Systems Theories:
Their Origins, Foundations, and Development

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Abstract

In it's broadest conception, a "system" may be described as a complex of interacting components together with the relationships among them that permit the identification of a boundary-maintaining entity or process. Since social and psychological phenomena tend to resist quantitative modeling by posing basic difficulties already on the plane of boundary identification, alternative approaches must be relied upon. One such approach draws on the body of knowledge derived from General System Theory and its application in the domain of human activity systems.

The line that separates the aspects of a system from those of its environment tends to blur as the unit of observation moves from natural and designed physical systems to human and conceptual social systems. While the former are easier to define and have relatively clear-cut aims or purposes, the latter are more difficult to define; most often they do not have clear-cut and agreed upon aims or purposes, and even when agreed upon, these may change over time. In addition, human activity systems (be they composed of individuals in a nuclear family, musicians in an orchestra, or members of a national or international organization) tend to have multiple and overlapping purposes, of which it is possible to distinguish at least three levels: the purpose of the system, the purpose of its parts, and the purpose of the system of which it is a part, the supra-system. The method proposed by systems theory is to model complex entities created by the multiple interaction of components by abstracting from certain details of structure and component, and concentrating on the dynamics that define the characteristic functions, properties, and relationships that are internal or external to the system.

The history of systems theories includes contributions from such seminal thinkers as Alfred North Whitehead, Ludwig von Bertalanffy, Anatol Rapoport, Kenneth Boulding, Paul A. Weiss, Ralph Gerard, Kurt Lewin, Roy R. Grinker, William Gray, Nicolas Rizzo, Karl Menninger, Silvano Arieti, and, in more recent years, the dynamical systems theorists, the family systems theorists, and those who deal with dissipative structures and holistic paradigms. This chapter traces the history of systems theories, their permutations, and their developments. Evolutionary systems design is introduced as one of the most recent advances in systems praxis. Cognitive maps are explored as an example of the conceptual tools stemming from systems theory that are positioned to contribute to the study of perception, the focus of this volume.

Key Words

General system theory; social science; societal evolution; evolution of consciousness; cognitive map; evolutionary systems design; evolutionary learning system.

Introduction

The relationship between systems theory and the study of perception is one of critical importance to our understanding of the changing nature of human cognitive maps at the dawn of the 21st century. The conceptual frameworks that embed our perceptions and their interpretations, and condition the depth of our awareness and its rise to consciousness, are shifting drastically as the nature of human relations transforms. Disciplinary efforts to interpret the meaning and significance of social change run the gamut of deconstructionist post-modern exposition, ranging from predictive/empirical, to cultural/interpretative to critical/post-structural epistemological stances. In areas of human endeavor concerned with valuing and assessing human achievement, the result has been a multiplicity of possible interpretive frameworks and a concomitant fragmentation of disciplinary worldviews. On the one hand, the natural sciences are moving toward theoretical syntheses through the construction of grand unified theories in physics and similar embracing theoretical frameworks in other realms of inquiry. On the other, the social sciences seem to manifest a countervailing trend toward relativistic positions on issues of cognitive evolution. This is compounded by a corresponding reticence for the postulation of generally applicable normative viewpoints on behavioral and attitudinal orientations that serve to meet the mounting challenges of uncertainty in our rapidly changing world.

Systems Theory as a Conceptual Field of Inquiry

The advantage of systems theory is its potential to provide a trans-disciplinary framework for a simultaneously critical and normative exploration of the relationship between our perceptions and conceptions and the worlds they purport to represent. Studies of cognitive development and human perception are beginning to rely more and more on the systems approach. Systems theory does much to render the complex dynamics of human bio-psycho-socio-cultural change comprehensible. Observed phenomena in the natural and human-made universe do not come in neat disciplinary packages labeled scientific, humanistic, and transcendental: they invariably involve complex combinations of fields, and the multifaceted situations to which they give rise require an holistic approach for their solution. Systems theory provides such an approach and can consequently be considered a field of inquiry rather than a collection of specific disciplines.

Origins and Foundation of Systems Theory

As a response to the increasing fragmentation and duplication of scientific and technological research and decision making in the first half of the 20th century, Ludwig von Bertalanffy advanced what he called *Allgemeine Systemlehre* (general theory of systems or, more popularly, general system theory -- GST). He described the set of theories that together comprise the framework of systems thought in the following passage:

> The 19th and first half of the 20th century conceived of the *world as chaos.* Chaos was the oft-quoted blind play of atoms, which, in mechanistic and positivistic philosophy, appeared to represent ultimate reality, with life as an accidental product of physical processes, and mind as an epi-phenomenon. It was chaos when, in the current theory of evolution, the living world appeared as a product of chance, the outcome of random mutations and survival in the mill of natural selection. In the same sense, human personality, in the theories of behaviorism as well as of psychoanalysis, was considered a chance product of nature and nurture, of a mixture of genes and an accidental sequence of events from early childhood to maturity.

> Now we are looking for another basic outlook on the world -- *the world as organization.* Such a conception -- if it can be substantiated -- would indeed change the basic categories upon which scientific thought rests, and profoundly influence practical attitudes.
> This trend is marked by the emergence of a bundle of new disciplines such as cybernetics, information theory, general system theory, theories of games, of decisions, of queuing and others; in practical applications, systems analysis, systems engineering, operations research, etc. They are different in basic assumptions, mathematical techniques and aims, and they are often unsatisfactory and sometimes contradictory. They agree, however, in being concerned, in one way or another, with "systems," "wholes" or "organizations"; and in their totality, they herald a new approach. (As quoted in Lilienfeld, 1978, pp. 7-8.)

Von Bertalanffy considered the principles of organization involved at various levels in the manifestation of natural systems. His first statements on the subject date from 1925-1926, during the time when Alfred North Whitehead was creating a related 'philosophy of organism.' At about the same time, biologist Paul A. Weiss also began to develop a systemic approach based on the importance of finding "the conceptual integration that renders the map of knowledge not only more complete, but more consistently coherent." (As quoted in E. Laszlo, 1972, pp. 159-160.) More than others before their time, von Bertalanffy, Whitehead, and Weiss became aware of the potential to develop a general science of organized complexity. Of them, von Bertalanffy gave the fullest formulation of a general theory of systems. He defined the aims of the theory as follows:

> (1) There is a general tendency toward integration in the various sciences, natural and social. (2) Such integration seems to be centered in a general theory of systems. (3) Such theory may be an important means for aiming at exact theory in the nonphysical fields of science. (4) Developing unifying principles running "vertically" through the universe of the individual sciences, this theory brings us nearer the goal of the unity of science. (5) This can lead to a much-needed integration in scientific education. (Von Bertalanffy, 1968, p. 38.)

