidman, 1953; Lawson, 1997; Mirowski, 1989), while at the same time eschewing the complex, messy interactive social processes characterizing society.

Gaussian-inspired statistical truths artificially structure the world so as to achieve significant reductions in complexity, a de-multiplication of explanatory entities with a consequent reduction in degrees of freedom. In line with the principles of Occam's razor—namely, that the *explanandum* should always be more compact than the *explanans*—they achieve *compressibility* and *parsimony*. In cosmology, the current search for a theory of everything is but the most recent expression of this concern with parsimony (Guth, 1977; Weinberg, 1994). In addition to its parsimony, of course, the worth of a theory is also based on its predictive power. Yet from an operationalist perspective (Bridgeman, 1936) predictability does not necessarily require understanding. Feynman, for example, famously pointed out that in spite of its remarkable predictive achievements "… no one really understands quantum mechanics" (Feynman, 1967: 129).

The Modernist approach did not go unchallenged. In contrast to the physical sciences, the social sciences had to deal with the fact that, even though the focus of their studies, i.e., people, were all subject to physical forces, people act primarily on the basis of representations and interpretations of the world that make the problem of *meaning* central to their concerns. The inability of the physical sciences to deal with the vexing question of meaning led to the rejection of the modernist ontology as a whole by many social scientists. After all, what, exactly, constitutes "replicability" when dealing with a complex social phenomenon within or between organizations? Who is to say in what respect two complex social outcomes are sufficiently similar to justify the claim of replicability? And how robust is the concept of inter-subjective objectivity—modernism's substitute for the god's eye view—given the social distribution of power, influence, and bias (Foucault, 1969; Shafer and Shapin, 1985)? Questions like these suggest an unbridgeable gulf between the natural and the social sciences. Sociologists of science go further by suggesting that in the natural sciences no less than in the social sciences, problems of interpretation and meaning, not to mention status and power, effectively contaminate all claims to objectivity (Golinski, 1998; Latour, 1988; Callon, 1986).

1.2 DEFINING POSTMODERNISM

Alvesson and Deetz (1996: 194) see modernism as

> …the instrumentalization of people and nature through the use of scientific-technical knowledge (modeled after positivism and other "rational" ways of developing safe, robust knowledge) to accomplish predictable results measured by productivity and technical problem-solving leading to the "good" economic and social life, primarily defined by accumulation of wealth by production investors and consumption by consumers.

Postmodernists hold that scientific knowledge represents one story among many that is shaped by local historical and cultural contexts (Calas and Smirchich, 1999). It is best viewed as a social construction that serves the ideological agenda of powerful elites (Koertge, 1998). The postmodern perspective challenged the Enlightenment project by introducing a radical subjectivity and the exercise of power as irreducible constraints on our access to an objective world (Foucault, 1975). To postmodernists, the world—and especially, perhaps, the social world—is not objectively given. It is kaleidoscopic rather than stable, and such that its constituent components are not unproblematically identifiable.

The stability that we impute to the world, and from which we derive our laws and our theories, is partly shaped by our interaction with other observers. For this reason, postmodernists distrust the summary "Gaussian" descriptions produced by the modernists and the grand and confident narratives that these give rise to (Lyotard, 1984)). Postmodernists' ontology is profligate rather than parsimonious. By entertaining multiple representations of phenomena ("voices") as equally valid alternatives, they shun what they see as the exclusions and repressions underpinning the modernists' claims to singular objective representations. Postmodernists seek "infinite conversations" undistorted by power considerations (Foucault, 1975; Derrida, 1978 ; Rorty, 1989). The postmodern emphasis on "playfulness" is designed to counter a desire to control everything and the despair at not being able to. Life in all its richness and messiness is more important to postmodernists than the impoverished conceptions of it that we find in psychology, economics, and other positivist-leaning social sciences. Expressed as a statistical strategy, postmodernists invite us to focus on the rich promises latently present in the variance rather than on an impoverished mean. Postmodernists believe, then, that the social sciences must either be revised so as to accommodate the theses of postmodernity or they become irrelevant or extinct.

Postmodernism itself, however, has also come under fire. The relativism that results when equal airtime is given to all, when one theory is deemed as good as another (Hollis, 1982), or when paradigms cannot be reconciled (Kuhn, 1962), makes it impossible to compare, evaluate, and select from competing alternatives. In the absence of a timely and "justifiable" consensus, productive social action, then, becomes problematic, if not impossible. As compared to the natural sciences, postmodernism massively increases the variety and degrees of freedom of the phenomena that social scientists are required to respond to. Variety and degrees of freedom, however, can be viewed as manifestations of complexity at work—they point to higher levels of interdependence among phenomena, to the irreversible effects of time and of path dependence (Cilliers, 1998). Assumptions of independence between phenomena are now challenged by complex feedback loops—both positive and negative—that were generated as much by how events are construed by intentional agents (Dennett, 1989) as by any physical causal links between them. Given such interdependencies, an exclusive focus on the mean of a distribution becomes dysfunctional and misleading since much of the relevant information now resides in the variance, which can no longer be treated as noise.

Given complex interdependencies stemming from densely connected causal networks, how should one proceed? The connectionist ontology that postmodernism implicitly supports massively increases the number of plausible patterns in need of causal analysis and interpretation. Given the movement's anti-reductionist orientation, however, Occam's razor will be of little help here. The complexity must be absorbed and lived with rather than reduced (Boisot and Child, 1999). For postmodernists, computational convenience does not constitute an epistemic justification for a reductionist stance. Their methodological preference is for case studies and, more generally, for qualitative research. Their interest focuses on unpredictable and emergent phenomena rather than on predictable regularities, i.e., on process rather than structure. In any trade-off between understanding and prediction, *understanding should take precedence*. The phrase in italics lies at the heart of *scientific realism*.

Scientific realists, however, argue that, as it stands, postmodernism offers no solution to the apparent failures of reductive positivistic strategies in the social sciences (Aronson et al., 1994; Bhaskar, 1957/1997; Hooker, 1987; McKelvey, 1999, 2003)—which is to say, it underplays the problem of epistemic justification. Realists also eschew instrumentally predictive positivism. But their approach to justified knowledge based on a probabilistic notion of truth still looks predominantly to physics and biology— disciplines that don't study networks of complex language-laden social interdependencies. The primacy postmodernism accords to the chaotic nuances generated by the swaying of the "trees" at the expense of *patterns* discernible in the "forest," effectively paralyses theory choice, undermining justification, and practitioner relevance. This poses a challenge to management research, concerned as it is to establish both valid truth-claims as well as actionable outcomes based on these. How can management inquiry contribute to practical action (1) if the truth claims of a theory cannot be disentangled from the "situated" interests that give rise to them; (2) if the language in which they are framed is incommensurable with meanings ascribed by other observers; (3) if the competing theory alternatives are incommensurable across observers; and (4) if the only way in which any two theories can be made to converge is through status, power, repression, and coercion?

