Zooming through the Evolutionary Window of Opportunity Created at the Kondratiev IV/V Interface

Kenyon B. De Greene

ABSTRACT

The field theory of living systems, and nested within that the theory of the Kondratiev cycle/structure, is reviewed and summarized. Particular emphasis is placed upon the evolution, instability, and structural change of macropsychological order-parameters and informational fields. The necessity of a fit between systems theory and applications to the evolving, reconfiguring world of reality is stressed. Two major areas of application are presented: to policy-making and decision-making, and to education. A number of features of order-parameter or paradigm exhaustion in the mid-1990s are given, and difficulties in preparing for the next century are discussed. Failure to implement systems thinking, coupled with the actual implementation of nearsighted policies, may have led in the former communist world both to a local closed window of opportunity and a warning of imminent global closure. Means of intervening in education and in policy-making, so as to induce self-organization of new order-parameters, are presented. Various implications for systems science are discussed. The role of the systems thinker as activist is emphasized.

Introduction

Making policies and decisions in complex systems, and teaching about systems complexity, is much more difficult than is commonly recognized. Difficulty increases figuratively by orders of magnitude when systems are viewed as dynamic rather than static, as meta-stable or unstable rather than as stable, as qualitatively structurally changeable rather than as structurally constant, and as basically and essentially evolutionary. These attributes of complex systems insure, at least at present, their general unknowability, unpredictability, and unmanageability. Thus, the basic challenge facing systems thinkers—and those policy-makers, decision-makers, educators, and others who might benefit from systems advice—is not more data, more information systems, more computers, more money, and so on. The challenge is rather for all of us to restructure our very way of thinking.

Kenyon B. De Greene, 4345 Chaumont Road, Woodland Hills, CA 91364.

Journal of Social and Evolutionary Systems 17(4):445-459
ISSN: 0161-7361

An easy first step is to assume an evolutionary perspective. Inherent in evolution are periodic instabilities and structural changes. A system and its environment coevolve; in their dynamic interactions, each places stress on the other. The processes of evolution are not just continuous or continual (discrete) and constant in rate. Rather evolution is punctuated by discontinuities, and there may be accelerations of rates. In organic evolution, discontinuities and rate changes can mark speciation; and in human societies, cultures, and civilizations, discontinuities and rate changes can indicate the emergence of a new kind of society, culture, or civilization. In the recent evolution of world society, various authors have identified waveforms or cycles called economic long waves or Kondratiev (Kondratieff) cycles. I believe that these forms are better described as macropsychological structures or order-parameters, and I have labeled them Kondratiev cycles/structures (KCSs) (De Greene, 1993a,d).

There are qualitative and quantitative differences not only among the four KCSs that have been defined since the beginning of the Industrial Production Revolution around 1785, but also within each KCS. Within each cycle/structure can be recognized four phases: recovery, prosperity, recession, and depression. Late in the phase of depression, the old socio-technical or techno-economic paradigm (macropsychological structure, order-parameter) has worn out and has become exhausted (De Greene, 1993b,c). At this time new opportunities for technological development, institutional design, and major restructuring of ways of thinking and acting arise. The changes that do occur can then drive the next KCS recovery. I believe that the great depression that will end the long KCS-IV began about 1990. Kondratiev depressions last 10-15 years. The developments just mentioned take about the same length of time to bear fruit. Hence, the next several years can be defined as a window of opportunity for the encouragement of the desirable structural change that can characterize a fifth-Kondratiev recovery. However, consider the discussion in one of my recent papers (De Greene, 1993d). If this window at the interface of KCS-IV with KCS-V is lost because of ignorance, hubris, and mismanagement, it may not recur for a long time if ever.

The next section summarizes the field theory of living systems and, nested within that, the theory of the Kondratiev cycle/structure. Particular emphasis is placed on the concepts of macropsychological order-parameter and informational fields. The third section presents an application of this systems theory to policy-making and decision-making. The fourth section does the same thing for education. The concluding section discusses future ramifications of theoretical development and application.

Synopsis of Field and Kondratiev Theory

This section summarizes theoretical developments presented recently in detail elsewhere (De Greene, 1993a,b,c,d, 1994a). Although I alone am responsible for the particular, integrated field/Kondratiev theory presented in these references and in this article, my thinking has been greatly influenced by a number of creative scholars. In addition, as in physics, I use the term "field theory" as a framework onto which can be "hung" other systems theories. To be emphasized here are the classical field theory in social science of Lewin (e.g., 1951); the system dynamics of Forrester (e.g., 1969, 1993); the dissipative-structure theory of Prigogine and colleagues (e.g., Nicolis & Prigogine, 1989; Prigogine

& Stengers, 1984), and the expansion of dissipative-structure theory and evolution theory by Jantsch (1980) and by Allen (1993); and the catastrophe theory of Thom and of Zeeman (e.g., Zeeman, 1977). Also important are the synergetics of Haken and colleagues (e.g., Haken, 1983; Weidlich & Haag, 1983). We should note that, except for system dynamics, very little of this theoretical work has seen practical application. Indeed, the greatest challenge to the systems community, a challenge that this article tries with modest optimism to begin to meet, is to translate the latest theoretical understanding into practical programs.