Although von Bertalanffy first presented his idea of a 'General System Theory' in a philosophy seminar at the University of Chicago in 1937, it was only after World War II that his first publications appeared on this subject. By the 1960s systems thinking began to be recognized as a paradigmatic effort at scientific integration and theory formulation on the transdisciplinary plane. No such effort derived from the natural sciences had been previously attempted.

Kenneth Boulding came into contact with the work of von Bertalanffy during the 1950s when he was conducting a seminar on the integration of the social sciences at the University of Michigan at Ann Arbor. In 1954, together with mathematician Anatol Rapoport and physiologist Ralph Gerard, von Bertalanffy and Boulding came together at the Palo Alto Center for Advanced Study in the Behavioral Sciences. There it soon became clear that, although approaching the subject from different directions, their thoughts were remarkably convergent.

The transdisciplinary endeavor of the systems approach was not restricted to the hard sciences but began to spread to the humanities as well. A 1953 letter from economist Boulding addressed to von Bertalanffy summarizes the situation:

> I seem to have come to much the same conclusion as you have reached, though approaching it from the direction of economics and the social sciences rather than from biology -- that there is a body of what I have been calling "general empirical theory," or "general system theory" in your excellent terminology, which is of wide applicability in many different disciplines. I am sure there are many people all over the world who have come to essentially the same position that we have, but we are so widely scattered and do not know each other, so difficult is it to cross the boundaries of the disciplines. (As quoted in von Bertalanffy, 1968, p. 14.)

General system theory, like other innovative frameworks of thought, passed through phases of ridicule and neglect. It has benefited, however, from the parallel emergence and rise to eminence of cybernetics and information theory, and their widespread applications to originally quite distant fields. Though it grew out of organismic biology, general system theory soon branched into most of the humanities. Its recognition as a platform for the study of human behavior has lead to recent applications in areas of social work, mental health, and the political and behavioral sciences. The rise and spread of systems theory has been aided by societal pressures on science calling for the development of theories capable of interdisciplinary application.

The various conceptual frameworks of the systems approach and related areas have much to offer for the construction of an holistic methodology for perceptual inquiry. As Prigogine noted, "the basis for any natural law describing the evolution of social systems must be the physical laws governing open systems, i.e., systems embedded in their environment with which they exchange matter and energy." (Prigogine *et al.*, 1977, p. 2.) Without reducing the study of psyche to physics, systems theory promises to offer a powerful conceptual approach for grasping the interrelation of human beings, and the associated cognitive structures and processes specific to them, in both society and nature.

Systems theory as a general frame of inquiry

In regard to applications in studies of perception, systems theory can model complex intrapersonal, interpersonal, intergroup, and human/nature interactions without reducing perceptual phenomena to the level of individual stimuli. It capitalizes on the emergence of parallelisms in different disciplinary interpretations of reality and consequently provides a platform for the integrated study of complexity in the human experience.

As a field inquiry concerned with the holistic and integrative exploration of phenomena and events, systems theory pertains to both epistemological and ontological situations. But rather than constitute either an epistemology or an ontology, it is more reminiscent of the Greek notion of *gnosiology* concerned with the holistic and integrative exploration of phenomena and events. There are aspects of the systems approach that are ontological and aspects that are epistemological, and aspects that are at once both and should not be circumscribed to either.

Definition of *System*

Methodologically, it is important to set apart a theoretical system from an empirical system. The former is a complex of concepts, suppositions, and propositions having both logical integration and empirical reference, while the later is a set of phenomena in the observable world that is amenable to description and analysis by means of a theoretical system.

The concept of ‘system’ serves to identify those manifestations of natural phenomena and process that satisfy certain general conditions. In the broadest conception, the term connotes *a complex of interacting components together with the relationships among them that permit the identification of a boundary-maintaining entity or process.* As reviewed in the previous section of this chapter on the origins and foundation of the systems theory, more specific denotations have been offered since the early formulations of a general system theory in the first half of the

20th century. For the purposes of this chapter, we provide a definition based on Russell Ackoff's suggestion that a system is a set of two or more interrelated elements with the following properties:

1. Each element has an effect on the functioning of the whole.
2. Each element is affected by at least one other element in the system.
3. All possible subgroups of elements also have the first two properties.

(Ackoff, 1981, pp. 15-16.)

By substituting the concept of ‘element’ for that of ‘component,’ it is possible to arrive at a definition that pertains to systems of any kind, whether formal (e.g., mathematics, language), existential (e.g., ‘real-world’), or affective (e.g., aesthetic, emotional, imaginative). In each case, a whole made up of interdependent components in interaction is identified as the system. In the most basic definition a system is *a group of interacting components that conserves some identifiable set of relations with the sum of the components plus their relations (i.e., the system itself) conserving some identifiable set of relations to other entities (including other systems).* In the words of Macy (1991, p. 72), a system is less a thing than a pattern.

This definition is general but not meaninglessly so: it specifies a limited set of entities in the real world. If any set of events in the physical universe is to conserve an identifiable set of internal relations it must be capable of at least temporarily withstanding the statistical outcome of disorganization predicted by the second law of thermodynamics. That law states that "entropy always increases in any closed system not in equilibrium, and remains constant for a system which is in equilibrium." (Bullock & Stallybrass, 1977, p. 634.) Systems will dissipate energy unless they are purposively maintained by an outside agency; thus there must be organizing forces or relations present which permit the conservation of its structure and function. Internal relations in an entity not possessing such characteristics tend to degrade until a state of thermodynamic equilibrium is reached.

Natural systems

An entity that does not degrade its structure to thermodynamic equilibrium but maintains it through the utilization of the energies available in its environment is a product of the slow but vast processes of evolution in nature. It has emerged in the course of time, maintains itself in the face of perturbations, and is capable of reorganizing itself to cope with changing conditions in its environment. Such an entity is a *natural system*, and includes individuals and communities.

Natural systems contrast with entities which obey the statistical predictions of entropy production dictated by the second law of thermodynamics. These types of entities are not products of sustained evolution in nature but are accidental agglomerations of natural entities, or else human artifacts. However, almost all the things we can identify as 'the furniture of the earth' are natural systems, or components of natural systems, or aggregates formed by natural systems. Stable atoms are natural systems, and so are molecules, cells, multicellular organisms, ecologies and societies. Individual cognitive maps, complex socio-cultural systems, and indeed the global system itself, form natural (rather than artificial) systems. This is important, for certain general propositions are true of natural systems, regardless of their size, origin, and degree of complexity, which may not be true of artificial systems. These propositions are true in virtue of the fact that in a universe governed by uniform laws certain sets of relationships are required to conserve and enhance order over time. Much can be understood of the system's basic properties by assessing its behavior in reference to the imperatives of natural system dynamics.