2 COMPLEXITY SCIENCE AS AN ALTERNATIVE BASIS OF LEGITIMACY

Over the past 150 years the natural sciences initiated a marked shift in our view of the universe and our place in it (Frazer, 2006). They showed how order can emerge out of chaos unaided by "global controls" as Holland (1988) puts it. The relationship between order and chaos has been the main focus of the new sciences of complexity. In what follows, we argue that complexity science offers a bridge between modernism and postmodernism.

2.1 SOME KEY ELEMENTS OF COMPLEXITY SCIENCE

Phase 1 was developed by Nobel Laureate Ilya Prigogine (1980, 1997) and others mentioned below who focus on adaptive tension and the so-called first critical value of imposed energy in physical systems—the "*edge of order*." Energy levels above the first critical value set off an emergent process of order creation. Exploring the properties of "*dissipative structures*"—pockets of new order governed by the 1st Law of Thermodynamics—Prigogine argued that conserving energy accelerated disorder, randomness, and entropy according to the 2nd Law of Thermodynamics (Swenson, 1989). We discuss this phase further later on.

Phase 2 emphasizes how new order arises in (living) biological and social systems (Pines, 1988; Arthur et al., 1997). These scholars concentrate on heterogeneous agents[2] interacting at what was early-on called "*the edge of chaos*," occurring at the so-called second critical value of imposed energy. In between the edges of order and chaos is the region of emergent complexity.

[2] "Agents" may be nucleotides, acids, genes/proteins, chromosomes, molecules, organelles, cells, organs, organisms, and species. At the human level, "agents" may be people, cognitive elements, groups, firms, societies, etc.

Kauffman's (1993) calls this the "*melting*" zone. Order creation begins when heterogeneous agents are motivated to interact and to link up. In biological systems such motivations are provided by the need to mate, to improve performance and hence fitness, to learn, etc. Bak (1996) argues that to survive, organisms must be able to stay within the melting zone, maintaining themselves in a state of "*self-organized criticality,*" (SOC).

Phase 3 is concerned with how order unfolds once the foregoing forces of emergent order creation are set in motion. A key element is *scalability*: Consider a cauliflower. Cut off a floret, cut a smaller floret from the first, then a smaller one, then another, and so on. Other than increasingly small size, each floret performs the same function and has roughly the same shape as the floret above and below it in size. This feature defines it as fractal—its structure and underlying causal elements are self-similar across multiple levels. Fractals are described by the *power-law* rank/frequency expression, $F \sim N^{-\beta}$, where F is frequency, N is rank (the size variable) and β, the exponent, is constant (Newman, 2005). Barabási (2002) connects scalability, fractal structure, and power-law findings to social networks. For example, a Pareto distribution describes many social "loners" at one extreme and one very well connected "star" at the other. Andriani and McKelvey (2007, forthcoming) show how pervasive power laws are in physical, biological, social and organizational phenomena—they list over 120 of them.

In what follows, we draw on Ashby's *Law of Requisite Variety* (Ashby, 1956), Gell-Mann's *effective complexity schema* (Gell-Mann, 2002), Haken's *slaving principle* (Haken, 1983a,b), and on Bak's SOC (Bak, 1996) to offer a way of reconciling what appear to be competing research agendas in management inquiry.

1.

2.2 ASHBY'S VARIETY AS THE BASIS OF EFFECTIVE COMPLEXITY

In his classic work, *An Introduction to Cybernetics*, Ross Ashby (1956: 130–134) says:

> When a constraint exists advantage can usually be taken of it.… Every law of nature is a constraint… Science looks for laws.… Constraints are exceedingly common in the world around us.… A world without constraints would be totally chaotic.… That something is predictable implies that there exists a constraint.… Learning is worth while only when the environment shows constraint.

He also notes that order (organization) exists between two entities, *A* and *B*, only if the link is "conditioned" by a third entity, *C* (Ashby, 1962: 255). If we take *C* as constituting an "environment," external to *A* and *B*, then *C* can be taken as a source of order-generating constraints that helps to organize the relation between *A* and *B* (Ashby, 1956). The influence of such external constraints, gives rise to Ashby's famous *Law of Requisite Variety* which states that: "ONLY VARIETY CAN DESTROY VARIETY" (p. 207; his capitals). It holds that for a biological or social entity to be efficaciously adaptive, the variety of its internal order must match the variety imposed by environmental constraints. If Ashby were writing now he would surely update his Law, as follows:

- Only variety can destroy variety
- Only degrees of freedom can destroy degrees of freedom
- Only internal complexity can destroy external complexity

We take degrees of freedom to be the most basic phenomenological manifestation of complexity at work. Our suggested rephrasing rests on the widely held view that emergent complexity is a function of the degrees of freedom present in phenomena (Gell-Mann, 1994). Wherever the degrees of freedom external to an adaptive biological or social system exceed the degrees of freedom internal to that system, there emerges what McKelvey calls an *adaptive tension* within the system (McKelvey, 2001, 2008). Four situations and outcomes are possible:

1. *Stable ecology*: The system generates sufficient internal complexity, and in a timely manner, to match the external complexity it confronts; the tension disappears as the system adapts.
2. *Unstable ecology*: The system's internal complexity fails to match the external complexity it confronts, in a timely manner, and so the system fails.

3. *Punctuated ecology*: Dramatic environmental changes impose infrequent but very high tension levels that demand dramatic and quick adaptive responses that Eldredge and Gould (1972) label *punctuated equilibrium*. Here, high levels of agent heterogeneity coupled with moderate degrees of connectivity among agents (Kauffman, 1993) will be most adaptive. Outcomes will partially dependent on local circumstances.
4. *Fractal ecology*: Ecologies may be fractal in the sense that they show fractal—power-law distributed—structures based on Pareto rank/frequencies. Andriani and McKelvey (forthcoming) list a variety of fractal industry sectors. Fractal ecologies fit Bak's SOC concept, so that the effects of "local circumstance" and "luck," also become Pareto distributed.

