CONCEPTOS
Y FENÓMENOS
FUNDAMENTALES
DE NUESTRO
TIEMPO
UNAM

UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO
INSTITUTO DE INVESTIGACIONES SOCIALES

# COMPLEXITY AND THE SOCIAL SCIENCES

RICHARD E. LEE

Octubre 2005

# COMPLEXITY AND THE SOCIAL SCIENCES*

Por Richard E. Lee[1]

There is nothing new in the realization that the social world is complex. Indeed, one of the primary considerations of social analysts has been, and in fact remains, whether or not it might be possible, or even advantageous, to simplify that complexity. All the same, over the past 150 years much social science work has dealt with procedures with this end in view. However, although the concern with complexity, whether reducible or not, is not new, the emergence of complexity studies in the sciences and mathematics does, I shall argue, cast new light on the question.

The end of the third great world conflict of modern times in 1945[2] was marked by conjunctural fluctuations of the processes reproducing the long-term structures of the modern world in the realms of production and distribution and coercion and decision-making. These were manifested as a Kondratieff A-phase of world economic expansion and the beginning of the period of U.S. hegemony in the interstate system. However, today we are living through a period characterized in the economic arena by a world-scale crisis of capital accumulation and in the geopolitical arena by intractable difficulties in reestablishing medium-term stability that all indications suggest are long-term, rather than cyclical, in nature.

In the third great realm of system processes co-constitutive with the economic and the geopolitical in reproducing the structures of the modern world, that of the structures of knowledge or the arena of cognition and intentionality, the existence of a long-term crisis, not just a medium-term, conjunctural adjustment, became observable after the upheavals of 1968. Indeed, today the processes reproducing the structures of knowledge are just as much in crisis as economic and geopolitical processes, suggesting that this is a single, secular crisis of the constitutive social relations of the modern world-system and that we are living

---

[1] Fernand Braudel Center, SUNY-Binghamton, Binghamton, NY 13902-6000 rlee@binghamton.edu

* Paper prepared for the conference “75° Anniversario, Instituto de Investigaciones Sociales, 1930-2005”, Instituto de Investigaciones Sociales, Universidad Nacional Autónoma de México, Mexico City, 27 June – 1 July 2005; forthcoming in *Review*.

Some of the material presented in this paper has appeared previously in my "Complexity Studies," in *Overcoming the Two Cultures: The Sciences versus the Humanities in the Modern World-System*, co-coordinators Lee, Richard E. and Immanuel Wallerstein (New York: Paradigm, 2004, 107-17) and “Social Knowledge for a World in Transition: Sociocybernetics and the Contemporary Transformation of the Structures of Knowledge,” *Kybernetes* **35**, 1/2, 2006.

[2] The Thirty Years' War, the French Revolutionary/Napoleonic Wars, the 1914-1945 World War(s).

through a transition leading to their transformation (see Hopkins and Wallerstein et al. 1996). This seems to me the most basic consideration from which social analysis must begin today and it is from this starting point that I will examine the relationship between complexity studies and the social sciences.

In the simplest terms, by the structures of knowledge I mean those patterns of what can and cannot be thought that determine what actions can and cannot be deemed feasible in the material world. These structures of knowledge of the modern world, which emerged along with the axial division of labor and the interstate system during the transition from feudalism to capitalism in the long-sixteenth century, are unique in human history in that they admitted as legitimate two ways of knowing, rather than just one. Those two ways of knowing were premised on a differentiation and separation between "truth" and "values" and were eventually institutionalized as a hierarchical separation between the "sciences" and the "humanities". The medieval structures of knowledge recognized diverse fields or subject-matters, yes (rhetoric was obviously not astronomy), but not differing bodies of knowledge based on contradictory visions of the way the world worked, which would become the norm. The mechanisms, such as the establishment of double entry bookkeeping and the renewal of the authority of the principle of the excluded middle, were clearly articulated with the political and economic developments we generally consider the markers of the transition: the rise in the status of merchants and the legitimation of profit-making (the virtù of the balance in the “bottom line”) and the transformation of the basic political entities of “realms” based on “parcellized sovereignty” into “states” with borders.

The long-term trend deepening this structure underwent two great conjunctural adjustments or "logistics" analogous to the waves of expansion and contraction in the economic arena and the cycles of relative concentration of power in the geopolitical realm (see Lee 2003a): first, the seventeenth-century Newtonian synthesis between Baconian induction and empiricism and Cartesian deduction and rationalism, which created the foundation for the dominant theoretical approaches and methodological practices in the sciences and led to the solidification of the separation of the sciences from the humanities; and second, the late nineteenth-century creation of the social sciences, situated in between the sciences and the humanities. The putatively value-neutral social sciences, which seemed to offer the possibility of a “scientific” or non-value-oriented policy-making process in the service of “progress”, came to occupy a tension-charged space in the wake of the irresolvable contest between the equally value-laden, but mutually exclusive, positions taken by conservatives and radicals in the humanities on the political future of the world following the French Revolution. The political consequences of this medium-term solution was the “scientific” legitimation of the hierarchical placement of groups on a racialized and gendered world division of labor and the rise of the “new liberalism” effectively eliminating clear alternatives.