Reduction to dynamics

The principal heuristic innovation of the systems approach is what may be called ‘reduction to dynamics’ as contrasted with ‘reduction to components,’ as practiced in the methodologies of classical science. Phenomena in the observed world are usually too complex to be understood by modeling all their parts and interactions; some form of simplification is necessary. Traditionally, scientists have simplified natural complexity by viewing individual items of observation in isolation from the complex set of relations that connect them with their environment, and ultimately with the rest of the world. They have isolated the object of their investigations, interested mainly in delimited inductive chains that could be readily mapped as linear — and perhaps circular — causality (that is, A affecting B, and B affecting C and possibly also A).

The heuristic of 'reduction to components' has led to the accumulation of vast storehouses of information about specific entities and the interactions among them. It enabled scientists to know how one molecule, cell, or organ reacts to a particular kind of energy or stimulant, and how one body reacts to a particular kind of force. The practical benefits have been many: medicines could be prescribed and bridges built based on such knowledge. But this type of knowledge proved deficient in one important respect: it did not disclose how complex things behave when exposed to a complex set of influences. Yet almost every real-world system contains a large number of components and is exposed to a large number of external forces and events. In consequence, another heuristic became necessary, capable of simplifying unmanageably complex phenomena by reduction to *dynamics* instead of to *components.*

Emergent properties and synergy

Structurally, a system is a divisible whole, but functionally it is an indivisible unity with emergent properties. An emergent property is marked by the appearance of novel characteristics exhibited on the level of the whole ensemble, but not by the components in isolation.

There are two important aspects of emergent properties: first, they are lost when the system breaks down to its components — the property of life, for example, does not inhere in organs once they are removed from the body. Second, when a component is removed from the whole, that component itself will lose its emergent properties — a hand, severed from the body, cannot write, nor can a severed eye see.

The notion of emergent properties leads to the concept of synergy, suggesting that, as we say in everyday language, the system is more than the sum of its parts. For example, the hydrogen atom, the simplest of the chemical elements, has a typical valence as an integral system made up of a proton and a neutron in the nucleus and an electron in the lowest energy shell around it, together with short-lived exchange particles and forces. The chemical valence of the entire structure is not present in the proton, the neutron, the electron, or any exchange particle taken in isolation; it is an emergent property of the whole ensemble and a result of the synergistic relationship among its parts. Consequently a reduction of the hydrogen atom to the level of its component elementary particles amounts to a simplification that eliminates some of the essential properties of the atom; in that regard it throws out the baby with the bath water.

With reference to the subject area of this volume, a similar observation applies at the opposite extreme of the scale of complexity in nature. The human brain, the most complex system of matter known to science, consists of some ten thousand million neurons, with up to a hundred billion connections among them. The emergent properties of the full cerebral system include patterns of sensation, emotion, thought, and volition familiar from introspective experience, as well as the complex homeostatic regulations performed by the autonomic nervous system. None of these characteristics and functions can be found in individual neurons, and in some cases reduction even to neural nets has proven impossible — as in the case of learned behavior and memory, which seem distributed throughout entire brain regions rather than being performed by individual nets or encoded in specific RNA sequences or engrams. (Pribram, 1991.)

The systems approach

As mentioned earlier, the definition of certain varieties of entities and events in the world as 'system' made for the mid-century emergence of a *general* theory of systems. Prior to that time a specialized way of seeing things held almost exclusive sway in modern science. According to the specialized perspective, the world and all that it contains is an assembly of small and distinct parts, fit largely for analysis and study in isolation. This fragmented way of approaching empirical phenomena is predicated on the belief that it is better to have specific and intimate knowledge of smaller and more well-defined items than general and abstract knowledge of larger and less well-defined ones. As a result, instead of focusing on the interacting and integrated ensemble — the ‘system’ — attention is drawn to the parts regardless of their position within the ensemble.

By contrast, the systems approach attempts to view the world in terms of irreducibly integrated systems. It focuses attention on the whole, as well as on the complex interrelationships among its constituent parts. This way of seeing is not an alternative, but a complement, to the specialized way. It is more all-embracing and comprehensive, incorporating the specialized perspective as one aspect of a general conception.

The specialized approach has created an orientation toward decision making that is currently in vogue in many parts of the world. It is based on individualism, competition, training for a specific profession, and indoctrination into a specific culture. On the other hand, the general systems approach encourages the development of a global, more unitary consciousness, team work, collaboration, learning for life, and exposure to the universal storehouse of accumulated knowledge and wisdom.

Current breadth and diversity in the systems sciences

The systems sciences comprise a transdisciplinary area of formal inquiry aimed toward general theory development, testing, and validation. Although they do not constitute a discipline, specific branches, such as cybernetics, can be thought of as disciplinary sub-areas of the general system theory field. As Boulding pointed out, general system theory (and systems science in general) "aims to provide a framework or structure on which to hang the flesh and blood of particular disciplines and particular subject matters in an orderly and coherent corpus of knowledge." (Boulding, 1956, p. 10.)

Qualitative aspects

The methodology of the systems approach involves an intuitive element in applying systems ideas, going beyond the methodology prescribed by the strictly analytical procedures of the classical sciences. Methodology itself is different from technique because it is not something which, if applied correctly, will inevitably lead to an answer. Procedures which follow a step by step path and lead to an end result are known as algorithms. The systems approach may also involve non-algorithmic procedures — known as heuristics — which in many cases prove to be sufficiently powerful to obtain satisfactory results.

In studies of perception, systems-oriented inquiry is not necessarily quantitative in execution. This is true especially in regard to the application of systemic theories to interpersonal cognitive phenomena. Such phenomena tend to resist quantitative modeling by posing basic difficulties already on the plane of system identification. In these and similar difficult cases, systems theory performs a qualitative heuristic function: it attempts to identify specific entities capable of being modeled as systems, and wider areas as their relevant environment. As Tehranian remarked, the systems thinker's perception always incorporates an element of human intuition. (Tehranian, 1974, p. 68.) Implicit here is the notion that an observer engaged in systems research will give an account "of the world, or part of it, in systems terms; his purpose in so doing; his definition of his system or systems; the principle which makes them coherent entities; the means and mechanisms by which they tend to maintain their integrity; their boundaries, inputs, outputs, and components; their structure." (Checkland, 1981, p. 102.)

Systems and environments

In systems theory the term 'environment' is defined as the set of all objects a change in whose attributes effects the system as well as those objects whose attributes are changed by the behavior of the system. (Hall & Fagen, 1956.) According to Ackoff, the environment of every social system contains three levels of purpose: "the purpose of the system, of its parts, and of the system of which it is a part, the suprasystem." (Ackoff, 1981, p. 23.)

This brings up the question, how systems thinkers formulate their perception of social reality in terms of what is a system, and what is an environment. Observers in the context of systems science have a clear conception of their mission as an integral part the social system with which they work. In performing a systems analysis of a problem or situation, they start from the problem, not from a preconceived model. Once the manifestation of the problem has been identified and described, they can proceed inward to the sub-systems and outward to the environment.