Although Ashby's law tells us nothing about the nature of the external complexity that a system must respond to, the fact that systems such as ourselves do adapt and survive suggests that within a certain range such complexity must be manageable. One reason for this is that the adaptive tension experienced by a system creates what Gell-Mann calls effective complexity (see below) and schemas that increase the system's ability to more effectively represent and then respond to the trillions of degrees of freedom that confront it (McKelvey and Boisot, 2008).

2.3 TENSION, CONN ECTIVITY, AND GELL-MANN'S EFFECTIVE COMPLEXITY

Guided by the principles of Occam's Razor, modernism in general, and positivist epistemologies in particular, minimize degrees of freedom—a strategy that has served the natural sciences well. Postmodernist strategies, by contrast, aim to maintain or increase degrees of freedom, so as to reflect the problematized relationship between language and the socially-situated researcher. The concept of degrees of freedom underpins most current definitions of complexity—and what Nobel Laureate Murray Gell-Mann (1994) calls *effective complexity*.[3] Researchers caught between the two tendencies have no legitimate rationale for deciding on an appropriate number of degrees of freedom. How much complexity is "requisite" in Ashby's

[3] Gell-Mann (1994) separates crude complexity (treating phenomena *as wholes*) from effective complexity (characterizing *regularities* underlying a phenomenon). He sees the first as indistinguishable from randomness.

sense, or "effective" in Gell-Mann's? To address this issue, we build on Haken's (1983a,b) insights concerning new order creation, a situation in which degrees of freedom are massively reduced by what he terms a "*slaving principle*" (p. 341–343) that defines the nature of new order in phase transitions. Haken argues that when the slaving principle ends up dominating a system, few degrees of freedom remain; where the principle fails to do so, chaos results.

We also follow Holland (1988), Gell-Mann (2002) and complexity science in general, by arguing that the long overdue recognition of the latent connectivities that characterize relationships among social and biological (and even physical) entities, at any level of analysis, challenges the centuries old "default" assumption of physical scientists and statisticians that data points are independent and additive (Andriani and McKelvey, 2007).[4] As entities represented by data points with some probability of becoming connected respond to imposed tension—at the tipping point they undergo a phase transition into a new 'connected' order—we recognize a new outcome of the slaving principle: As enslavement reduces degrees of freedom, there is some probability that a process of self-organization among connected data points will occur, setting in motion scalability dynamics. Under such circumstances, tiny initiating events among a few connected entities can occasionally scale up into extreme outcomes (Holland, 2002; Lorenz, 1963, 1972; Gell-Mann, 2002). These may take on positive or negative values.

Thus, we do not have to choose between a connectionist ontology and an atomistic one. The implication is that the high degrees of freedom espoused by postmodernists and the low degrees of freedom that modernists aspire to are but transitory moments in a broader process that encompasses them both. Connectionism and atomism, then, become lenses that we bring to bear on events for particular purposes and complexity theory provides us with an integrated

[4]Andriani and McKelvey (2007) show that connectivity-based extreme events extend across 32 magnitudes of physical and 27 magnitudes of biological phenomena. We also see it across 11 magnitudes of social phenomena,

perspective that allows them to peacefully coexist. The dynamics of connectivity and interaction effectively capture the essence of complexity science. We argue that the complexity perspective, and more specifically Gell-Mann's concept of *effective complexity*, together with the human representations and action schemas that he derives from it, can play a mediating role in the modernist-postmodernist confrontation.

In acknowledging the existence of tension and of connectivity dynamics, an epistemology based on complexity science offers a more compelling basis of legitimacy for organizational researchers than either a modernist or a postmodernist epistemology on their own, one that is well aligned with emerging concepts of organization (*Organization Science*, Vol. 10(3), 1999; see also *Emergence: Complexity and Organization*). If effective organizational complexity lies between Order and Chaos, between the "*too few*" and "*too many*" degrees of freedom, then, by implication, so does the "effective legitimacy" of management research. This theoretical shift implies a methodological shift: Away from the world of stable entities generated by Gaussian distributions and towards the more problematic Pareto distributions frequently generated by tension coupled with connectivity.

2.4 HAKEN'S ORDER-CREATION PROCESS AT THE TIPPING POINT

Adaptive tension is at work in purely inanimate physical systems as much as in biological ones. Prigogine (1980), for example, drawing on the work of Henri Bénard (1901), saw any kind of Newtonian order as equilibrium-seeking "*dissipative structures*" that conserved energy in line with the 1st Law of Thermodynamics. Since Bénard, the science of fluid dynamics (Lagerstrom, 1996) has primarily focused on the 1st critical value, R_{C1}—the Rayleigh number—that separates turbulent from laminar flows. Below the 1st critical value, viscous damping dominates the flows so that the self-organization required to produce an emergent (new) order does not occur. Above the R_{C1} number, however, self-organization does occur. For example, in a Bénard cell—i.e., a rolling boil in a teapot—the 1st critical value, R_{C1}, constitutes a tipping point beyond which any energy input measured as temperature, ΔT, initiates a phase transition, i.e., new order creation. A similar dynamic can be observed in social and economic systems when the tensions generated by unmet demands bring forth dissipative structures called entrepreneurial firms—emergent responses that reduce the tension.

External energy inputs, then, are sources of adaptive tension that drive a process of self-organization. At R_{C1}, therefore, new structures emerge, that is, equilibrium-seeking ordered states that conserve energy in conformity to the 1st Law of Thermodynamics. The coming into existence of such "*far from equilibrium*" "dissipative" structures, however, speeds up the natural progression from structured to unstructured regimes as per the 2nd Law of Thermodynamics (Swenson, 1989)—which is to say, dissipative structures speed up entropy production.[5]

In sum, external inputs of energy push a physical system above some critical value, thus initiating a phase transition. Haken (1983a,b), Mainzer (1994), Rosser (2004), and McKelvey (2004) extend this idea to social phenomena: environmentally imposed shocks generate causal tensions that threaten an organization's existing coherence and lead to new order creation.

Hermann Haken (1983a,b) frames the order-creation process as one that reduces the degrees of freedom present in a system. How is such reduction brought about? Haken invokes a what he terms a "*slaving principle*:" Out of the myriad degrees of freedom that characterize a system's complexity, a few—Haken terms these "*order parameters*"—eventually dominate the system as most of the other degrees of freedom are enslaved by chaotic degrees of freedom in the

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[5] Whereas the 1st Law of Thermodynamics deals with energy conservation, the 2nd Law holds that temperature differences in open systems in contact with each other will even out. Work may be obtained from these nonequilibrium differences, but heat is lost in the form of *entropy* production when work is done.

environment. As R_{C1} tips over the 1st critical value, chaotic external degrees of freedom increasingly connect to internal degrees of freedom, thereby enslaving them (making them chaotic) thus allowing the last few internal degrees of freedom that are not enslaved to emerge as order parameters determining the nature of the emergent new order creation and the process of adaptation. In Haken's view (1983a: 14, 195–199, 249–250; 1983b: 3–5), as the environmental energy gradient or adaptive tension approaches R_{C1} in different physical and biological systems characterized by phase transitions—Bénard cells, lasers, cell formation in slime molds, chemical reactions such as the Belousov-Zhabotinsky reaction, predator/prey growth and decline rates, etc.—changing external degrees of freedom enslave internal degrees of freedom that, below R_{C1}, had acted independently of each other.