Thus, this division of labor found on one side the factual, universal, positivistic, empirical, objective, fact-producing, and quantitative disciplines of the sciences engaged in explaining order in a world where past determined a predictable future via universal laws. On the other side was to be found the particularistic (for instance, with regard to social contexts, locales, or time frames), chaotic, value-oriented, and qualitative disciplines of the humanities where scholars dealt with an unpredictable and relativistic world of free human agency. In their continuing quest for legitimacy, the social science disciplines continued after 1945 to be torn between the scientism, in both theory and method, of economics (econometrics), sociology (structural-functionalism), and political science (behaviorism) and the more narrative bent of history and anthropology. Although all the disciplines exhibited to some extent both tendencies, scientism seemed to be gaining throughout, even in history and anthropology. Similarly, even the humanities, in their effort to retain a credible voice, sought to echo the decontextualization, atemporality, and presumptive objectivity of the sciences. Twentieth-century “new criticism,” for instance, rebelled against the romantic exaltation of the poem as a reflection of the personality of an exceptional individual (the so-called intentional fallacy) or the impresssionistic record of interior experience (the so-called affective fallacy). It tacitly privileged the individual creator and separated him (sic!) from the unique object, the text (conceived as a repository of meaning), to be interpreted using such approaches as “close reading.”

The tensions have remained apparent in the epistemological debates over reductionism versus holism, structure or determinism versus agency or freedom, and order versus disorder—each antinomy manifesting the division between the sciences and the humanities. However, just as the acceptance of this structure, and its hierarchy, as natural and beyond question reached its peak in the post-1945 period, and, like the axial division of labor and the interstate system, it became global in extent, within the sciences were appearing voices that diverged from the standard positivistic, analytic model in the direction of an organic, relational model.

Over the two decades after 1945, an ensemble of new approaches to scientific inquiry gained ground in opposition, especially, to the reigning positivism and reductionism. In one way or another these new approaches were conceived as appropriate to the study of "systems that are intrinsically complex", as Ross Ashby noted (1991[1958]: 249). Organized complexity, the middle ground Warren Weaver (1948) posited between simplicity (the problems of classical physics with few variables, the realm of necessity) and disorganized complexity (problems with many variables amenable to statistical description where chance holds sway), had proven particularly resistant to the analytic method, that is, to the development of mathematical models or equations expressing general laws in which all contributing causal factors appeared as variables. The issues involved were addressed by, among others, the elaboration of General System Theory (GST) and Cybernetics.

Exemplary in the work of Ludwig von Bertalanffy,3 the domain of GST may be specified as those general aspects, correspondences and isomorphisms or rigorous analogies that are common to systems in general. GST cut across disciplinary, cultural, and ideological lines. It tended to negate the nomothetic-idiographic or quantitative-qualitative divide and was "apt to bridge the opposition of C.P. Snow's 'Two Cultures'" (von Bertalanffly 1968: xxiii) of the sciences and the humanities. In the living world, and the more so in the human world, there were no apparent analogues of the laws of motion. Thus, this scientific reorientation called for inquiry into questions of organization and configurational wholes, those "wholes" that had been shunned as metaphysical by the logical positivists, over the analytic, mechanistic and summative causality of classical science and its primary units of discrete elements or events.

During the same post-war period in the social sciences, a mode of inquiry, theorized as structural-functionalism and operationalized through quantitative techniques and survey data, progressively came to define macro social research. This was the heyday of

---

[3] In 1968 von Bertalanffy published *General System Theory: Foundations, Development*, Applications; this work, however, reproduced articles going back to 1940. In 1954, von Bertalanffy formed the Society for *General Systems Research* with Kenneth Boulding (an economist), Ralph Gerard (a physiologist), and Anatol Rapoport (a mathematical biologist).

"modernization theory". Modernization theory expressed, within the structures of knowledge, the conjunctural context of the world economy and geopolitics: the real concern for large-scale inequalities during the Kondratieff expansion and the search for cold-war allies to bolster (or contest) U.S. hegemony. From the beginning the foundation was in "systems analysis”, but the methodology was comparative, necessitating multiple units, and the goal was to explain (and thereby imply remedies for) differential development on a world scale. GST provided the explicit framework for conceptualizing social structures and institutions as performing functions in systems where a "society" was a self-sufficient social system. But "societies" were ultimately associated with the state and time was conceived as a function of autonomous society/state units positioned at different points on a putatively single developmental trajectory (“horizontal history”). Finally, intentional action modifying social structures was postulated as a primary mechanism of change and "progress."

At various points in the work of von Bertalanffy from the 1940s through the 1960s are to be found statements indicative of how applying GST to the "sciences of man" at the macro level could result in a transformed vision of such inquiry. For instance, von Bertalanffy wrote that "[h]istory is not a process in an amorphous humanity, or in Homo sapiens as a zoological species. Rather it is borne by entities or great systems, called high cultures or civilizations ... each presenting a sort of life cycle" (1968: 200). This reflection included the world of contemporary social relations. He also noted the level of technological development and the planetary extent of "our civilization ... which explode the cyclic scheme of history and seem to place our civilization at a different level from previous ones" (1968: 204). The consequence, of course, is that "our civilization"—the modern world-system, if I might editorialize—was not amenable to explanation via comparative analysis, but rather would have to be treated as a system comprising a singular and unique unit of analysis.