Proceeding from the more macroscopic concepts and constructs to the less macroscopic, itself a process of hierarchization of control, we can make the following points.

The living systems of Earth and the physical environments with which they interact can be treated as a global force-field, the world system-field of forces. The world system-field in turn consists of the mutually interacting world societal-field and the world ecosystem. The world societal-field is of most concern in this article. A force-field possesses certain properties such as inherent instability, differential sensitivity to continual fluctuation, breakdown of homogeneity or symmetry to yield new spatio-temporal structure, and the existence of attractive and repulsive forces. Force fields can spontaneously generate the new. They can show "trigger-and-ripple" effects: A change triggered in one part of the system-field by an internal fluctuation or external perturbation can ripple throughout the field leading to surprising reconfigurations elsewhere. The field has become correlated. For the most part, field behavior stems from strongly nonlinear interactions among the elements of the field.

These fundamental field properties, and others not mentioned here, apply to both living and nonliving systems. The properties in turn generate the systems package of evolution, instability, and structural change which is of major theoretical and practical concern in this article. The things that evolve are structures, functions, and behaviors. The environmental field of forces does not allow permanency—no physical, biological, or social structure can be stabilized indefinitely. Of course, structures and their associated functions and behaviors can be quite tangible, like biological organisms and human buildings and cities. But some structures are not very tangible and may even be nebulous. Islands of order in lakes of disorder on continents of order amidst oceans of disorder—phenomena seen in physical fields at the atomic and molecular levels, but also observable in the hydrosphere and atmosphere—provide one kind of example. More specific examples include the collective phenomena associated with phase transitions, the electromagnetic fields attempting to control an atomic fusion reaction, and the emergence of the atmospheric ozone hole and possible greenhouse warming. Fields whose instability is increased by human perturbation are obviously very important in environmental policy-making.

There are other kinds of intangible or nebulous fields, and an understanding of the general properties of these fields may well be one of the most important contributions that systems theory can make to policy-making, decision-making, and education. To further this understanding, let us next consider the concept of order-parameter. The concept arose in the study of the physics of phase transitions and collective phenomena (e.g., Wilson, 1979). The order-parameter is a collective or macroscopic entity or variable. Order, a form of broken symmetry, emerges at a critical point or threshold out of the strongly nonlinear interactions of huge numbers of system elements. Short-term forces

generate long-term order and cooperative behavior. Emergence of an order-parameter reflects stochastic/deterministic processes. Metal alloys and magnetized iron are examples of such emergent order. The Curie temperature, below which magnetization occurs, is an example of a critical point. The synergetics school has developed the concept of order-parameter further and has applied it to various cultural and social situations (Haken, 1983; Weidlich and Haag, 1983). The interactions of myriad human individuals induce a collective field, the order-parameter, and this field in turn constrains the behavior at the individual level. The "slow variable"—the order-parameter—"slaves" and reduces the degrees of freedom of the fast microvariables. Collectivities of voters and consumers are order-parameters; so are languages. The models of the synergetics school are mathematically very well developed.

Let us next introduce the concept of macropsychology. Macropsychology is at the same hierarchical level of study as are macroeconomics and sociology and much of organizational behavior, political science, and international relations. Macropsychology deals with the same kinds of things as does psychology at the level of the individual and small group. Macropsychology is the study of collective perception, feeling and emotion, consciousness, intelligence, thinking, learning, anxiety, values, attitudes, opinions, expectations, and behaviors such as consumption, panic, and hysteria. The more stable collective behavior is induced via relatively fast interactions among individual learning, values, expectations, and so forth. Human belief systems, including the great theistic religions, capitalism, communism, and the Newtonian paradigm of science and society, are macropsychological order-parameters. As will be discussed further below, these belief systems can be viewed as informational fields.

Societal (macropsychological) order-parameters themselves possess a number of properties of evolving fields. For example, the order-parameter field can display a variety of qualitatively different behaviors such as multi-equilibrium and multi-stability, limit cycles, deterministic chaos, and self-organization far from equilibrium. Once established an order-parameter has a certain life cycle, and people tend to fit new information into that order-parameter. Near bifurcation points, new order-parameters can spontaneously emerge or disappear. Order parameters can cooperate or conflict with one another. Importantly, a new order-parameter can enter into conflict with and replace an existing (status quo) order-parameter. And an existing order-parameter can be greatly destabilized and weakened by surprises or shocks that generate widespread anxiety.

These features are part of the window of opportunity stressed in this article. At the bifurcation point itself, the situation may be "equal opportunity," allowing the potential self-amplification into a nucleation of any number of fluctuations. But once the system has "made a choice," the successful nucleation may damp competing fluctuations, closing the window of opportunity.