2.5 BAK'S SELF-ORGANIZED CRITICALITY PROCESS OF ADAPTATION

Prigogine, Haken, and Gell-Mann extend theories developed for physical phenomena to human social systems. Typically, however, physical systems operate with far fewer degrees of freedom available to them than human social systems or, even biological ones. Tension can also stem from an agent's motivation to improve fitness, learning, performance, etc. Consequently, human social systems are capable of establishing far wider and varied patterns of connectivity than purely physical systems, thus adding new layers of complexity to Haken's theory. Biological systems, for example, do not respond directly to externally imposed tensions but rather to "*representations*" of these, representations that have the character of hypotheses that can be falsified and gradually corrected—indeed, Popper has described these respresentations as "hypotheses that die in our stead" (Popper, 1972: 248). And in the case of biological systems capable of intelligence and social action—i.e., the case of human societies—the capacity for achieving complex and sophisticated representations massively increases, thus dramatically expanding in space and time the range and variety of external tensions that such systems may be required to adaptively respond to.

Yet much depends on whether the degrees of freedom that are reduced to order parameters inside the system—via “effectively complex” representations and schema (Gell-Mann, 2002)—generate the levels of complexity required to “effectively” match the degrees of freedom encountered outside the system. These constitute a potential source of order that the system can leverage to its own advantage. In the absence of emergent order parameters, however, the tension(s) at R_{C1} is likely to create internal chaos rather than new order.

Having tipped over the 1st critical value, R_{C1}, agents enter the region of “*emergence*”—Kauffman’s “*melting*” *zone* (1993: 219)—between R_{C1} and R_{C2}, where self-organization occurs. The latter has long been termed the 2nd critical value—the so-called “*edge of chaos*” (Lewin, 1992). In the physical world this region is very narrow and precisely defined; in biological and social spheres it can be much wider, with the critical values varying considerably (Mainzer, 1994). Within this region, Bak (1996) identified a *third* tipping point—“*self-organized criticality*” (SOC)—where a system self-organizes to maintain itself in a particular state. To illustrate his idea, Bak referred to the slope of a sandpile. If one keeps adding grains of sand to the pile, at some critical point the slope becomes steep enough that tiny-to-large avalanches occur which flatten the steepness of the slope to a point where the grains of sand remain stable.

In living systems SOC is the point of adaptive stability—systems make continual small-to-large changes in maintaining efficacious adaptation. Whether or not this point is reached in human systems depends on whether the slaving process that creates the order parameters takes the form of a coercive top-down authority structure, or whether order parameters result from bottom-up self-organization by those involved (McKelvey, 2001, 2008). In any system, SOC is a function of (1) level of tension imposed; (2) degree of connectivity; and (3) the extent to which the connectivity is imposed top-down. Below R_{C1} nothing happens. But, as the levels of tension and connectivity increase to the point of *SOC*, at which self-organization not only emerges but maintains itself, adaptation occurs. Kauffman (1993) demonstrates that moderate connectivity offers the best chance of maintaining SOC and of pursuing fitness.[6] With zero connectivity, no learning occurs and there is no possibility of achieving SOC. With too much connectivity, by contrast, agents become paralyzed so that, again, neither learning nor SOC are achieved.

Bak claims that SOC reflects a universal law, as does Brunk (2002). Although some contest this claim (Frigg, 2003), we believe that the application of Haken's slaving principle to self-organizing processes makes SOC a pervasive phenomenon. Avalanches, earthquakes, and hurricanes are all responses to universal tension-inducing forces. Biological organisms respond to pervasive tensions induced by thirst, hunger, sex, for territory, predator-prey dynamics, etc. Intelligent social systems respond to all the above as well as to tensions induced by needs for sustenance, security, friendship, self-esteem, and self-actualization.[7]

To summarize: As connectivity gets established under conditions of increasing tension and the enslaving process reduces the available degrees of freedom, a *third* tipping point, *SOC*, is reached at which Kauffman's (1993) "*moderate complexity*" findings prevail. At this point a *moderate* degree of connectivity is most likely to trigger the tiny initiating events that lead to Gell-Mann's effective complexity and to the scalability dynamics previously discussed

2.6 THE ASHBY SPACE BETWEEN ORDER AND CHAOS

We depict the foregoing in what we label the *Ashby Space* (Boisot and McKelvey, 2007) in Figure 1. On the vertical axis we register the variety of external stimuli that an agent is subjected

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[6] Applications to organizations of Kauffman's idea and *NK* modeling are summarized in Maguire et al. (2006).

[7] Maslow hypothesizes that the latter are hierarchically ordered (Maslow, 1943).

to. On the horizontal axis we register the variety of responses generated by an agent. In each case, variety ranges from low to high. The diagonal indicates points at which the variety of responses is adaptive in that it at least matches that of the incoming stimuli. Adaptive responses locate an agent either on or below the diagonal. Taking variety as the external manifestation of complexity allows us to partition the Ashby space into different complexity regimes, namely Chaotic, Complex, and Ordered Regimes. In the diagram, for simplicity of exposition, we only partition the vertical axis—which describes incoming stimuli—into the three regimes

>>>Figure 1 about here<<<

We can now use this diagram to interpret Ashby's and Haken's theses. The horizontal arrow proceeding from point A to point B traces out a postmodernist implementation of Ashby's law. It expands the variety (degrees of freedom) of the response to match that of the stimulus—thus remaining in the Chaotic Regime. Ashby, however, does not distinguish between variety that should be treated as noise by the agent and variety that has relevance for it—a difference described by Gell-Mann (1994) as one between crude and effective complexity. In accommodating all variety (the weak voices) and refusing to be selective, the postmodernists' response contains too much variety to be effective—i.e., a postmodernist agent responds to variety as such with no attempt at selecting any one interpretation as a basis for responding.