Cybernetics derives its name from the Greek word for steersman and thus means something on the order of the art of steering. Cybernetics as it first developed from the 1940s belied an engineering approach and was particularly concerned with technological systems (homeostasis or equilibrium maintenance) in which negative feedback loops and circular causality figured prominently. Writing from the perspective of what would come to be called first-order cybernetics, Norbert Wiener anticipated a fundamental concern. He noted that “[a]ll the great successes in precise science have been made in fields where there is a certain high degree of isolation of the phenomenon from the observer. ... It is in the social sciences that the coupling between the observed phenomenon and the observer is hardest to minimize” (1948: 162-63). The term, second-order cybernetics was invented by Heinz von Foerster in the early 1970s. The field deals primarily with living systems and, unlike first-order cybernetics, explicitly includes the observer and considers a series of "self"-prefixed characteristics (self-organization, self-steering, self-reference, autocatalysis, autopoiesis).

But these have not been easy roads. In matters of application, Anatol Rapoport, an early protagonist of GST, has been concerned with the exploitation of systems approaches in the management of military organizations and in consulting work where the goal was corporate profit-making (1998: 16). Felix Geyer has articulated the larger question:

the more realistic—and therefore less parsimonious—a theory, the more complex it becomes, and the more difficult to test the hypotheses and subhypotheses derived from it which are used in collecting and interpreting the data. ... For the time being, sociology should perhaps … force itself to give up the ambition to make accurate medium- and long-term predictions, except in delimited areas of research where complexity is still manageable or can be more or less contained (1995: 28).

This statement alludes to both a boundary problem and to the ultimate ambition of the social sciences, prediction. On the one hand, it has become clear that defining a set of interactions for which the external context can be ignored (in the sense of having negligible impact) is extremely problematic. On the other hand, work in contemporary complexity studies (see Lee 1992) shows that prediction itself is possible for only a subset of systems studied even in the natural sciences, and then only under certain, limited circumstances—much less for the world of human interactions.

At the very moment of the worldwide triumph of the Newtonian worldview, that is of a deterministic world of natural laws based on time-reversible dynamics, a new knowledge movement that would challenge its premises began to take root. This movement, which eventually came to be known as complexity studies, was an outgrowth of the internal advance of science itself. Paul Davies (1989) has characterized contemporary scientific research as falling into three categories—at the frontiers of the very large, the very small, and the very complex. This new appreciation of complexity, foreseen by Warren Weaver, dealing with the universal features of complex systems, irrespective of the peculiar aspects of the different systems, is especially marked with regard to humanly perceivable macrosystems.

Although there is no consensus on the exact meaning of "complexity," during the last four decades it has become increasingly apparent that there exist complex phenomena that arise from very simple mechanisms (Aida et al. 1985; Atlan et al. 1985; Cowan, Pines & Meltzer 1994; Peliti & Vulpiani 1988; Stein 1989; Waldrop 1992; Lee 1992). The rethinking that we are witnessing today, which has grown out of concrete research in complex systems, represents a synthetic approach as opposed to a reductionist one; indeed, a science of complexity holds out the possibility of representing change—that is, "describing our collective reality as a process"—without reverting to reductionism (Casti 1994: 273). It marks a shift away from the Newtonian worldview emphasizing equilibrium and certainty and defining causality as the consistent association of antecedent conditions and subsequent events amenable to experimental replication and hypothesis testing.4

The field, which also involves strong cross-disciplinarity (e.g., Cutright 2001; Goertzel 1994; Kiel and Elliot 1996) and the effort to include "intractable" problems (Pagels 1988; Stein 1989), exploded in the late 1970s, especially after the first conference devoted to the subject of "chaos" in 1977 (Gleick 1987: 184). Along with the creation of new journals (including Complexity, founded in 1995) and scholarly associations, PhD programs, subfields, and even new university departments, there have also been major extramural institutional ventures devoted to the study of complexity. One such has been the Santa Fe Institute where, according to Murray Gell-Mann, the aim was to create a new kind of institution "free from the drag exerted by past specialization and the tyranny of the departments" by recruiting "Odysseans," those "tortured souls" who find themselves in the middle between the Apollonians tending "to favor logic, rationality, and analysis" and the Dionysians, who "go in more for intuition, feeling, and synthesis" (1988: 14, 12).

---

[4] In 1986, Sir James Lighthill, President of the International Union of Theoretical and Applied Mechanics, apologized on behalf of "practitioners of mechanics . . . for having misled the general educated public by spreading ideas about the determinism of systems satisfying Newton's laws of motion [implying complete predictability] that, after 1960, were to be proved incorrect" (1986: 38).

It has generally been argued, first, that complexity is linked to nonlinearity. Second, work in the expanding field of complexity, especially of chaos, or seemingly random behavior that displays an underlying order—order-in-chaos (strange attractors); order-out-of-chaos (self-organization, dissipative structures); and visual representation of pathological functions and natural forms exhibiting noninteger dimensions (fractal geometry)—either constitutes an implicit call for a reappraisal of the assumptions of classical science or actively undertakes a reconceptualization of the objects of study, methods of analysis, and goals of inquiry long taken for granted as constituting "scientific" practice.