Method

The method proposed by systems theory is to model complex entities created by the multiple interaction of components by abstracting from certain details of structure and component, and concentrating on the dynamics that define the characteristic functions, properties, and relationships that are internal or external to the system. Such simplification — the above-noted 'reduction to dynamics' — is necessary throughout the range of systems inquiry from hydrogen atoms to human social structures. Atoms are composed of a handful of particles and forces, yet physicists find that their interactions require multidimensional spaces for adequate modeling. The human organism, on the other hand, is composed of some five octillion atoms, and the specific interconnections among them surpass any conceivable method or instrument of calculation. Even social systems are not simple; a detailed consideration of their interaction with natural and artificial systems involves a number of factors and variables that surpasses the capacity of any presently known heuristic system or calculating device.

When framed as a process of inquiry, these perspectives cannot be adequately presented by the familiar three-step process of the classical analytical sciences. Traditionally, the scientific method of analysis has involved:

1) the deconstruction of that which is to be explained;
2) the formulation of explanations that account for the behavior or properties of the components taken separately; and
3) the synthesis of these explanations into an aggregate understanding of the whole.

A four (rather than three) step approach of analysis/synthesis is needed to render possible the consideration of entities as diverse as atoms, organs and organ system, individuals, and societies through the common rubric of systems theory. The starting point is consideration of the embedding context that includes, and is to some extent defined by, the phenomenon under consideration. The second step involves description of what may be defined as 'sub-wholes within the embedding whole': identifiable discrete entities existing in their own right within the larger framework of the overall ensemble. Third, attention shifts to the specialized parts within the identifiable wholes, with emphasis on understanding the structures, their compositions and modes of operation, much as in the three-step process described above. The fourth and final step refocuses on the embedding context, integrating the perspective obtained at each of the preceding steps in an understanding of the overall phenomenon, including its internal and external context. Key to this understanding is the emphasis on function as well as structure, on relationships and bonds in addition to the elements and components to which they pertain, so that the resulting understanding of the entity or process under consideration is expressed in terms of its roles and functions within the embedding whole.

Recent trends in systems thinking

An exploration of the development of systems theory can be traced over a range of intellectual activity and practical endeavor. A number of distinctions have to be made. If we begin with the entire field of endeavor pertaining to systems theory, the first distinction is between the development of systems ideas *per se* (as in cybernetics, for example) and the application of systems ideas within an existing discipline (as in the application of systems concepts to humanistic psychology (Krippner *et al.*, 1985, pp. 105-115)). This results in two broad areas of systems inquiry (see Figure 1).

In the branch concerned with work in the systems sciences as such, we can distinguish between the purely theoretical development of systems ideas and their interrelationships, and work aiming to develop systems ideas useful to interpreting and/or handling real-world situations. General evolution theory is an example of the former, while the development of social systems design methodology is an example of the latter. There are others examples as well, leading to a three-fold distinction: *hard* systems approaches (such as are employed in systems engineering), *soft* systems approaches (such as are drawn upon in humanistic psychology), and mixed systems approaches — such as those employed in operations research — used as an aid to decision-making.

The classification of systems into *hard* and *soft* represents an effort to draw attention both to the degree of knowledge about a system, and about the system's aims or purposes. Checkland developed this classification to represent two ends of a continuum. Hard systems are more easy to define and have more clear-cut aims or purposes. They are typically the subject matter of engineers concerned with real-world problem-solving: mechanisms, machines, aircraft, and power plants are examples. Simplicity of purpose and clarity of boundary, however, do not necessarily mean ease of design, operation, or maintenance: hard systems, as we know, can indeed be highly complex. At the other extreme are *soft* systems, characterized by human beings as their principal components. Such systems are difficult to define; they do not have clear-cut and agreed aims or purposes. At the level of the individual psyche there are multiple processes of perception, interpretation, representation, explanation, and communication that push and pull at our individual and collective cognitive maps as they shape our subjective image of phenomena and events. At the level of a multiperson organization there are frequently different and conflicting aims operating simultaneously. In both cases, the images and the aims of the system, even if agreed upon, may change over time.

Figure 1 here

Critical systems thinking

Recent work in the area of soft systems thinking has led to the development of what has become called emancipatory systems thinking. It has a branch that leads to critical systems thinking and adopts an epistemological stance toward systems that leaves aside ontological considerations. Such thinking advocates the critical and complementary use of various systems approaches.

Critical systems thinking is a robust recent trend in humanistically oriented systems work. Spearheaded by work of Ulrich (1983), Flood (1990), and Flood and Jackson (1991), this approach manages to accommodate the knowledge-constitutive interests of Jürgen Habermas (1971) and the interpretive analytical orientations of Michel Foucault (1972) through a meta-methodology involving constant critical reflection. The meta-methodology serves as the basis for the generation of a new methodology that critically applies various systems approaches to problem solving. In doing so, critical systems thinking pursues five areas of commitment:

1) critical awareness,
2) social awareness,
3) complementarism at the methodology level,
4) complementarism at the theory level, and
5) human emancipation.

Through critical awareness, a person is enabled to analyze the assumptions, strengths, and weaknesses of the theoretical underpinnings of the systems methods and techniques brought to bear both at a particular level of the system under consideration, and at the level of the system as a whole. Social awareness brings into play the societal or organizational climate that influences the acceptability of a given systems approach at a particular time. Complementarism of methodology addresses the use of different sub-methodologies for the attainment of particular tasks. Theory-complementarism advocates respect for different theories while seeking to address constitutive interests. Finally, the notion of human emancipation seeks to raise the quality of life and work for the persons involved in a systems intervention.

Total systems intervention

A specific and highly promising sub-area of critical systems thinking is the total systems intervention (TSI) approach. As a meta-methodology, TSI departs from the assumption that all problem solving methods are complementary. The requirement for each problem situation is a combination of the best methods for each aspect of the problem. The selection of a 'package' of complementary methods is accomplished by the problem solver (the person faced with the problem situation) with the aid of certain operational procedures. These procedures surface through the three modalities of TSI: the critical review mode, the problem-solving mode, and the critical reflection mode. (Flood, 1995, p. 3.)

Even though critical systems thinking holds much promise for the study of perception, it is bounded by the overriding rationality that serves as an all-embracing framework for its approach to reality, and has a tendency to place heavy emphasis on the purely epistemological aspect of systems theory construction. Although this is one of the most recent branches of systems inquiry, there are already indications of offshoots sprouting in the direction of multimodal systems thinking. These offshoots seek to break the bounds of the autonomous rationality that is still implicit in critical systems thinking and to develop a more normative conception of reality. Multimodal systems thinking, as put forward by J.D.R. de Raadt, is informed by a perspective that places human reason as part of a supra-subjective and supra-arbitrary normative order of reality. This normative order is taken to precede reason and rationality, and to determine the status of reason and the boundaries and limitations of science. Complete control is viewed as an illusion in real-world systems interventions. This sub-branch of critical systems thinking swings the pendulum back toward ontological considerations.