The vertical arrow going down from A to C, on the other hand, describes a cognitive process of variety reduction undertaken by an *intelligent* agent—a scientist, for example—that *has* to be selective. Here the agent attempts to interpret the incoming stimuli and make sense of them by exploiting the latent regularities that they contain—what Gell-Mann terms their effective complexity. The postmodernist holds that such latent regularities are in the eye of the agent, and that in its concern to reduce the variety that it has to respond to so as to move into the ordered regime, the agent's reductionist strategy is often coercive rather than cognitive in nature.

We argue that organizational research will fare better by locating scholars somewhere in the region of point D in the Complexity Regime so that they may more easily progress toward Gell-Mann's effective complexity. This requires organizational researchers to buy into some of the basic tenets of evolutionary epistemology—the view that sciences progresses toward a higher probability of truth by slowly weeding out inferior theories (Hahlweg & Hooker, 1989; McKelvey, 1999; Radnitzky & Bartley, 1987). By all means generate epistemic variety, but do not then shrink from selecting from it. Defer to postmodernist sensibilities by making the selection more forgiving than the modernist would have it, but allow Haken's slaving principle to select a few interpretive schemata. Use these to gradually secure a collective interpretation of the stimuli in the ordered regime. Finally, accept that in pursuing this approach the pace at which knowledge accumulates in the ordered regime will be slower than in the natural sciences.

3 BRIDGING TO ORGANIZATIONS

In what follows, we argue that complexity theories offer us ways to select among the range of alternative hypotheses identified by postmodern epistemic strategies. They do so by exploiting the emergent properties of certain subsets of these. How? By exploiting the scalability properties of power laws and by applying abductive as well as inductive and deductive inferential strategies. We turn to this next.

3.1 APPLYING COMPLEXITY THINKING TO THE DEBATE

How might we interpret modernism and postmodernism using the Ashby space? To the extent that modernism aims for a stable and predictable order, it aims at reaching point C in Figure 1. To do so in adaptive ways, however, it will have to tame the variety that it encounters along the way and bring it under control. For this it needs fully predictive models that can extract the relevant information from the background noise in every situation that it encounters. The modernist agenda is built around the core assumption that this is possible. The postmodernist, by contrast, believes that this is only possible in very local situations, and the reach of such "local" models is very limited. Attempts to extend the reach of local models through "grand narratives" are invalid and doomed to failure. To the extent that postmodernism refuses to accord primacy to one interpretation over another, ideas such as Haken's slaving principle—like other modernist thinking—are dismissed as power-driven, coercive, and vulnerable to excessive simplification—i.e., reductionism. Postmodernists, therefore, are drawn back down towards point A. Yet such a response is both inefficient and wasteful of resources if incoming stimuli are high in noise content. If "anything goes" (Feyerabend, 1975), it can rapidly lead to disintegration. Is there, then, some intermediate trajectory in the space between these two alternatives? The complexity perspective we introduced earlier provides one.

3.2 TOWARD A PARETO-BASED SCIENCE IN THE COMPLEXITY REGIME

Given moderate connectivity and SOC emergent new order appears in the Complex Regime. It starts with tiny initiating events that propagate through small moderately connected networks, subsequently spreading through ever larger ones (McKelvey and Lichtenstein, 2007). It is increasingly evident that such order creation at the point of SOC—whether it applies to physical, biological, social, or organizational phenomena—is predicated upon scalability and fractal structures, both of which reflect power laws at work (Bak, 1996). Power laws and consequent Pareto rank/frequency distributions are the outcomes of connectivity and tension effects.

Power laws usually signify Pareto distributions. These have "*long tails*," potentially infinite variance, unstable means, and unstable confidence intervals (Andriani and McKelvey, 2007). We stylistically illustrate Pareto-distributed rank/frequency phenomena in Figure 2. Toward the lower-right in the diagram we see the increasingly high-ranked, very rare, *extreme* outcomes that defy prediction, i.e., earthquakes, floods, bankruptcies, stock-market crashes, large firms like Microsoft and Wal-Mart, etc. Such extreme and unpredictable outcomes place these phenomena in the Chaotic Regime—the connectivity dynamics that precede and generate them do not allow us to distinguish *ex ante* what is usable information from what is noise. Towards the upper-left, by contrast, we see a representation of the thousands of small outcomes—such as the ~16,000 quakes per year in California that most people never feel, or the 17 million Pa&Pa stores that didn't become Wal-Mart—that we usually treat as independent of each other and often feel comfortable summarizing with a normal distribution. These signify the Ordered Regime. The external application of an adaptive tension, however, increases the connectivity between phenomena and creates a bridge between the Ordered and the Chaotic Regimes of Figure 1. We call this bridge the Complex Regime; here, phenomena are much more likely Pareto distributed.

>>>Insert Figure 2 here<<<

Intelligent agents in the Ashby space can now be thought of as complex adaptive systems (CASs) striving for improved fitness, growth, and survival via self-organizing processes that we associate with the Complex Regime of Figure 1. Many of their behaviors and interactions reflect the existence of power laws at work. In order to economize on scarce energetic and computational resources, for example, they typically seek out the Ordered Regime in Figure 1. Occasionally, however, on account of their own collective actions or of naturally occurring events, they find themselves in the Chaotic Regime.

Intelligent agents act on the basis of beliefs and ontological assumptions—pre-modern, modern, postmodern, etc. Modernism expresses the ontology of the Ordered Regime of Figure 1, the region of atomistic independent events and of quantitatively testable predictions.

Postmodernism gives us the ontology of the Chaotic Regime in the Figure. It remains ensconced in the upper region of the Ashby space on the grounds that any move toward the lower region in the space involves sacrificing degrees of freedom, a process that, in their view, is driven by idiosyncratic interpretations of the phenomenal world and the social and psychological dynamics of status, power, and conflict. For them, Haken's slaving principle offers no royal road to truth. Postmodernists, then, are driven by an ontology of connectivity and interdependence rather than the atomistic one of independence.

The postmodernist is acutely aware that the explanatory tools forged by the modernist in the upper left region of Figure 2 rapidly lose their purchase as one moves down towards the right in the diagram, towards ever larger and more complex events. All too often, such moves degenerate into vaporous grand narratives built around a few arbitrarily selected variables of dubious explanatory value. Potentially meaningful degrees of freedom are then eliminated in an over-hasty search for the predictability and statistical significance characteristic of the upper-left region of Figure 2. Postmodernists are not alone in distrusting the explanatory power of grand narratives when these are applied to complex social systems. Robert Merton (1949), for example, also distrusted comprehensive systems theorizing. He wanted theories of the middle range—i.e., theories that deliberately limit their explanatory coverage. Modernists, on the other hand, argue that studies of extreme outcomes—typically the focus of case studies—that are unconstrained by positivist-like methodologies leave a science too vulnerable to the idiosyncrasies of individual interpretations and of socially inspired constructions, and hence too vulnerable to the power and control of the few. Reliable knowledge cannot be built on just-so stories.