The concept of criticality is central to the theory being described. An evolutionary system does not function and behave over time in an identical manner. As noted above, new challenges and opportunities arise near to and at critical or bifurcation points. Fluctuations that previously were damped—a mean-field or law-of-large-numbers behavior—now have the opportunity to cooperate and to drive structural change. Certain fluctuations stand out as critical fluctuations. Also the behavior of the entire system may slow down or speed up—behaviors called "critical slowing down" or "critical speeding up." One interpretation of the former is that the system has become more sluggish and

takes longer and longer to respond appropriately to perturbations (external forces) and to noise (external fluctuations). Critical speeding up represents the opposite situation. Again, these are features associated with the window of opportunity.

Finally, the Kondratiev cycle/structure can be viewed as a macropsychological order-parameter. The first evidence for the existence of the economic long wave or Kondratieff cycle came from the statistical analysis of economic time-series data. N. D. Kondratiev was a genuine systems thinker, but is still largely unappreciated by the systems community, let alone mainstream economists. Kondratiev's theory included many factors like moods of the times, the emergence of new nations, social discontent, and the origin of wars—factors that go well beyond bare-bones economics. Analysis of time-series data indicated the existence of waves or cycles of about 55 years' mean duration. About half the duration could be expressed as a rising leg and about half as a falling or declining leg. Typical measures were wholesale prices, wages, inflation, employment/unemployment, and various production figures. Later J. A. Schumpeter suggested a further breakdown of the Kondratieff cycle into phases of recovery, prosperity, recession, and depression. Schumpeter also noted a clustering of innovations in the phase of depression—innovations that would drive the next recovery. G. Mensch and other workers provided additional evidence for depression clustering and depression triggering of recovery. See discussions in De Greene (1993a).

The window of opportunity stressed in this article lies in the phase of depression; thus, the features of that phase are of particular importance. A KCS can be viewed as a dissipative structure bounded by instabilities at each end. A KCS can also be viewed as being captured in sequence by chaotic, limit-cycle, fixed-point-equilibrium, limit-cycle, and chaotic attractors. A KCS can further be viewed as an informational field that emerges, grows, and becomes exhausted (De Greene, 1993b,c). The sociotechnical system as a whole is a processor of information and knowledge. The field constrains the meaning of information, and a known answer provides no uncertainty and no information. A saturated informational field is homogenized and in a state of maximum replication and certainty. At the interface between successive KCSs, there is maximum potential novelty (potential innovation), but as the KCS evolves the ratio of confirmation (mere process improvements or clones of innovations) to novelty increases. Society moves from divergent thinking to convergent thinking.

Late in the phase of recession and early in the phase of depression, reconfirmation of the status quo becomes a dominant societal mode. But eventually the control capability of confirmation and reconfirmation erodes, and the macropsychological order-parameter of society becomes critically unstable. Instability is expressed by wild oscillations and the critical fluctuations of decline, expressed in the form of fads, hysterias, and panics. These behaviors seek mainly to reconfirm and to expand the known, the secure, and the predictable. The critical fluctuations of innovation (qualitatively different from those of decline) cannot at first make themselves felt. As the KCS nears its end, a "chaotic" regime provides new opportunity and new choice (here "chaotic" includes stochastic mutations as well as strictly deterministic behaviors).

Application of the Systems Theory to Policy-Making and Decision-Making

The evaluation of policy and decisional outcomes must always involve some degree of value judgment. Part of the evaluation of present and past policies entails a look at

externalities and perceived undesirable side effects. In addition, whether a body of systems theory is applicable and desirable or not is a function of the fit between that theory and the perceived evolving world of reality. One must ask whether policies and kinds of decisions, once judged to be appropriate and desirable, now fit the quantitatively changing and qualitatively restructuring world that can be observed.

The present is a time of great uncertainty and of great anxiety. Many people sense that old forms are being lost without any indication of what replacement forms might be. Concern about what is happening now and what the future will bring is worldwide at the grassroots level. There is also significant if not yet widespread concern in academia and in think-tanks with preparing for the twenty-first century (e.g., Kennedy, 1993), and with ascertaining the "trends that are shaping our future" (Brown, Kane, & Ayres, 1993). But these kinds of efforts are theoretically limited and assume structural constancy and the projection of present situations and trends into the future. In addition, trends do not shape the future. Trends are the usually most obvious indications of structure and behavior that may or may not continue into the future. And, as all systems theorists know, complex systems may show time lags, counter-intuitive behavior, different kinds of surprises, absent or misleading feedback, distortion of information, swallowing up of policy and decisional actions, and disproportionate or nonlinear responses.