Although all developments were not equally successful, as evidenced by the history of catastrophe theory, what did turn out to have enormous resonance in the long run, in terms of extensive theoretical pertinence and broad areas of application, was the study of chaos. The recognition of the existence of chaotic behavior exhibited by nonlinear systems flew in the face of Laplacian predictability. As these systems evolve over time, they rapidly magnify small perturbations and are thus highly sensitive to small changes in initial conditions. Despite this, there remains evidence of an embedded order underlying the seemingly random evolution of certain dynamical systems. A breakthrough came with the discovery of "strange attractors," beginning with the identification of the elegant "butterfly" attractor of Edward Lorenz. By accident, Lorenz had discovered in his rudimentary computer simulations of the weather in the early 1960s that his simple system diverged dramatically from arbitrarily close initial conditions rather than maintaining approximately the same behavior when starting from approximately the same points. The mathematical system Lorenz studied, three equations in three variables, visualized by plotting each iterative solution set graphically in phase space, neither converged to a single point or steady state nor a periodic loop or continual repetition. His system was infinitely complex and nonperiodic; it never passed through any single point more than once (Lorenz 1963a, 1963b, 1964). Unaware of Lorenz's work, in 1971 David Ruelle and Floris Takens (1971) invented the term "'strange' attractor" to describe such phase-space portraits of the stable but nonperiodic behavior of a dynamical system. Tien-Yien Li and James A. Yorke (1975) first defined "chaotic" as describing a nonperiodic $\{\mathrm{F}^n(x)\}$ sequence in 1975.

The development of what came to be loosely known as chaos theory on so many fronts opened up the possibility of applying deterministic models, formerly restricted to the "closed universe" of "completely predictable systems," rather than stochastic models, to certain systems that behave randomly. Such randomness, of course, leaves open a place for chance and therefore creativity and change. But in natural systems, not all theoretically possible states turned out to be realizable. Only some, those that lie on the strange attractor of such systems, will actually appear in nature. Ivar Ekeland has called this an "admirable and subtle mix of chance and necessity" (1998: 13, 12, 15).

Doyne Farmer and Norman Packard asserted that the "new wave science" addressed questions that "cry out for synthesis rather than reduction" (Farmer et al. 1986: viii), where research on systems involving at least two time scales is based on simulation and cuts across disciplinary lines. This was no longer a question of one problem, one answer but of following the evolution of an existing system or setting up a model, watching it evolve, and observing changes in its development as perturbations are introduced. Such simulation is computation-intensive, and paper and pencil were adequate only where linear systems were involved. None of this new work would have been possible without high-speed computing. According to Ivar Ekeland, the computer "reveals to the mathematician the phenomena to study and the mathematician exposes the limits of the computer. . . . The power of calculation available to men from now on is changing their universe. It is transforming their environment, it is transforming their societies, it is transforming them, it is transforming their science. Chaos theory is a beginning, not an end" (1998: 18, 21). Indeed, it might be argued that among the unanticipated consequences of the qualitative changes we have seen in recent times, speed of computation, for instance, may be one of those parameters, which by surpassing a threshold (analogous to a change in heat input resulting in water passing from a solid to a liquid state), has contributed to initiating a transformation of the relational structures of the modern world-system.

Although chaos, like complexity, found multiple meanings (Gleick 1987: 306), a new view of the world—of the nature of physical reality, of change and predictability, and of clear disciplinary boundaries among problem sets as well as research strategies—was being born. "Hard" scientists were using mathematics in new ways and mathematicians seemed almost to be doing experiments. With Mitchell Feigenbaum's (1983) discovery of universality in cascading bifurcations of certain nonlinear systems, the mesoscale of humanly perceivable phenomena gained a universal constant that indicated that systems from such varied fields as mathematics, population biology, and fluid dynamics behaved identically in one fundamental, and measurable, way.

In the classical quest for simplicity, it was the nonlinear elements of the equations describing system evolution that had to be finessed through linear approximations. Markus, Müller, and Nicolis (1988), however, presented the emergence of nonlinearity as a unifying principle in which universalities in a variety of open, self-organizing systems (that export entropy into their environment) offered a common language to chemists, biologists, ecologists, physicists, mathematicians, and medical doctors. Drawing on an immense body of work by Ilya Prigogine (which won him the Nobel Prize) and carried on with his colleagues in Austin and Brussels where complexity has been understood in terms of system “behavior” rather than of system interactions (Nicolis & Prigogine 1989), Prigogine and Isabelle Stengers (1984) presented chaos not as the opposite but as the source and confederate of order. They considered that a conceptual transformation of science was taking place. This transformation was growing out of the challenge to Newtonian mechanics associated with contemporary research in thermodynamics focusing on nonlinearity (instability, fluctuations, order-out-of-chaos) and the irreversibility of the evolution of far-from-equilibrium, open systems, characterized by self-orga-nizing processes and dissipative structures.

Bénoit Mandelbrot (1983) has shown how “the same pathological structures that the mathematicians invented to break loose from 19th-century naturalism turn out to be inherent in familiar objects all around us” (Mandelbrot 1983: 3–4). His fractal geometry describes shapes that fit somewhere between the Euclidean categories of points, lines, planes, and solids. Although when compared with the ordered mathematical world of Newton and Descartes, the world of Cantor’s sets and Peano’s space-filling curves were a wrenching affront to commonsense; but indeed, the undeniable aesthetic appeal of these self-similar structures with

noninteger dimensions is due to the fact that the physical world is made up of them. Examples include Mandelbrot’s now classic description of the coastline of Britain that increased in measured length as the length of the measuring tool decreased, and pulmonary and vascular systems whose volumes were found to be inadequate to hold their known contents. Fractals have also been associated with strange attractors and representations of the temporal evolution of real-world systems. The ubiquity of fractals expresses the particular combination of order and disorder characteristic of complexity studies in general and has furnished a powerful and stimulating new mode of description refocusing attention on the whole and challenging reductionism.