Both modernists and postmodernists aim for reliable knowledge, but holding competing ontologies, end up talking right past each other. Figure 2, however, suggests that there is a time to be Gaussian and a time to be Paretian, and that it is the degree of adaptive tension present in a system—as indexed by some order parameter—that establishes the degree of connectivity present among phenomena, and thus points to the appropriate ontology. Brunk (2002: 36) says:

> Instead of the bulk of the data being produced by one process and the "outliers" by another, all events—both minuscule and the historically monumental—are produced by the *same* process in an SOC environment.

To be Paretian, one has to be willing to settle for anticipation rather than prediction, for being roughly right rather than precisely wrong. In a Paretian world, the "justification" of knowledge resides in its contribution to adaptability and survival rather than to the attainment of an eternal truth. The criterion of demarcation between science and non-science remains essentially Popperian since "false" knowledge threatens both adaptation and survival.

This insight has relevance for organizational research. If we view organizations through a network lens (Boisot and Lu, 2007), we see that organizational research studies the regularities that govern the interactions between different nodes in a network—i.e., the structure and the dynamics of their connectivity. Since nodes can be individuals, departments within an organization, or whole organizations, we see that many of the regularities may be scalable. And since connectivity is a variable that reflects the level of adaptive tension, organizational research must engage with the Pareto distribution as a whole without privileging one particular region at the expense of another. It cannot therefore presume that studies of "average" or "typical" organizations accurately reflect an entire Pareto distribution. As a leading complexity researcher, Axtell recently put it "*The typical organization does not exist*" (2008: paraphrased).

4 IMPLICATIONS FOR MANAGEMENT RESEARCH

4.1 MULTIPLE ONTOLOGIES AND EPISTEMOLOGIES

From the perspective of evolutionary epistemology, both the generation of variety and the selection from variety so generated are legitimate and essential steps in the creation of knowledge (Hahlweg & Hooker, 1989; McKelvey, 1999; Radnitzky & Bartley, 1987). Modernism, however, perceives the variety generated by postmodernist thought as excessive and not necessarily relevant to its agenda. Postmodernism, on the other hand, perceives the selection processes operated by modernist strategies to be unduly narrow, self-serving, and often coercive. Although neither perspective accords validity to the other, both are present in organizational research (Calás & Smircich, 1999; Clegg, Hardy, Lawrence, & Nord, 1996/2006; Locke, 2003; McKelvey, 2003; Westwood & Clegg, 2003). Yet, to the extent that they are believed to be paradigmatically incommensurate, they deprive management inquiry of a set of integrated foundational concepts that command consensus. It is therefore worth asking whether these two antagonistic perspectives can be reconciled.

We believe that the new sciences of complexity in general, and power-law thinking in particular, provide an encompassing set of concepts that help mitigate the centrifugal tendencies of variety generation central to postmodernist thinking. At the same time they legitimate a process of selective convergence on Gell-Mann's concept of effective complexity while avoiding its reduction to Gaussian statistics, and "averages." Here, Haken's slaving principle can help narrow down uncontrollable degrees of freedom, but this does not have to entail a swift or mindless leap into the Ordered Regime. Thus while complexity *concepts* find application in all three regimes in the Ashby space of Figure 1, the Complexity *Regime* in this space—far from operating some kind of compromise between competing modernist and postmodernist ontologies—establishes an ontology of its own together with matching epistemic strategies.

But how do Ashby and Pareto relate to each other? As long as events remain small, frequent, and unconnected—i.e., the level of adaptive tension in the system remains below R_{C1}—we can think of the upper-left region of Figure 2's stylized Pareto distribution as a platform from which we might see evidence of transitions from the Ordered Regime to the Complexity Regime of the Ashby space. In that region, we see a large variety of independent events characterized by massively reduced degrees of freedom, but with some *possibility* of increasing these. With sufficient increases in adaptive tension, however, *possibility* becomes *probability*: we can expect progression toward the lower-right region of Figure 2 under the influence of scalable—power-law driven—self-organization dynamics at the point of SOC. Eventually we encounter extreme outcomes, the products of myriad interactions that are scalable in nonlinear, non-predictable ways. The Pareto distribution as a whole then acts as a bridge between the edges of order and chaos, a bridge resulting from connectivities subject to adaptive tensions.

Organizational researchers study phenomena that typically fall somewhere within the Complexity Regime—i.e., they are neither so lacking in structure as to remain stuck in the Chaotic Regime of Figure 1, nor so structured as to end up in its Ordered Regime. The Complex Regime is the one in which the power-law distribution of Figure 2 makes its appearance. Yet while the ebb and flow[8] of adaptive tension allows travel in either direction along the Pareto distribution, modernist thinking wants to draw research permanently down into the ordered regime of Figure 1—this corresponds to the "Gaussian" region located in the upper left part of Figure 2—while postmodernist thinking believes that its rightful place resides up in the chaotic regime, i.e., the region of extreme events located in the lower right part of Figure 2. However, since variations in adaptive tension allow scalable outcomes to travel in either direction along the Pareto distribution, so should organizational analysis. How should it do this? By using an inferential strategy that we label *scalable abduction.*

[8] Needless to say, the size and frequency of the "ebbs and flows" of tension events are themselves Pareto distributed, as is characteristic of all change events at SOC.

4.2 SCALABLE ABDUCTION

Peirce used the term "*abduction*" to describe the way we construct possible explanations of puzzling phenomena—he sometimes called it *retroduction*. According to Peirce, "abduction…consists of examining a mass of facts and in allowing these facts to suggest a theory" (1935, p. 205); it is "*inference toward the best explanation*," one that turns on the coherence with which events can be related to each other (Thagard and Shelley, 1997; Thagard, 2006). Abduction provides: "Canons of reasoning for the discovery, as opposed to the justification of, scientific hypotheses or theories." (Audi, 1995: 1). Some see it as a variant on Bayesian inference (Niiniluoto, 1999; Thagard and Shelley, 1997). As Bayesian inference, however, abduction comes across as somewhat *reductionist*—it limits itself to studying the links among just a few underlying variables from which to update options. *Scalable abduction* infers toward the best *scalable* explanation, it studies multiple levels of explanation and the progression of outcomes as they move up or down the Pareto distribution. Thus, in abducing scalable causes and theories, scalable abduction draws on tiny initiating events, scalability, and power-law thinking to explain infrequently occurring extreme outcomes. With scalability, a given causal relation crosses multiple levels of explanation with a theory to match; Gell-Mann (2002: 23) calls it "*middle level*" theorizing. Thus, there is one kind of epistemology for the upper-left, another for the lower-right, and a third "scalable" epistemology, abduction, that bridges between them, exploring the dynamics by which certain tiny events come to generate extreme outcomes.