General evolution theory

An action-oriented systems approach to the development of human and natural systems has emerged from the study of evolutionary processes in nature and society. It is known as General Evolutionary Systems Theory (or general evolution theory for short). (E. Laszlo, 1987.) The evolutionary trend in the universe constitutes a 'cosmic process' that manifests itself through particular events and sequences of events that are not limited to the domain of biological phenomenon but extend to include all aspects of change in complex open dynamic systems with a throughput of information and energy. Evolution relates to the formation of stars from atoms, of *Homo sapiens* from the anthropoid apes, as well as to the formation of complex societies from rudimentary social systems.

Human societies evolve through convergence to progressively higher organizational levels. When flows of people, information, energy, and goods intensify, they transcend the formal boundaries of the social system. Thus neighboring tribes and villages converge into ethnic communities or integrated states, these in turn become the colonies, provinces, states, cantons, or regions of larger empires and eventually of nation-states. Today, we are witnessing yet a further level of convergence and integration as nation-states are joining together in the creation of various regional and functional economic and political communities and blocs, in Europe as well as in North America and elsewhere in the world.

Through the notion of 'bifurcations' (nonlinear and often indeterminate transitions between system states), evolutionary systems theory refers to conditions that prevail when societies are destabilized in their particular time and place. They then either reorganize their structures to establish a new dynamic regime that can cope with the original perturbations, or disaggregate to their individually stable components. Bifurcations are revolutionary transformations in the development of society. The reins of power change hands, systems of law and order are overthrown, and new movements and ideas surface and gain momentum. When order is reestablished, the chaos of transformation gives way to a new era of comparative stability.

Societal bifurcations can be smooth and continuous, explosive and catastrophic, or abrupt and entirely unforeseeable. However, they always describe the point at which a social system traverses a period of indeterminacy by exploring and selecting alternative responses to destabilizing perturbations.

The promise of general evolution theory is captured succinctly by Laszlo, Masulli, Artigiani, and Csányi as follows:

> The description of the evolutionary trajectory of dynamical systems as irreversible, periodically chaotic, and strongly nonlinear fits certain features of the historical development of human societies. But the description of evolutionary processes, whether in nature or in history, has additional elements. These elements include such factors as the convergence of existing systems on progressively higher organizational levels, the increasingly efficient exploitation by systems of the sources of free energy in their environment, and the complexification of systems structure in states progressively further removed from thermodynamic equilibrium.
>
> General evolution theory, based on the integration of the relevant tenets of general system theory, cybernetics, information and communication theory, chaos theory, dynamical systems theory, and nonequilibrium thermodynamics, can convey a sound understanding of the laws and dynamics that govern the evolution of complex systems in the various realms of investigation. ..... The basic notions of this new discipline can be developed to give an adequate account of the dynamical evolution of human societies as well. Such an account could furnish the basis of a system of knowledge better able to orient human beings and societies in their rapidly changing milieu. (E. Laszlo *et al.*, 1993, pp. xvii, xix.)

In relation to the study of perception, general evolution theory provides a conceptual foundation for theories and tenets of evolutionary consciousness, evolutionary action, and evolutionary ethics. It suggests that human destiny can be placed in human hands, since it postulates moving toward conscious evolutionary strategies by which to guide the sustainable development of human communities. When this theory is combined with the emancipatory systems approach, a normative imperative emerges for the proactive design — or redesign — of the human future. It accents the empowerment of individuals and groups through the envisioning and subsequent co-creation of evolutionary pathways to desired future states of multiperson evolutionary systems.

Systems design

The design of open social systems is a relatively new mode of inquiry. It emerged recently as a manifestation of open systems thinking and corresponding soft-systems approaches. As a disciplined inquiry, it serves to enable evolutionary systems designers to align the systems they create with the dynamics of civilizational change and the patterns of sustainable environmental development.

The systems design approach seeks to understand a situation as a system of interconnected, interdependent, and interacting problems. Likewise, the solutions it seeks to create emerge from a vision of the entity taken as a whole. Such an orientation permits the design of the future through an informed understanding of the dynamics that govern evolutionary systems. It implies that we take responsibility for the creation of our future in co-evolutionary interdependence with our social and physical environment. This is based on the belief that we can shape our future on the one hand through the power of understanding the characteristics and requirements of the environment, and on the other through our aspirations and expectations.

Systems design is participatory by nature: significant social change can be brought about only if those who are most likely to be affected by it participate in soliciting it, and choose how it is to be implemented. Since in societal systems human beings are the critical factor, change must necessarily both emanate from and incorporate them. Systems design advocates *anticipatory* democracy, where people actively apply their skills to the analysis and design of socially and ecologically sustainable systems by becoming active participants in shaping their future. Groups of people engaged in purposeful systems design form an evolutionary learning community, and such communities make for the emergence of a culture of evolutionary design.

Systems theorist Bela Banathy characterized systems design in the following terms:

> Science focuses on the study of the natural world. It seeks to describe what exists. Focusing on problem finding, it studies and describes problems in its various domains. The humanities focus on understanding and discussing the human experience. In design, we focus on finding solutions and creating things and systems of value that do not yet exist.

> The methods of science include controlled experiments, classification, pattern recognition, analysis, and deduction. In the humanities we apply analogy, metaphor, criticism, and (e)valuation. In design we devise alternatives, form patterns, synthesize, use conjecture, and model solutions.
> Science values objectivity, rationality, and neutrality. It has concern for the truth. The humanities value subjectivity, imagination, and commitment. They have a concern for justice. Design values practicality, ingenuity, creativity, and empathy. It has concerns for goodness of fit and for the impact of design on future generations. (Banathy, 1996, pp. 34-35.)

Evolutionary systems design

Recent efforts to apply general evolution theory to social systems design have marked the birth of evolutionary systems design. (A. Laszlo, 1996.) Evolutionary systems design is an area of systems praxiology oriented to the creation of evolutionary pathways for the sustainable development of life on earth. Given the theoretical constructs of general evolution theory, and the methodological constructs of social systems design approaches, evolutionary systems design confronts the challenges posed by pursposeful stewardship of the earth's life support systems. The orientation of this praxiology is captured in a writing that dates from well before the emergence of evolutionary systems design: "Having become conscious of evolution, we must now make evolution itself conscious. If we so willed it, the next leap in the development of human society can be intentionally guided." To do so, we must create a "holarchic path where individuals and communities collaborate of their own accord in flexible social systems." (E. Laszlo, 1991, p. 104.)