Implicit in complexity research is a call for a reconceptualization of time itself, an undoing of the perspective of classical science, described as follows by Prigogine and Stengers: “The integration of the laws of motion leads to the trajectories that the particles follow. . . . The basic characteristics of trajectories are lawfulness, determinism, and reversibility. . . . The remarkable feature is that once the forces are known, any single state is sufficient to define the system completely, not only its future but also its past” (1984: 60). In the light of instability and chaos, and the association of the arrow of time with order as well as disorder, Prigogine and Dean Driebe have maintained that the laws of nature now express possibilities instead of certainties. There is no longer any contradiction between dynamical and thermodynamical descriptions of nature. Far from being a measure of our ignorance, entropy expresses a funda-mental property of the physical world, the existence of a broken time symmetry leading to a distinction between past and future that is both a universal property of the nature we observe and a prerequisite for the existence of life and consciousness (1997: 222).

Such conclusions explicitly contradict the duality of determinism and probability in our understanding of “life in the universe” expressed once again by Steven Weinberg (1994) and the duality inherent in the introduction of the so-called anthropic principle by Stephen W. Hawking along with his association of time with a geometrical cosmology (1988). But Weinberg constructs the world from the bottom up, from simple laws, and contends, echoing Ludwig Boltzman, that “thermodynamics has been explained in terms of particles and forces” (Rothman 1997: 28). For Prigogine, on the other hand, it is a top-down world:

In order to determine whether . . . coffee is aging [cooling] I cannot consider the water molecules taken separately. If I do that I will not see the aging process. But if I consider the relationship between molecules I can then see quite clearly that the coffee is aging. We must view the encounters, the collisions and correlations between molecules in order to see the flow of time. . . . This is the time of humanity, or the time of recollections and not the time of human beings taken separately. The concept of time is dependent on a collective approach (Prigogine in Snell & Yevtushenko 1992: 24–25).

Of course, these views remain controversial. Gell-Mann has contended that irreversibility might be nothing more that an artifact of “coarse graining,” or incomplete information, that is, our own ignorance (1994). This is certainly not true for Roger Penrose, who would agree with Prigogine that it is the fundamental laws of physics as now understood that inhibit our understanding. Even Penrose, however, like Hawking and Weinberg, nurtures a worldview ultimately rooted in time-symmetric theories. In the words of Tony Rothman, “Weinberg [has] maintained that philosophy had done science more harm than good [and has] declared that, for the most part, ‘the results of research in physics . . . have no legitimate implications whatever for culture or politics or philosophy’.” Rothman reckons that “Prigogine sees himself as a counterforce—perhaps the counterforce—to Weinberg, Penrose, and Hawking” (Rothman 1997: 29).

Prigogine, looking for the roots of time, “became convinced that macroscopic irreversibility was the manifestation of the randomness of probabilistic processes on a microscopic scale. But what then was the origin of this randomness?” (1996: 60). His answer hinges on

a unified formulation of quantum theory incorporating Poincaré resonances into a statistical description and deriv[ing] diffusive terms that lie outside the range of quantum mechanics in terms of wave functions . . . to achieve the transition from probability amplitudes to probability proper without drawing on any nondynamical assumptions. . . . [T]he observer no longer plays any special role. The measurement device has to present a broken time symmetry. For these systems, there is a privileged direction of time, exactly as there is a privileged direction of time in our perception of nature. It is the common arrow of time that is the necessary condition of our communication with the physical world; it is the basis of our communication with our fellow human beings. (Prigogine 1996: 53–54)

The recognition that probability is more fundamental than trajectories implies what Prigogine (1996) calls “the end of certainty,” and the end of certainty in scientific prediction connotes an open future of creativity and choice in natural systems and, as a consequence, a vindication of freedom, agency, and creativity in the development of social systems, but with particular significance in times of crisis or transition. Robert Shaw has underlined the creative aspect of chaotic behavior. It is, he notes, “completely ubiquitous in the physical world.” Strange attractors transmit perturbations from the microscale to the macroscale: “The constant injection of new information into the macroscales may place severe limits on our predictive ability, but it as well insures the constant variety and richness of our experience” (1981: 107, 108).

Not only has a significant scientific subculture of complexity studies or “complexity community” developed (Cowan, Pines & Meltzer 1994: xvi), but also the abundance and scope of popularizations attest to the wide resonance and cultural influence of these recent developments. Now, there are those who argue that models developed for the study of complexity can be usefully, and directly, appropriated for the study of human reality. There is a literature dedicated to such applications. More importantly, the emphasis in complexity studies—on contingency, context-dependency, multiple, overlapping temporal and spatial frameworks, and deterministic but unpredictable systems displaying an arrow-of-time—suggests, as some scientists are beginning to say, that the natural world as they now see it is beginning to more closely resemble the social world, rather than vice versa, as unstable, complicated, and self-organizing, a world whose present is rooted in its past but whose development is unpredictable and cannot be reversed. The vision of truth-values governed by the law of the excluded middle that has underpinned enduring ideas of classical logic, science, and common sense seems now to demand a reformulation in order to conform, in the language of complexity, to an image of possibility basins separated by fractal boundaries. Herein lies the real impact on the social sciences.