When applied to the distribution of phenomena governed by power-laws, scalable abduction offers an inferential process allowing one to derive limited but nonetheless useful expectations concerning multilevel system dynamics and the underlying scale-free causal processes that underpin them.[9] It allows one to ***anticipate*** outcomes. As noted earlier, anticipation is 'softer' than prediction, bridging between the strong predictions achievable in, say, particle physics and the unpredictable and often seemingly chaotic press of singular events that confront us daily at the human level. In sum, if Gaussian abduction takes extreme events to be outliers—too different from other events in the sample to be entertained as a probability and thus to form part of the distribution that one is called to respond to—scalable Paretian abduction incorporates outliers (some call these butterfly-events or frozen accidents) as forming a significant part of the distribution and, thus, requiring an adaptive response.

Even if they cannot make them *probable*—unstable means and potentially infinite variances prevent it—power laws signify the existence of scale-free phenomena worthy of our consideration—i.e., it renders them *plausible*. We may not be able to predict such events, but we can at least anticipate them. Both prediction and anticipation shape our expectations and orient our responses. Both draw on evidence for their justification even if anticipation achieves less precision than prediction. Although under conditions of complexity predictability is not on offer, anticipation remains adaptive and contributes to survival. What are the implications of this kind of reasoning for management inquiry?

4.3 MORE RIGOROUS WAYS TO STUDY N=1

Scalable abduction turns out to be the basis of Dilthey's (1959) *Verstehen* (understanding), a diacritical concept that distinguishes between the natural and the cultural sciences. While scalable abduction does not necessarily yield strong or precise predictions (Burrell & Morgan,

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[9] More specifically, one identifies scale-free dynamics by studying the many lower-level "tiny initiating events" some of which become butterfly-events that propagate and explode into the larger events and "frozen accidents" out in the Pareto tail. Once these regularities are discovered, one may extrapolate out to less frequent (more extreme) events that come with much stronger consequences

1979), it offers a new answer to the old question of whether a science of history is possible. Historicism argues that history is subject to laws that allow prediction. From a modernist perspective, however, samples of one—unique events—cannot exhibit law-like behavior and hence remain beyond the reach of prediction. Yet do we not also hear that those who fail to learn the lessons of history are condemned to repeat them? Could we not argue, therefore, that even though it does not allow the levels of prediction achievable in many parts of the natural sciences, abductive inference justifies a certain level of *anticipation*, a level that can be adaptive? A key challenge here is to separate the small events that are likely to remain independent (and random) from the small events that are likely to become scalable, given and driven by connectivities stimulated by adaptive tensions. Such events don't usually have labels on them telling us which is which, so that without some knowledge of scalable causal dynamics of the kind given in Table 1 and stylistically illustrated in Figure 2, it is hard to see how "butterfly-events" could reasonably be distinguished *ex ante* from random independent events.

>>>Insert Table 1 about here<<<

By focusing on circumstances under which independent events and processes connect up, power laws become the signature of SOC in natural and social systems. The message for management research is clear. It is not called upon to choose *between* Gaussian and Paretian perspectives—and, by implication, *between* modernist or postmodern ones. It must integrate both under a single overarching framework that offers guidance about (1) which distribution is appropriate to a given set of circumstances; and (2) which methods work best for each. But what methods best get us to actually *practice* anticipatory scalable abduction?

Some time ago, Eisenhardt (1989) stressed the advantage of using several cases for the purpose of conducting inductive research. We take this idea a step further here. While most case analyses are about good or bad examples, drawn from history and/or from firms, and while these cases are often selected because they make interesting stories—i.e., they are non-average or unusual—they are not necessarily about extreme outcomes. Suppose, however, that we have a set of cases describing just such extreme outcomes—perhaps collected in book form, as with Peters and Waterman (1982) or O'Reilly & Pfeffer (2000).[10] These cases are typically written from the point of view of one or two privileged observers claiming access to a "deep truth"—a "God's Eye View" (Hendrickx, 1999: 342). To understand what generated an extreme outcome, we need to apply the principles of scalable abduction. We might, for example, draw on multiple observers in the case of a once-in-a-lifetime extreme event—as is practiced in earthquake science where #9 quakes occur once per century.

Scalable abduction relies on the coherence of the inferential process and calls for a hermeneutic approach. In a 1975 article, Donald Campbell recanted his earlier dogmatic disparagement of case studies, accepting that "…each ethnographer be asked to cross-validate, and invalidate, the other's interpretation of the culture they had studied in common" (p. 191). For enhanced scientific credibility, then, we call for *multiple* observers of one or more cases. From hermeneutics we accept the *Principle of Charity*—at the outset all individuals and all perspectives have equal credibility (Hendrickx, 1999). A coherent theory of the phenomena then emerges from the interplay of various idiosyncratic initial interpretations of one or more cases. The events described in the actual cases are taken as having an objective reality—they exist independent of the eye of the beholder (Campbell, 1958). Campbell (1991) drew on the "validity-seeking" hermeneutic circle that achieves ever greater *verisimilitude*—truthlikeness—by iterating parts and wholes (Popper, 1935). He argued that increased trust among multiple

[10] One might think that Collins' book, *Good to Great* (2001) should be mentioned. But, in fact, it is an example of Collins and his *team* working up the book. It is a pretty good example of hermeneutics in action in the modern day.

observers, each matching patterns (hypotheses) against phenomena and against those of colleagues, would gradually increase cross-observer correspondences and improve the quality and scope of explanations (McKelvey, 1999). Campbell also cautioned: "This is not to say that such common-sense naturalistic observation is objective, dependable, or unbiased. But it is all that we have. It is the only route to knowledge—noisy, fallible, and biased though it be" (p. 179).