There are, therefore, serious hurdles to overcome before we can effectively prepare for the world of 7 or 10 or 25 years from now. Anybody who has had experience with the development of weapons, space, and civil systems knows that years, even decades, may pass before an idea reaches fruition. But we are on the horns of a dilemma. If we want a given system to be operational in 10 years, then our policies and conceptual designs must already exist. On the other hand, how can we make policies and conceive designs for a world that structurally may be radically different? Is our only recourse that of faith?—faith that our present kind of world will continue indefinitely.

The situation of the dominant coalition of politico-economic power holders (the symbolic and actual upholders of the present dominant paradigm) is less clear than are those of the people (the microscopic elements of a societal order-parameter) and of some intellectuals (fluctuations or mutations). The reasons for this are probably several-fold. First, there is the well known murkiness and obfuscation of "politics." Second, acquiring positions of power is a highly selective process, and those who are successful may be blinded to anything that is different or changing and that therefore may be psychologically threatening. But, third, there appears to be a great deal of ignorance involved.

Apparently, large-scale ignorance underlies attempts to convert the former communist world to capitalism. Ignorance is expressed as either/or thinking, as confusion of the short term with the long term, and as a failure to understand the huge inertia of a large cultural/sociotechnical system and the great difficulty in turning such a system around. Consider the following. If the world is bipolar, with choices only between capitalism and communism, and if communism as practiced has failed, then the greener capitalist grass on the other side of the fence must offer salvation. And because the once forbidden fruit of capitalism can produce miracles, the application of the proper "reform" strategies would produce, as Boris Yeltsin once promised, within three years an economy like that in the West. But the social system that has evolved is of course very different from that envisioned by the reformers. Rather than having attempted to implement a religious faith, promulgated by the Western missionaries as to the quickly realizable benefits of widespread

privatization, reformers should have developed policies that encouraged the saving and improving of viable factories and industries, the preservation of employment, and the protection of the natural environment.

The destabilized force-field and unraveling of control mechanisms have indeed led to new entrepreneurial opportunities, but often the fluctuations have developed into black marketeering, gangsterism, other crime, prostitution, shortages of necessities, further impoverishment, an increasing gap between the new rich and most people, and further environmental destruction. International instability and the danger of major war may now be greater than during the Cold War. Western Cold Warriors should have thought more about alternative futures.

In the case of the ex-communist countries, the old order-parameter had worn out, and the signs of failure were evident to almost everyone. But a mistake was made in the attempt to implement another failing order-parameter. A local window of opportunity opened, and this window may now have closed. But the signs of societal and environmental stress are now worldwide. Table 1 summarizes some of the dominant aspects of the mid-1990s; these are aspects of global paradigm exhaustion. Many of these symptoms have been identified as those of decline of the fourth KCS and of hegemonic (Great Power) decline (e.g., De Greene, 1993a, and references therein). In some cases, an order-parameter may encompass more than one KCS. As expected from theory, the weakening or collapse of the reigning order-parameters has allowed the reemergence of what many would regard to be more primitive (e.g., tribal, ethnic) order-parameters. In addition, there may be local eddies and counter-eddies within the order-parameter field. For example, unemployment in the industrialized world may be associated with employment in the developing world. And certain countries, especially the United States, may show emergent properties of the debility and exhaustion of the modern paradigm that later spread to other Western and developing countries.

At a window of opportunity around a bifurcation point, one would expect that radically different strategies and policies might be necessary. Over the years, systems advisors and consultants have had a great deal of experience with policy-makers, decision-makers, and business leaders. A huge literature has been built up in the overall area of systems analysis on topics like models in the policy process. The accumulated wisdom has included this form of advice: If one wants his/her model, funded effort, or discipline output to be accepted and used, then he/she should make sure that the decision-maker understands that the effort can save the decision-maker money. Less formally acknowledged is the fact that a model can expand the decision-maker's power.

How should systems thinking be practiced, however, if as emphasized in this article the old macropsychological order-parameter or old paradigm has become exhausted and has itself either become a cause of the sorts of trouble summarized in Table 1 or is helpless to prevent them? What sorts of interventions can be envisioned at a time when chance can take precedence over necessity? Can systems science have an impact now, considering that our impact over some 40 years has been far less than hoped? Indeed, apparently the practice of systems approaches in large-scale systems has actually decreased! Consider, for example, the separate policies and decisions at the urban or regional level—if there are any—regarding violent crime, nonviolent crime, drug abuse, homelessness, ethnic factors, urban decay, suburban sprawl, economic growth, population growth, environmental conservation and preservation, protection from natural hazards, local governance, taxation, educational opportunities, and transportation.