The question remains, if complex behavior is not amenable to explanation through hypothesis testing and theory construction because such systems, including now social systems, albeit deterministic, are inherently unpredictable, how can we proceed? Indeed, the hypothesis testing mentioned earlier may be part of the contemporary epistemological quandary. In fact, it is part of a framework oriented towards the development of explanations for particular phenomena and the generalizations on which such explanations rest. This framework includes the corollary that once the theory is known, outcomes of specific interventions can be predicted and, therefore, social science knowledge can be exploited in policy-making. This was the basis for the cross-national comparative research (the analogue of laboratory studies in the natural sciences) on which modernization theory depended. By the 1960s, the empirical failure of this work called seriously into question its theoretical and methodological underpinnings (not incidentally, just as the world-economy entered a period of contraction, U.S. hegemony came to an end, and the politics of knowledge formation became an issue for anti-systemic movements).

One answer to how to proceed, at least as proposed for natural systems, is simulation. Simulations allow for the exploration of the parameters of possible, and thus also impossible, future system evolution or behavior. But what of social reality and the social sciences? Although there is some work being done on simulation in the human world, the larger point, nonetheless, is that of individuating possible futures, or what Immanuel Wallerstein has called “utopistics”(Wallerstein 1998) and what Ilya Prigogine lamented as his fear “of the lack of utopias” (2004 n.p.). Embodying an analogy between narrative and simulation, social analysts may henceforth feel licensed by the developments in complexity studies to make the shift from fabricating and verifying theories to imagining and evaluating the multiple possible con-sequences of diverse interpretative accounts of human reality and the actions they entail. Herein lies an alternative for a unified historical social science to the predictive, Newtonian model of social scientific inquiry. It constitutes a mode of constructing authoritative knowledge of the human world, that is of engaging in science, by producing defensible accounts and future scenarios, without chasing the chimera of predictability.

Contemporary events in our globally integrated world have shown that methods that specify (often only implicitly) an exemplar and then endeavor to predict the impact of interventions designed to move supposedly autonomous units towards some ideal state perform poorly. This is what both scholars and policy-oriented analysts are experiencing today, to their dismay. All the same, large-scale regularities do persist over time and particularistic "rich description”, or interpretive accounts based on an understanding, verstehen, of local value contexts, or resorting to "human creativity" or "free will" explanations fail as well to capture the interrelatedness of structure and emergence.

An assessment of systems approaches uncovers an inherent paradox of social analysis: "the accumulation of knowledge often leads to a utilization of that knowledge both by the social scientists and the objects of their research—which may change the validity of that knowledge" (Geyer 1995: 19). One reading of this is that social knowledge is not universal, but knowledge for specific times, today for our times, fitting nicely with findings in complex systems research, and the realization that human interactions constitute such a complex, deterministic but unpredictable, system. Necessity and chance can no longer be viewed as mutually exclusive options in social research.

The combination of the conviction that there is a “real” world and that the future, although it is “determined” by the past, is nonetheless unpredictable and the parallel assaults on dualism (e.g., Barrow 1995; Prigogine 1996) challenge the epistemological status of the sciences as unique discoverers, guardians, and purveyors of authoritative knowledge, that is, truth, by redefining what it means to describe the evolution of natural systems.5 Across the disciplines these arguments may be represented as a concern for spatial-temporal wholes constituted of relational structures representing the persisting regularities normally associated with a "scientific" approach on one hand and, on the other hand, the phenomenological time of their reproduction and change (the ineluctable reality of the arrow-of-time) that captures the play of incommensurable differences associated with a "humanistic" approach. Difference, of course, involves values. We are thus presented with a re-fusing of “is” (the realm of facts and the goal of science) and “ought” (the field of values and the challenge of the humanities) in the construction of systematic knowledge of human reality. Values no longer need be, must no longer be, construed simply as a matter of individual ethics or morality in the creation of authoritative knowledge of human reality, but must hereafter be conceived as an integral part of a historical social science. Thus, a social science for our times, of necessity singular, must do two things: firstly, it must be premised on the indissoluble unity of the regularities of social relations, their structure, and change, their history; secondly, it must recognize that the latter supposes the integration of values as integral to inquiry, not simply as a matter of the personal inclination of the analyst. The effect on such debates as those over eurocentricism and the seemingly cross-cutting roles of race, gender, and class may well be imagined.

---

[5] Ilya Prigogine has argued that the “sciences are not the reflection of a static rationality to be resisted or submitted to; they are furthering understanding in the same way as are human activities taken as a whole” (1988: 3). He goes so far as to state that “I believe that what we do today depends on our image of the future, rather than the future depending on what we do today” (Prigogine in Snell & Yevtushenko 1992: 28).

In this secular crisis of the structures of knowledge, the message for social scientists so convincingly conveyed by research in complexity studies (along with cultural studies in the humanities and science studies in the social sciences, but that is another story) is that the grand intellectual antinomies that have been the subject of hot debate for so long—holism versus reductionism, structure versus agency, determinism versus freedom, order versus disorder, fact versus value—are dependent not just on contradictory epistemological positions, but more surely on a specific ontological view of the world that can no longer be taken for granted. We are not living the "new world order" but a transition period of "new world disorder”, a time of massive fluctuations far from equilibrium in the language of complexity studies. Change will not depend only on our normatively motivated action for its initiation. During a period of wide fluctuations in the constitutive processes of a system driven far from equilibrium, including, I submit, a system of social relations, small fluctuations can have enormous impact even to the extent of effecting total systemic transformation—instabilities expanding possibilities, that is opportunities, by reducing constraints. By the same token, the direction of change will, as complexity studies show, be exquisitely dependent on small fluctuations, for instance, in the form of our value-laden decisions and actions (see Lee 2001 and 2003b). This is not so much the simple return of agency, but the manifestation of the fundamental relationship between agency and structure—the indivisibility of chance and necessity.