Evolutionary systems design seeks to develop "evolutionary competence." Evolutionary competence refers to the state of self-actualization (of individuals and groups) that is marked by the mastery of the knowledge, the abilities, the attitudes, and the values required for co-evolutionary actions, and therefore, for the pursuit of sustainable modes of being. Such modes of being concern both the products *and the processes* of change in terms of the degree to which they are —

- socially desirable
- culturally acceptable
- psychologically nurturing
- economically sustainable
- technologically feasible

- operationally viable
- environmentally friendly
- generationally sensitive

By monitoring all these aspects simultaneously, a process of development (individual, societal, or global) can be said to be evolutionary if it involves an adaptive strategy that ensures the continual maintenance of an increasingly robust and supportive environment. Evolutionary design seeks to identify opportunities for increasing the dynamic stability and self-sufficiency of an individual or group in interaction with its the broader set of compenents of its particular time and place. It indicates areas of evolutionary potential to be developed to the advantage of the complex dynamic systems involved in ecosystemic interaction now and into the future.

The stewardship of evolutionary competence is one of the principle objectives of evolutionary systems design. Through processes that cultivate individual and collective empowerment in the creation of pathways of evolutionary development, current research in evolutionary systems design seeks to define and promote real-world models of evolutionary learning communities (ELCs). The work of others along similar lines marks a trend toward convergence on the normative issues of evolutionary systems design. Dee Hock has for some years been working on the notion of the organization that exists between chaos and order — what he calls the "chaordic organization." According to Hock, "all organizations are merely conceptual embodiments of a very old, very basic idea — the idea of community." (As quoted in Waldrop, 1996, p. 8.) His notion of the chaordic organization is meant to capture this concept of community, and to address issues of social development "in ways harmonious with liberty, the human spirit, the biosphere and the fundamental principles of evolution. Only a new concept of organization in which the whole does not control the parts and none of the parts control the whole, can competition and cooperation be blended, order emerge, and effective, efficient, equitable" systems of human activity evolve. (Hock, 1994, p. 6.)

Notions such as these point to the need for the systems design of effective evolutionary learning communities. An ELC can be defined as a group of two or more individuals with a shared purpose and a common identity that develops evolutionary competence by learning how to learn in harmony with the dynamics of its physical and sociocultural milieu. ELCs do not adapt their environment to their needs, nor do they simply adapt to their environment. Rather, they adapt *with* their environment in a dynamic of mutually sustaining evolutionary co-creation.

Situations of uncertainty are turned into opportunity — provided a basic level of evolutionary competence that permits understanding of the principles that explain the patterns of change described by all complex dynamic systems with a throughput of information and energy.

Normative considerations

The increasing complexity and interrelatedness of human social systems highlights the need for a systems theory that combines the humanities and the sciences in an holistic interpretation of current realities — one that foments the robust design of desired (and desirable) futures as legitimate responses to the perception of global and individual needs. Conscious human guidance is an ongoing requisite since the ability of societies to evolve, and even to survive, depends in a great measure on their ability to adapt with changing realities. A systemic orientation is needed to maintain an holistic, critically self-reflective attitude that seeks to integrate individual satisfaction (including the physical, mental, emotional, and spiritual needs of human beings) with their societal and natural environments in consideration of dynamic developmental laws and processes.

However, given that they are culture-conditioned, social systems are embedded in an even more mercurial environment than are biological systems. What the reality is that affects the existence of social institutions, political states, and economic systems depends not only on what the case is, but on what its members and its leadership perceive it to be. Since reality is not an absolute given, systems theorists should not seek to design absolute solutions to contemporary challenges; solutions should take the form of flexible surveillance systems that help decision-takers select humanistic and sustainable responses to the issues they confront.

Systems Theoretic Tools for the Study of Perception

Systems inquiry offers a rich array of conceptual tools for the study of perception. The process of meaning generation involved in acts of perception, interpretation, conceptualization, reflection, contemplation, explanation, articulation, and communication may be addressed from a variety of systems perspectives, as described above. For the purposes of this chapter, we have chosen to focus on one example; that of the 'cognitive map.' We hope to indicate how systems theoretic tools, such as represented by the concept of individual and collective cognitive maps, can help explore the link between perception, individual dispositions, and cultural attitudes. We begin with a brief review of some definitions and descriptions of the concept of perception.

'Perception' refers to the organization of sensory information into meaningful patterns. It begins with the reception of information by the senses and then involves selection as well as active computation. Just as 'behavior' and 'activity' are labels for output phases of an operation of some types of living structures, 'perception' is a label for an input phase.

'Exteroception' is a label for the perception of external objects and events by means of such senses as vision, hearing, taste, touch, and smell. 'Interoception' is a label for the perception of body states and events such as feelings of pain, internal pressure, bodily position (i.e., 'proprioception'), and movement (i.e., 'kinesthesis'). Perceptual events are processed for some time before an organism becomes aware of them.

Cognitive maps

Cognitive maps, in general, serve to navigate the topography of socio-cultural and physical environments. We derive an understanding of this terrain through the structure of these maps. Over the ages, models of cognitive maps have undergone evolution, have been fine tuned and, at times, have been discarded as more meaningful ways of understanding became available. This process afforded an ever broader view of ourselves, and allowed us to see an ever larger, clearer, and more detailed picture of the perceptual and conceptual realities in which we are immersed, both individually and collectively. For the most part, however, it has not been a conscious process. It soon may be possible to elucidate the structure, function, and operational process of the evolving human cognitive map for the benefit of decision takers and the lay-public alike.

How we see aspects of the world in which we live and our relationship to them is dependent on our understanding of ourselves as living beings in complex social, psychological, and physical settings. For example, how do we arrive at an understanding of the preferences we, singly and collectively, adopt regarding technology? A proper response to this question requires an exploration of the values and beliefs that underlie human behavior with regard to technology choice. Consequently, it would be important to elucidate the foundations of the technology-related cognitive maps that describe these values and beliefs and to explore the aspects that distinguish such maps from similar cultural paradigms and *Weltänschuungs* or *Weltänsichts*, whether based on myth or on science. A truly operational framework for technology policy could be constructed on the bases of a model that would permit description of the set of conceptual and perceptual filters that orient societal attitudes with regard to technology choice. To begin with, the general notion of the cognitive maps of individuals in society and, in the collective, of societies themselves is subsequently considered.

The concept of a cognitive map is becoming part of the accepted terminology used to describe human-environment interactions in evolutionary and adaptive studies. It has been most widely used to denote the mental representations by which animals and humans (indeed, all living creatures) navigate their evolutionary landscapes. The concept of a specifically human cognitive map derives from the notion that human beings "map" their environment as a conceptual representation of that environment. (E. Laszlo *et al.*, 1993.)