Table 1
Systemic Aspects of Paradigm Exhaustion in the mid-1990s

Wars and genocide ("ethnic cleansing") on five continents
National capabilities cannot meet expectations and promises
National leaders, to avoid intractable internal problems, cry "The enemy is at the gates"
Leaders exacerbate tensions, e.g., jobs versus the environment
The changed world of work means underemployment and unemployment in agriculture and manufacturing and often poor-quality service jobs
Overcapacity and saturation in numerous areas of agriculture, industry, and the services
Administrative overhead (bureaucratic bloat) increases
Automation and mechanization used to reinforce existing political and economic power structures
Polarization of the rich and poor both within and between nations
Uncontrollable migration from poorer to richer areas
Uncontrolled population growth leads to unsustainable development and to a class of superfluous people
Information/knowledge lost as the media fuse news, entertainment, and commercials
Money emphasis overwhelms almost all other goals
Stock markets bloated with speculative content
Environmental degradation on almost every front
Loss of or hiatus in explanatory power by mainstream science
Institutions and programs dominated by reconfirmation of the established, while discouraging search for and acceptance of the conceptually new
Fusion of the main parties in the Western democracies, leading to voter choice of tweedledee or tweedledum or two peas in a pod
Increased vulnerability of individuals, institutions, societies, and environments
Decreased tolerance of behavioral differences and increased punitiveness
Increased hopelessness and dissatisfaction with the status quo on the part of multitudes of people
Sense of loss of old forms of support without awareness of replacement forms

A decline in the allure of the systems approach is also consistent with systems theory. Part of the problem was that too much of a specific, quantitative, "hard-systems" (Checkland, 1981) or "technical-perspective" (Linstone, 1989) nature was promised. There was too much of an inappropriate search for verified and validated models that could be turned over to the policy-maker for straightforward and useful application. Most systems thinkers now believe that theories and models of complex systems can never be verified, validated, or even conclusively falsified. The evolution of each complex living system is one of a kind and is dependent on antecedent, unique chance and necessity, novelty and confirmation, stochasticity and determinism. Even the testing of hypotheses may be meaningless because of the systems property of swallowing up perturbations most of the time, while reacting surprisingly and nonlinearly some of the times (viz., in the vicinity of bifurcation points). Empirical evidence can never establish absolute truth—only the lesser or greater likelihood of presumed truth. Thus, theories and models are ultimately only of heuristic value, but this is a very important and indispensable value in both science and society. An excellent review of the inappropriateness of trying to verify and validate models in the earth sciences is provided by Oreskes, Shrader-Frechette, and Belitz (1994). [*Editor's Note 1: See Karl R. Popper, e.g.,* Objective Knowledge, *New York: Oxford, 1972*/

1979, for thorough discussion of the impossibility of validation and verification, and the relation of this to evolution. In the Popperian schema, the best we can hope for in the growth of knowledge is corroboration of theories via their survival of fallible falsification.–PL.]

Finally, I propose that there needs to be a further major step beyond the soft-systems approach. If the reigning paradigm is as deficient as emphasized herein, then work within that paradigm would seem to be futile at best and could undesirably prolong the existence of the paradigm at worst. We might do well here to try to implement a Schumpeterian strategy of creative destruction while the window of opportunity remains open. This means taking a more active and less passive role, a more leadership and less follower role, in contributing to the evolution of society. Table 2 at the end of the following section gives some tactics for such active intervention.

Application of Systems Theory to Education

Modern societies emphasize the importance of free, compulsory, universal education at the pre-college levels. People think that society as a whole benefits from this practice. In addition to imparting knowledge and skills, universal education socializes children as to various mores, expectations, and practices. Many of these societies also provide, or have provided until recently, free or relatively inexpensive education at the college and university levels. Education provides the individual a route for upward mobility. For the purposes of this article, education should include the providing of persons of the next generation who are qualified to fill leadership roles in policy-making and decision-making at all levels.

Unfortunately, education is in a critical state in some of these countries, especially the United States. There are many reasons for this crisis, some of which may be unique to a given country, some indicated in the factors listed in Table 1. Not every specific aspect of the educational crisis can be covered in this article. For example, in the U. S., crime and violence are contributing to the destruction of the public schools in many areas, but these and other important concerns are beyond the scope of this essay. Let us rather seek again to apply the general theoretical concepts summarized earlier. (In passing, we note another, and gratifying, effort to teach systems thinking and practice: that of the system dynamicists—like Forrester, 1993—who are educating junior high school students in their approach.)

In the present phase of depression that is ending KCS Number Four, the educational subsystem, like the health care, criminal justice, foreign policy, and other subsystems, has worn out and become exhausted. Confirmation dominates novelty. (As indicated above, communication of what the receiver already knows with certainty means no information and no knowledge, in the sense of information theory; see De Greene, 1993b,c). Education is run like a business or factory with appeals to greater efficiency, more funding, selective cost cutting, and attention to the bottom line. Bureaucratic bloat has increased. Rules and procedures take precedence over spontaneity and creativity, which may be actively discouraged. Convergent thinking dominates divergent thinking. Administrative power and control are expressed through tighter and tighter accountability of teachers and staff. These mechanistic forms include well defined (even stereotyped) lesson plans, syllabi, and learning objectives; various kinds of tests of teachers as well as of students; so-called merit

reviews; and the use of committees beholden to the administration. Evolution is toward greater and greater rigidity. Negative feedback and the law of large numbers reign. The system has become overcontrolled. As challenges or crises arise, more of the same old strategies and tactics are applied. But these strategies and tactics are applied differentially by the more powerful against the weaker and are expressed as cutbacks in teaching programs, rising tuitions, and general down-sizing. Meanwhile, the perquisites of the dominant coalition actually increase.