As I have argued elsewhere (Lee 2001/2) and as the work rehearsed in the preceding paragraphs I believe attests, the definition of authoritative knowledge in terms of "who, what, when, where, why" and the "view from nowhere" is giving way. As organic intellectuals all, we may (in truth, I would argue we must), without forsaking our dedication to "science", turn our attention to "for whom, for what, for when, for where" and "from whose point-of-view".

Complexity, then, has taken on new significance for social research. Developments in complexity studies and, indeed, across the disciplines, underscore the covert, long-term, structural nature of the debates, including those contemporary disputes that have come to be known as the culture wars and the science wars (see Lee 2004: 189-202; Santos 2003). The con-sequences of these developments impinge directly on the manner in which scholars make claims for the legitimacy of their interpretations of social reality, and thus amount to overturning the dominant model shaping our understanding of the human world. There is no way, however, that we can know if the transformation underway at present, and in which we will all play our part, will result in a more substantively rational human world. But developments across the disciplines, of which complexity studies are a part and systems approaches pioneers, at least hold out that possibility.

Works Cited:

— Aida, S., et al. 1985. The Science and Praxis of Complexity: Contributions to the Symposium Held at Montpellier, France, 9-11 May, 1984. Tokyo: United Nations University.

— Atlan, Henri, et al. 1985. La sfida della complessità. A cura di Gianluca Bocchi e Mauro Ceruti. Milano: Feltrinelli.

— Ashby, W. Ross. 1991[1958]. “General Systems Theory as a New Discipline." Reprinted in Facets of Systems Science edited by George J. Klir. New York: Plenum, 249-257.

— Barrow, John D. 1995. The Artful Universe: The Cosmic Source of Human Creativity. Boston: Back Bay.

— Bertalanffy, Ludwig von. 1968. General System Theory: Foundations, Development, Applications. Revised Edition. New York: George Braziller.

— Casti, John. 1994. Complexification: Explaining a Paradoxical World through the Science of Surprise. New York: HarpurCollins.

— Cowan, George A., David Pines, and David Meltzer. 1994. Complexity: Metaphors, Models, and Reality. Reading, MA: Addison-Wesley.

— Cutright, Marc, ed. 2001. Chaos Theory and Higher Education: Leadership, Planning, and Policy.New York: Peter Lang.

— Davies, Paul, ed. 1989. The New Physics. Cambridge: Cambridge University Press.

— Ekeland, Ivar. 1998. “What is Chaos Theory?” Review XXI, 2:137-50.

— Farmer, Doyne, Alan Lapedes, Norman Packard, Burton Wendroff, eds. 1986. Evolution, Games and Learning: Models for Adaptation in Machines and Nature, Proceedings of the Fifth Annual International Conference of the Center for Nonlinear

Studies, Los Alamos, NM 87545, USA, May 20-24, 1985. Physica D: Nonlinear Phenomena, 22D.

- Feigenbaum, Mitchell J. 1983. "Universal Behavior in Nonlinear Systems." Physica D: Nonlinear Phenomena, 7D: 16-39.
- Gleick, James. 1987. Chaos: The Making of a New Science. New York: Viking.
- Gell-Mann, Murray. 1988. “The Concept of the Institute.” In The Emerging Synthesis in Science. Edited by David Pines. Redwood City, CA: Addison-Wesley, 1-15.
- ---. 1994. The Quark and the Jaguar: Adventures in the Simple and the Complex. New York: W.H. Freeman.
- ---. 1995. “What is Complexity?” Complexity 1,1:16-19.
- Geyer, Felix. 1995. "The Challenge of Sociocybernetics." Kybernetes 24, 4, 6-32.
- Geyer, Felix and Johannes van der Zouwen. 1986. "Preface". In Sociocybernetic Paradoxes: Observation, Control and Evolution of Self-steering Systems. Edited by Felix Geyer and Johannes van der Zouwen. Beverly Hills: Sage, vii-viii.
- Geyer, Felix and Johannes van der Zouwen, eds. 1978. Sociocybernetics: An Actor-oriented Social Systems Approach. Leiden: Martinus Nijhoff.
- Goertzel, Ben. 1994. Chaotic Logic: Language, Thought, and Reality from the Perspective of Complex Systems Science. New York: Plenum Press.
- Hawking, Stephen W. 1988. A Brief History of Time: From the Big Bang to Black Holes. New York: Bantam.
- Hopkins, Terence K. and Immanuel Wallerstein, et al. 1996. The Age of Transition: Trajectory of the World-System, 1945-2025. London: Zed.
- Kiel, L. Douglas and Euel Elliot. 1996. Chaos Theory in the Social Sciences: Foundations and Publications. Ann Arbor: University of Michigan Press.
- Lee, Richard. 1992. "Readings in the 'New Science': A Selective, Annotated Bibliography." Review, XV, 1, Winter, 113-71.
- Lee, Richard E. 2001. "After History? The Last Frontier of Historical Capitalism." Protosoziologie 15, 87-104.
- ---. 2001/2. "Sesión Inaugural." Inaugural Address, Third International Conference on Sociocybernetics, Spanish-English Parallel Text. Journal of Sociocybernetics, 2, 2, Fall/Winter, 43-8.