When humans map their social interactions cognitively there is actually a double representation. On one level, sensory stimuli are mapped; on the other level, the linguistic descriptions of interactions appear. This dual representation makes human cognitive maps characteristically complex. Their information is communicated through linguistic portrayals, skilled behaviors, technologies, and other artifacts. To prioritize and preserve this information, cognitive maps involve values: "the human ability to symbolize permits not only complex human mental models but the possibility of choosing among them. A 'value' is an expressed preference among a series of alternative mental models." (Adams, 1988, p. 93.) Values are symbols that record phenomena and catalyze reactions to them. They encourage repeating behavioral sequences, forming stereotypes, and performing rituals. By incorporating values derived from cultural contexts, individual maps incorporate a certain amount of developmental leeway. Much of the information in linguistic portrayals, skilled behaviors, technologies and the like — information on which individual maps depend — is transferred from others. Thus, human cognitive maps can be constructed without direct experience. The nature of these learning processes and their representation through individual cognitive maps contributes to making our realities socially constructed.

At the most general level, therefore, individual human cognitive maps can be thought of as the means by which we structure and organize our experiences in a coherent manner. As such, individual maps refer to the specific representations or images of social and physical reality formed in the mind. According to Ervin Laszlo *et al.*, a cognitive map can be understood to represent "the process by which an organism makes representations of its environment in its brain." (1993, p. 2.)

More specifically for the purposes of this discussion, it is possible to define the concept of a cognitive map as *the mental image or representation made by human individuals and groups of their environment and their relationship to it, involving not only the rational aspects of attitudes and behaviors, but also the values and belief components that shape human perception.* As distinct from *culture,* cognitive maps pertain to individuals as well as to social groups, whereas culture is, by definition, a property of the group or of the individual's relationship to the group. Furthermore, while it is true that cognitive maps are defined by their general cultural context, they may also depict specific aspects of culture, such as the values and preferences of people or of a people toward a given sociofact.

The "map" depicts a mental representation of one's environment and one's relationship to it inasmuch as it *is* the image, even though it is never an exact and one-to-one representation of external reality. To search for the map is to try to decipher the image, while "mapping" the map would be akin to creating an image of the image. The goal of any such search is to create a model of the mental representation of the various aspects of culture which take the form of cognitive maps; to generate a "map of the map," or a meta-map, such as schematically represented in gross outline form in Figure 2.

Figure 2 here

On an individual level, cognitive maps are conditioned by the values and beliefs that are dominant in society at the time. Within a given culture, values and beliefs are relatively coherent. As a result, it is possible to speak of a collective or *societal* cognitive map of the environment (social, cultural, as well as natural) that is greater than the sum of the interpersonally coherent individual cognitive maps of which it is comprised. Such a societal cognitive map describes the general orientation of a given culture at a given time.

Cognitive maps that serve as vehicles for societies to probe environments quickly and effectively are the means to their ability to keep pace with accelerating rates of change. When "in sync" with socio-cultural dynamics, such maps permit cultural behavior that matches societal change through the efficient processing of environmental information and the effective exploration of various structural responses to future possibilities. When not in sync, they tend to perpetuate singular responses that no longer fit with the realities of a changed and changing environment. This is because information about one's environment is normally processed so as to reduce, rather than to increase, behavioral uncertainty. When information can no longer be effectively processed, individuals begin to rely on their personal representations of local experience rather than on the cultural representations of collective experience described by their societal cognitive maps.

It is reasonable to suppose that evolutionarily unadaptive or unstable responses to environmental change in and across societies could be made more adaptive through attempts to couple more closely the mutually defining influence of cultural attitudes and notions of evolutionary development. In other words, if it is possible to elucidate the collective cognitive map that dominates contemporary attitudes and dispositions toward change in given societies, then it should be possible to elaborate on such maps and to seek a more felicitous harmonization between evolutionary systems design alternatives and cultural development. This requires evolution of the design-related cognitive maps which portray the cultural hachures (a term borrowed from cartography, used to denote “any of a series of short, thin, parallel lines used ... to represent a sloping or elevated surface (*Webster’s New World Dictionary*, 1966)). that serve to describe values and preferences regarding notions of change (from deterministic or fatalistic to subjectively teleological). The following line of reasoning sets forth the basic assumptions implicit in such inquiry:

1. Everyone has a way of ordering their perceptions and conceptions to make sense of the world around them and of their place in it. To do so, individuals evolve what are called *cognitive maps* of their external environments.

2. These maps are influenced by a shared culture which serves as a supraordinate framework that lends them interpersonal coherence.

3. Coherent individual cognitive maps amount to a collective cognitive map which is, in fact, the cognitive map of a society. At this level, that aspect of culture which channels the general disposition of a people describes the cognitive map of their society.

4. Society's cognitive map can be researched and its main features identified. This is then a model of the existing cognitive map (a "map of the map" which serves as an operational framework to describe the society's culture).

5. Society's cognitive map includes values and preferences regarding notions of change. These can likewise be modeled (in other words, the change-related aspects of the cognitive map can be systemically mapped).

6. Difficulties arise when individual cognitive maps do not jibe with societal directions regarding alternatives for cultural development.

7. To harmonize this disjunction, it would be necessary to explicate and enhance individual cognitive maps through specifically designed educational media (thereby addressing the imbalance on one side), while providing the conceptual means whereby evolutionary systems designers could better adapt their interventions to prevailing cognitive maps (thereby addressing the imbalance on the other).

8. Through social, historical, and therefore systemic, case-studies it would be possible to provide a heuristic mapping of society's change-related cognitive map. Such a model could be used to make evolutionary (i.e., personally, interpersonally, and environmentally optimal) development choices.

9. The mapping could be accomplished through the generation of a change–culture typology wherein alternatives for cultural development are matched against culture types: the types of life-ways, values, myths, and images of social reality that have the closest mesh with specific modalities and technologies of evolutionary development in given cultures.

Since cognitive maps are constructs of our underlying patterns of conception and perception, they are amenable to empirical research. Bringing the lessons of nonlinear thermodynamics to bear on our understanding of societal systems could provide the starting point for the generation of policy-oriented meta-maps of culturally appropriate developmental pathways. Such inquiry would serve to provide a clearer and sharper picture of interactions within and between social systems and their environment. For its empirical grounding, it would draw on the "sciences of complexity" which are based on the study of nonlinear processes in nature. Systemic processes obeying natural laws in the cultural sphere could best be illustrated through analogies with laws in the biological realm.

The rational basis for the natural laws governing the evolution of human social and psychological systems can be grasped through comparisons with analogous processes in the life sciences. For instance, the foregoing discussion of cognitive maps related the notion of culture (as a group phenomenon) to the notion of the *Weltänschuung* (as an individual phenomenon). This relationship derives from the view that individual and societal evolution are examples of processes following general evolutionary principles. This type of relationship can be illustrated by way of analogical processes in biology. For instance, it is possible to consider the information encoded in culture to play a role comparable to the information in DNA: it guides the replication of societal structures much the way DNA informs the replication of biological structures and provides an operational context for individual action. Extending the role of culture beyond individuals to societies, through such conceptual tools as the notion of individual and collective cognitive maps, may permit the application of systems-scientific theories of dissipative structures in nature to the evolution of individual and collective aspects of human social systems.