We can see here that systems theory is applicable at two levels: a more macro-level of policy-making and strategic planning (see Emery, 1993, for a discussion of the differences) as just summarized and a more micro-level of the given curriculum or course. At the macro-level, activist systems practice should be along the lines indicated in the preceding section on policy-making and decision-making. Some means of improving curricula and courses follow.

Let us start with the mind of the student or of anybody else. Following the early Gestalt psychologists, I believe the brain and the derived mind to be force-fields. Mind can be operationalized via the mental or cognitive/emotional models (De Greene, 1993a) that essentially all people possess. The force-field of mind has properties like those presented above in "Synopsis of Field and Kondratiev Theory." For example, important properties are differential stability and susceptibility to fluctuations and perturbations, and potential for (cognitive) structural change. Learning by insight, as opposed to trial-and-error and rote, can be viewed as a sudden restructuring of the cognitive field.

Learning—and teaching—can be classified here into two categories or approaches, one based mostly on reconfirmation of the once novel (thinking converging onto the right answer) and the other based on search for and initial confirmation of novelty (thinking diverging toward various answers). The former is important to skill acquisition and training. Some rote learning is undoubtedly valuable in the early learning of, say, language and mathematics. However, even professional educators often mistake training for education. And confirmation of the known and convergent thinking soon reach a domain of diminishing returns.

Further, viewing the mind as an open system capable of self-organization seems intolerable to many holders of relative power, ranging from parents to school administrators to formulators of national educational policy. This situation may obtain at rather high levels of education such as the university graduate school, where signs of stereotyped, bottom-line focus and faculty-administration conflict are increasing.

Following the second—divergent—approach, two kinds of needs can be identified: the need to develop independent, critical, deep thinking and the need to re-learn tactics and material that were inappropriately or falsely learned. Responding to the second need is not unlike Kurt Lewin's approach to organizational learning—unfreezing, changing, and refreezing—except that I would reject refreezing as too rigidifying. In order for deep thinking to be induced, we may need to break down old mental models. This is conceptually somewhat different from Forrester's (1993) argument that mental models are imprecise, and that precision can be improved via system dynamics causal-diagramming and computer simulation. I consider the breaking down of faulty models prerequisite to improving the precision of a newly developed mental model.

I have found this approach, as indicated by the sophistication of individual written research papers, oral presentations, and daily class discussions, to be highly successful and

personally gratifying. I teach courses in principles of systems, systems analysis, and organization-environment interaction in a graduate systems management program at the University of Southern California. Most students enter the program with rather deficient mental models and expectations that the course will be just like the course they just finished, and the course before that, and the course before that. Mental models may be deficient for many reasons. For example, students often accept without question what they have been told, and most students have never learned independent observation and to search for variety. A sad comment on education, in the U.S. at least, is that a standard course applies from the elementary school to the graduate school. The standard course employs one or more textbooks, lectures or advice by the instructor, perhaps a small term project, and periodic examinations geared to test for mastery of known and previously defined material.

Reports are that computers have had little impact on improving the quality of education as measured in several ways, in spite of much touting of the benefits and the expenditure of sizable amounts of money. The reason is, I propose, that computers and information systems simply automate the conceptual status quo. As I sit at my personal computer typing this manuscript, I realize that I can print out the finished article and mail it in several different ways, I can print out the article and fax it, and I can transmit the unprinted article by e-mail. I can request the search of data bases. I may never again have to rely on a typist because that job has been, for my purposes, automated out of existence. But these improvements in the quality of my worklife do not in themselves stimulate greater learning, insight, and creativity. One is reminded to beware of technological determinism. The overall situation discussed in this article may, however, change greatly when real-time interactive television becomes widely available, and users can actively challenge the dominant paradigm in education, business, and government. [*Editor's Note 2: The situation has already changed with the advent of online education–courses which challenge the place-based, book-paced traditional modes of education with asynchronous, multiple dialogues conducted between faculty and students, and among students, via exchange of electronic text via computers and modems. See Paul Levinson,* Learning Cyberspace: Essays on the Evolution of Media and the New Education, *San Francisco, CA: Anamnesis Press, 1995 for more–PL.*]

We must emphasize here that systems practice in education goes far beyond teaching students some systems principles and methods of systems analysis that can be learned and passively "regurgitated" according to the standard course. As with policy-making, the systems thinker must actively intervene so as to stimulate independent deep thinking. But this is not always a straightforward task. Students may indeed reject the old, only to accept without question what the systems instructor offers. This danger is especially likely if the instructor is charismatic. The result can be brainwashing that replaces the earlier brainwashing that instructor and student are trying to overcome.