5 CONCLUSION

Our paper is a plea for a new direction in organization and management research, and more broadly in the social sciences. The paradigmatic competition between modernism and postmodernism has not been fruitful. Natural scientists continue to espouse the modernist stance and many social scientists that of postmodernism (Kelso & Engstrøm, 2006). Consequently, the legitimacy-bases of would-be truth-claims from management research remain in an epistemological quagmire. Morin (1992), however, points out that the distinction between the natural and the social sciences is now dissolving and that the new complexity sciences are accelerating the dissolution process. In particular, the complexity perspective suggests that where prediction is not on offer, *anticipation* remains adaptive and hence a legitimate goal for scientific endeavors. Thus while the criteria of demarcation that separate science from non-science need not be abandoned—as advocated by Feyerabend and some postmodernists—they need to be more accommodating than those put forward by the modernists.

We draw on ideas from complexity science to suggest ways of building epistemological bridges between the order-seeking regime of the modernists and the richness-seeking regime of the postmodernists—between those accounts that minimize degrees of freedom by theorizing and those that take degrees of freedom as they find them. We draw on Gell-Mann's (2002) concept of effective complexity principle to set the target for an efficaciously adaptive number of degrees of freedom in social dynamics and we posit that the conjunction of tension and connectivity in social phenomena gives rise to Pareto rank/frequencies rather than normal distributions.

We propose using scalable abduction, hermeneutics, and coherence theory to strengthen truth-claims based on isolated idiosyncratic outcomes of the kind that characterize the lower right hand region of Figure 2. As organizational researchers gradually move beyond samples of one that are characterized by high degrees of freedom, and toward the opposite Pareto extreme of large samples characterized by low degree-of-freedom, they need to draw from a variety of research methods adapted to the nature of the distributions that they confront. Organization researchers study interdependent agents—individuals, departments, firms, etc—in interaction and these simply do not behave like a collectivity of autonomous agents. Informed interaction is the stuff of organization and, indeed, of life itself. Postmodernists organizational researchers are right in thinking that the complexity that results is not well captured by the analytical tools forged by modernist thinking. They are, however, wrong in thinking that such complexity is beyond the reach of any kind of analysis.

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Figure 1: Three Regimes in the Ashby Space

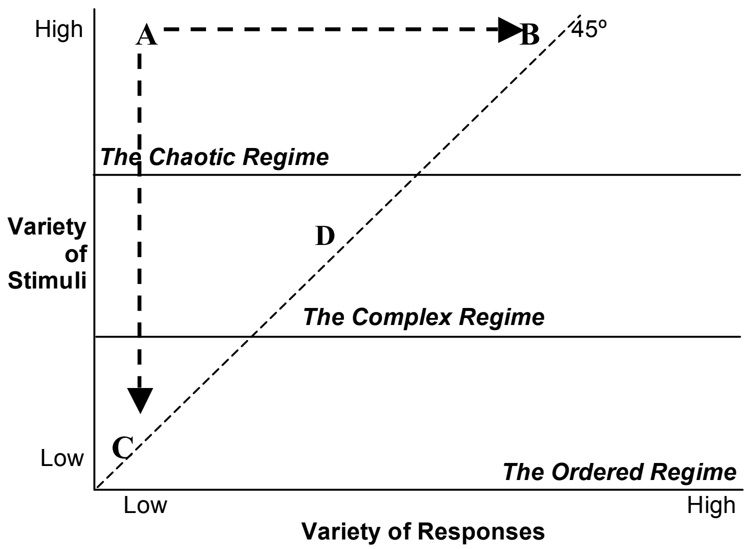

Figure 2: Stylized Pareto Distribution on Log-Log Scale

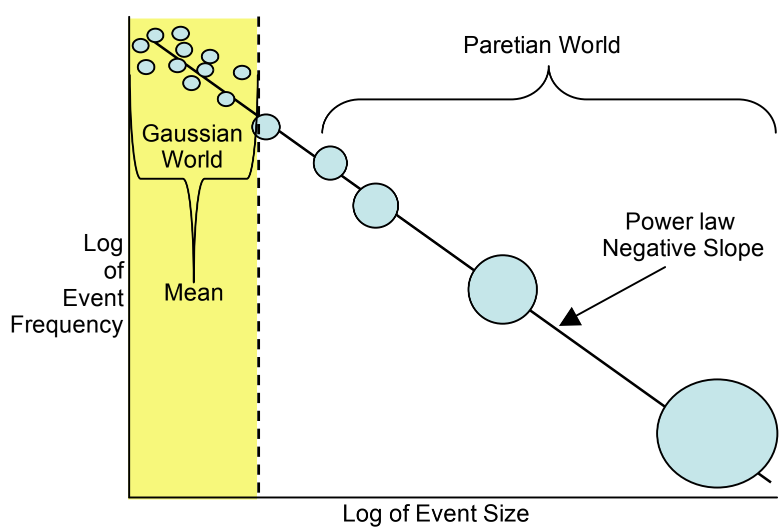

Table 1: A Sample of Scale-free Theories of Nature†

1. *Phase transition*: Exogenous energy impositions cause autocatalytic, interaction effects such that new interaction groupings form (Prigogine, 1997).

2. *Spontaneous order creation*: Heterogeneous agents seeking out other agents to copy/learn from so as to improve fitness generate networks; with positive feedback, some networks become groups, some groups become larger groups & hierarchies (McKelvey & Lichtenstein, 2007).

3. *Preferential attachment*: Given newly arriving agents into a system, larger nodes with an enhanced propensity to attract agents will become disproportionately even larger (Barabási, 2002).

4. *Combination theory*: Multiple exponential or lognormal distributions or increased complexity of components subtasks, processes) sets up, which results in a power law distribution (Newman, 2005; West & Deering, 1995,)

5. *Least effort*: Word frequency is a function of ease of usage by both speaker/writer and listener/reader [Zipf"s (power) Law]; now found to apply to firms and economies in transition (Ishikawa, 2006; Podobnik et al., 2006)).

6. *Square-cube law*: Surfaces absorbing energy grow by the square but organisms grow by the cube, resulting in an imbalance; fractals emerge to balance surface/volume ratios (Carneiro, 1987).

7. *Connection costs*: As cell fission occurs by the square, connectivity increases by $n(n-1)/2$, producing an imbalance between the gains from fission vs. the cost of maintaining connectivity; consequently organisms form modules or cells so as to reduce the cost of connections (Bykoski, 2003; Simon, 1962).

8. *Self-organized criticality*: Under constant tension of some kind (gravity, ecological balance), some systems reach a critical state where they maintain stasis by preservative behaviors—such as Bak"s small to large sandpile avalanches—which vary in size of effect according to a power law (Bak, 1996).

† We use nine out of fifteen scale-free theories discussed by Andriani and McKelvey (forthcoming).