— ---. 2003a. "The 'Third' Arena: Trends and Logistics in the Geoculture of the Modern World-System." In Emerging Issues in the 21st Century World-System. Edited by Wilma A. Dunaway. Westport: Greenwood, 120-27.

— ---. 2003b. Life and Times of Cultural Studies: The Politics and Transformation of the Structures of Knowledge. Durham, NC: Duke University Press.

— ---. 2004. “The ‘Culture Wars’ and the ‘Science Wars’.” In Overcoming the Two Cultures: The Sciences versus the Humanities in the Modern World-System. Coordinated by Richard E. Lee and Immanuel Wallerstein. Boulder, CO: Paradigm, 189-202.

— Lee, Richard E. and Immanuel Wallerstein, cords. 2004. Overcoming the Two Cultures: The Sciences versus the Humanities in the Modern World-System. Boulder, CO: Paradigm.

— Li, Tien-Yien and James A. Yorke. 1975. "Period Three Implies Chaos." American Mathematical Monthly LXXXII, 10, December, 985-92.

— Lighthill, Sir James. 1986. "The Recently Recognized Failure of Predictability in Newtonian Dynamics." Proceedings of the Royal Society of London, 407, 1832, 8 September, 35-48.

— Lorenz, Edward N. 1963a. "Deterministic Nonperiodic Flow." Journal of the Atmospheric Sciences, 20, 2, March, 130-41.

— ---. 1963b. "The Mechanics of Vacillation." Journal of the Atmospheric Sciences, 20, 5, September, 448-64.

— ---. 1964. "The Problem of Deducing the Climate from the Governing Equations." Tellus, XVI, 1, February, 1-11.

— Markus, M., S.C. Müller, and G. Nicolis, eds. 1988. From chemical to biological Organization. Berlin: Springer-Verlag.

— Mandelbrot, Benoit B. 1983. The Fractal Geometry of Nature. New York: W. H. Freeman and Company.

— Pagels, Heinz R. 1988. The Dreams of Reason: The Computer and the Rise of the Sciences of Complexity. New York: Simon and Schuster.

— Peliti, L. and A. Vulpiani, eds. 1988. Measures of Complexity: Proceedings of the Conference, Held in Rome September 30-October 2, 1987. Berlin: Springer-Verlag.

— Prigogine, Ilya and Dean J. Driebe. 1997. “Time, Chaos, and the Laws of Nature.” In Nonlinear Dynamics, Chaotic, and Complex Systems. Edited by E.R. Infeld, R. Zelazny, and A. Galkowski. New York: Cambridge University Press, 206-23.

— Prigogine, Ilya. 1986. "Science, Civilization and Democracy: Values, Systems, Structures and Affinities." Futures, 18, 4: 493-507.

— ---. 1988. "The New Convergence of Science and Culture." UNESCO Courier May, 9-13.

— ---. 1996. The End of Certainty: Time, Chaos, and the New Laws of Nature. New York: Free Press.

— ---. 2004 “Beyond Being and Becoming.” New Perspectives Quarterly 21, 4: n.p.

— Prigogine, Ilya and Isabelle Stengers. 1984. Order out of Chaos: Man's New Dialogue with Nature. Foreword by Alvin Toffler. New York: Bantam Books.

— Rapoport, Anatol. 1998. "The Organismic Direction in General System Theory." Paper delivered at the 5th European School of Systems Science, Centre interfacultaire d'études systémiques, Université de Neuchâtel, Switzerland, 7-11 September.

— Rothman, Tony. 1997. “Irreversible Differences.” Sciences 37,4:26-31.

— Ruelle, David and F. Takens. 1971. "On the Nature of Turbulence." Communications in Mathematical Physics XX, 167-92.

— Shaw, Robert. 1981. "Strange Attractors, Chaotic Behavior, and Information Flow." Zeitschrift für Naturforschung 36a, 1: 80-112.

— Snell, Marilyn Berlin and Yevgeny Yevtushenko. 1992. "Beyond Being and Becoming." New Perspectives Quarterly 9, 2, Spring, 22-28.

— Stein, Daniel L., ed. 1989. Lectures in the Sciences of Complexity: The Proceedings of the 1988 Complex Systems Summer School Held June-July, 1988 in Santa Fe, New Mexico. Redwood City: Addison-Wesley Publishing Company.

— Waldrop, M. Mitchell. 1992. Complexity: The Emerging Science at the edge of Order and Chaos. New York: Touchstone/Simon & Schuster.

— Wallerstein, Immanuel. 1998. Utopistics: Or, Historical Choices of the Twenty-first Century. New York: New Press.

— Weaver, Warren. 1948. "Science and Complexity." American Scientist, 36, 4, 536-44.

— Weinberg, Steven. 1994. “Life in the Universe.” Scientific American 271, 4:44-49.

- Wiener, Norbert. 1948. Cybernetics: or Control and Communication in the Animal and the Machine. Second Edition. Cambridge, MA: MIT Press, 1961.