Table 2 gives some of the tactics, based on systems constructs and principles, that can be used to intervene actively in a student's mental model. As in other applications, the instructor is much more a facilitator of cognitive structural change than a provider of memorizable facts. The instructor perturbs the student's mental force-field and provides an environment for self-organized learning. This is a top-down approach, somewhat similar to the development of a case history, and more specific principles are provided in the lectures, class discussions, and reading materials. I propose that these tactics are also valuable for intervention in the policy process.

Table 2
Tactics for Intervention for Change in Established Order Parameters, Paradigms, and Personal Mental Models

Point out systems failures and ask students to speculate on the causes of these failures
Point out established explanations for system failures and ask students to compare their explanations with the established ones
Ask students to propose and explain likely system failures that have not yet taken place
Ask students to state what they observed today or since the last class and to explain their observations
Point out examples of the variety of things that can be observed— e.g., the effect of a geological fault, that certain trees are dying because of pollution, and that closed stores can indicate economic recession or depression
Ask students to compare constancy and change and to give examples
Ask students to describe and explain change and the different kinds of change and to give examples
Ask students to explain causality and the different kinds of causality and to give examples
Ask students what is meant by truth, certainty, and evidence and to provide examples
Ask students to develop varied interpretations, including mainstream interpretations, of realworld happenings and to enter into dialogue in defense of these interpretations
Factor in specific systems constructs like criticality, bifurcation, nonlinearity, feedback loops, logistic evolution, deterministic chaos, and self-organization and ask students to explain how and when the constructs apply or do not apply

Concluding Remarks

The translation of systems theory into systems practice requires the answering of some important questions.

1. Does the theory appear to match present and especially future reality?
2. Does the theory fit into or conflict with the dominant paradigm?
3. Will the theory in the longer term be an improvement over past and present theories and related systems-thinking that have been applied to similar kinds of situations?

The answer to none of these questions is simple, straightforward, or rational. All questions come with an emotional loading. As Prigogine and Stengers (1984) have emphasized, scientists are deeply conservative and have not welcomed the scientific revolutions that have swept their disciplines. On a larger scale, the power structure of the world's political and economic elite does not encourage real change and certainly not revolutionary change.

In response to the first question, if the world is essentially linear—in a state of equilibrium or equilibrium-like steadiness to which it returns when perturbed—if the world is static, non-evolutionary, and structurally constant, then the theory presented herein would appear to be inappropriate. If on the other hand, the opposite conditions obtain, then the theory would be—as I propose—highly relevant, but it would at this stage still require fine-tuning. In response to the second question, an idea or practice that can operate within the existing paradigm of politico-economics, education, and so on will tend to be

much more acceptable than will one that does not so fit. An existing paradigm represents a tremendous investment, not only in terms of capital, organization designs, physical structures, processes, rules, and procedures, but also in terms of psychological commitment. Psychological commitment means less anxiety and greater feeling of security at all levels of needs. A ruling paradigm is not easily overturned, and paradigm change occurs essentially only under the conditions theoretically described in this article—that is, near a bifurcation point when the system-field has become destablized and the extant control mechanisms can no longer successfully reconfirm the status quo. The window of opportunity opens in the vicinity of the bifurcation point.

In response to the third question, science has markedly influenced social thinking since at least the time of Newton. But the Newtonian paradigm of strict determinism, reversible trajectories, dispassionate observation, precise measurability, highly quantitative and solvable problems and model questions, lack of impact of the observer on what is measured, and highly predictable clocklike or machine-like behavior, as applied outside classical physics, has come under increasing criticism (e.g., the discussion in Allen, 1993; De Greene, 1993a). The economy, for example, is not a Newtonian machine, as has been forcefully argued by Georgescu-Roegen (1971). Contributions of science to areas of concern in this article have included Marxism, the capitalism of Adam Smith, Keynesian economics, and psychological testing. These areas have also received a great deal of criticism. Even systems contributions may be suspect. General systems theory has seen slight application and cybernetics (including for convenience here system dynamics) somewhat more so. But cybernetics has been criticized for being non-evolutionary, for only functioning, and for dealing only with the maintenance and restoration of stability and of structure. I propose that the theory summarized in this article offers an improvement over past and present theory and practice. Note again the number of authors who have contributed to the various aspects of the theory, whose time may finally have come.

The opportunity for building better policy and education systems and the choice of potential pathways can indeed emerge at times of great instability, far-from-equilibrium conditions, bifurcation, random or quasi-random fluctuations, and deterministic chaos. At such times the old macro-psychological order-parameter has worn out, and a window of opportunity allows, when coupled with wisdom, the development of a new order-parameter. But opportunity may knock but once.

If the theoretical interpretations given in this article are as true as I believe them to be, and if the signs of global societal and environmental dissolution are as deeply indicative of the underlying dynamics as they appear to be, then the alternative to applying field/Kondratiev theory (or a comparable theory or theories) may well be oblivion. If we look at the various systems approaches that we have taken over the past two or three decades, the picture is not one of which we should necessarily be proud. Operational researchers still moan: why won't decision-makers use our models? Over 25 years ago, human-factors theory was concerned that, unless some forceful steps were taken, human-factors experts would remain consultants and designers of little things. The human-factors community now talks about the big things that human-factors could have done to prevent such disasters as Three Mile Island, Chernobyl, and Bhopal. But the situation has changed little if at all.

Finally, if systems science really matters in the large, turbulent, often grimy world of reality, then through the window of opportunity may sound the clarion call to revolutionary activism. This line of thinking is followed further elsewhere (De Greene, 1994b).

References

Allen, P. M. (1993) "Policy in a World of Evolution, Learning, and Ignorance," in De Greene, K. B., ed. *A Systems-Based Approach to Policy-making*. Boston, MA: Kluwer.

Brown, L. R., Kane, H., & Ayres, E. (1993) *Vital Signs 1993: The Trends That Are Shaping Our Future*. New York: Norton.

Checkland, P. B. (1981) *Systems Thinking, Systems Practice*. New York: Wiley.

De Greene, K. B. ed. (1993a) *A Systems-Based Approach to Policy-making*. Boston: Kluwer.

De Greene, K. B. (1993b) "The Growth of Exhaustion." *European Journal of Operational Research, 69 (1)*, 14-25.

De Greene, K. B. (1993c) "Evolutionary Structure in the Informational Environmental Field of Large-Scale Human Systems." *Journal of Social and Evolutionary Systems, 16 (2)*, 215-230.

De Greene, K. B. (1993d) "Will There Be a Fifth Kondratiev Cycle/Structure?" *Systems Research, 10 (4)*, 41-55.

De Greene, K. B. (1994a) "The Challenge to Policy-making of Large-Scale Systems: Evolution, Instability and Structural Change." *Journal of Theoretical Politics, 6 (2)*, 161-188.

De Greene, K. B. (1994b). "The Systems Thinker as Revolutionary." Paper given at the 38th Annual Meeting of the International Society for the Systems Sciences, 14-19 June, 1994, Asilomar Conference Center, Pacific Grove, California.

Emery, F. E. (1993) "Policy: Appearance and Reality," in De Greene, K. B., ed. *A Systems-Based Approach to Policy-making*. Boston: Kluwer.

Forrester, J. W. (1969) *Urban Dynamics*. Cambridge, MA: Productivity Press.

Forrester, J. W. (1993) "System Dynamics and the Lessons of 35 years," in De Greene, K. B., ed. *A Systems-Based Approach to Policy-Making*. Boston: Kluwer.

Georgescu-Roegen, N. (1971) *The Entropy Law and the Economic Process*. Cambridge, MA: Harvard University Press.

Haken, H. (1983) *Synergetics: An Introduction, 3rd. ed.* New York: Springer-Verlag.

Jantsch, E. (1980) *The Self-Organizing Universe*. New York: Pergamon.

Kennedy, P. (1993) *Preparing for the Twenty-First Century*. New York: Random House.

Lewin, K. (1951) *Field Theory in Social Science: Selected Theoretical Papers*. Chicago, IL: University of Chicago Press.

Linstone, H. (1989) "Multiple Perspectives: Concept, Applications, and User Guidelines." *Systems Practice, 2 (3)*, 307-331.

Nicolis, G. & Prigogine, I. (1989) *Exploring Complexity: An Introduction*. New York: Freeman.

Oreskes, N., Shrader-Frechette, K., & Belitz, K. (1994) "Verification, Validation, and Confirmation of Numerical Models in the Earth Sciences." *Science, 263*, 641-646.

Prigogine, I., & Stengers, I. (1984) *Order Out of Chaos*. New York: Bantam.

Weidlich, W. & Haag, G. (1983) *Concepts and Models of a Quantitative Sociology: The Dynamics of Interacting Populations*. New York: Springer-Verlag.

Wilson, K. G. (1979) "Problems in Physics with many Scales of Length." *Scientific American, 241 (2)*, 158-179.

Zeeman, E. C. (1977) *Catastrophe Theory: Selected Papers 1972-1977*. Reading, MA: Addison Wesley.

About the Author

Kenyon B. De Greene, Ph.D., is Professor of Systems Science and Systems Management at the Institute of Safety and Systems Management, University of Southern Californian,

Los Angeles. He is author of more than 100 articles and several books, including *The Adaptive Organization: Anticipations and Management in Crisis* (Wiley, 1982). His last contribution to the *Journal* was "Evolutionary Structure in the Informational Environmental Field of Large-Scale Human Systems" in Vol. 16, No. 2.