Conclusion

The above insights have led to the development of an orientation in the systems sciences that may provide a solid bridge between systems theory and studies of perception. In this context it is useful to recall Rapoport's description of the fundamental aim and orientation of general system theory:

> ...the task of general systems theory is to find the most general conceptual framework in which a scientific theory or a technological problem can be placed without losing the essential features of the theory or the problem. The proponents of general systems theory see in it the focal point of resynthesis of knowledge. There was a time when the man of knowledge was a generalist rather than a specialist, that is, he embodied the knowledge of principles rather than skills. He was the philosopher and the sage, and his epistemological creed was most clearly stated by Plato, who believed that all real knowledge comes from within rather than from without, that is, from the contemplation of what *must* be rather than what seems to be. (Rapoport, 1968, p. 457.)

The erstwhile future of systems thought is now the practice of the contemporary action-oriented systems theorists. Evolutionary systems design, drawing on emancipatory systems thinking, and based in evolutionary systems theory and social systems design, presents the humanistic manifestation of systems theory in its fullest expression. In the context of individual and collective human activity systems, evolutionary systems design is a rigorous future-creating area of inquiry and action. Much as Rapoport suggests, people engage in design in order to devise a model of a system based on their vision of what *should* be. They seek a design that has a 'good fit' with the dynamics of their society, with their own expectations, and with the expectations of their milieu.

Through action-oriented systemic inquiry on issues of individual and collective cognitive maps, it may be possible to guide social systems design efforts in ways that simultaneously heighten individual perceptions of inclusion and meaningful participation in the dynamics of change, while creating adaptive strategies for evolutionary development by ensuring the continual maintenance of an increasingly robust and supportive environment. Design efforts that re-align contemporary cognitive maps with the imperatives of evolutionary development can be brought to individuals and communities through the vehicles of participation and empowerment. Evolutionarily empowered individuals not only perceive the dynamics of change of which they are a part and are conscious of the urgency for responsible interaction with their evolving socio-ecological system, but manifest their perceptions and consciousness in value shifts that re-align individual cognitive maps with the new realities of the world around them.

Evolutionary systems design derives from a general system theory that provides the constructs for interpreting the processes of change in open dynamic systems and is infused by studies of perception that shed light on how we navigate the diachronic terrain of physical and social reality. It holds out the hope of creating the conditions in which individuals and groups may gain the evolutionary competence needed to co-create sustainable evolutionary pathways for humanity — in interactive ways that allow the other beings as well as the earth’s life support systems to evolve sustainably, as well as with dignity and harmony.

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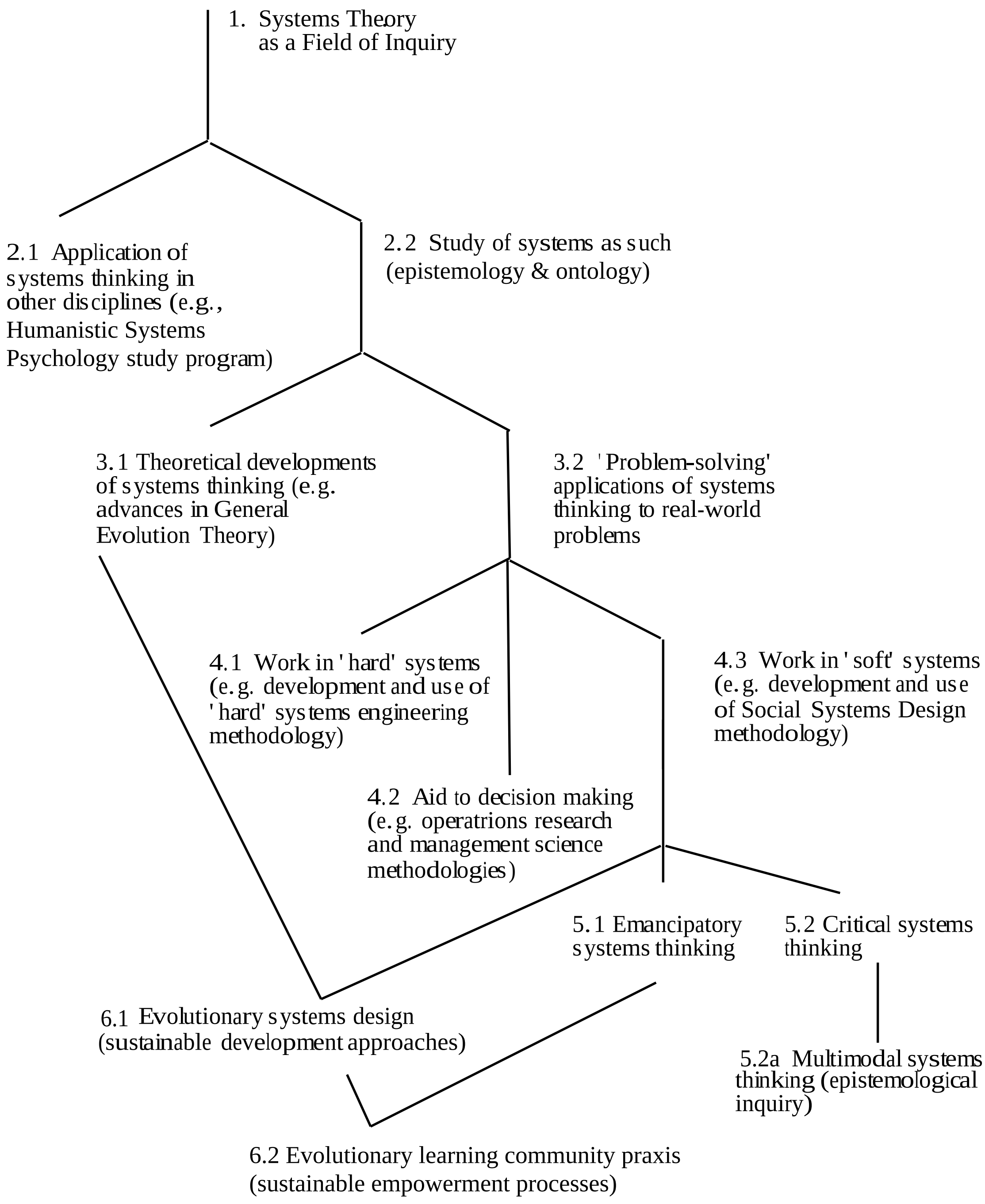

Figure 1. **The shape of the systems movement, indicating the progressive development of particular theoretical branches**

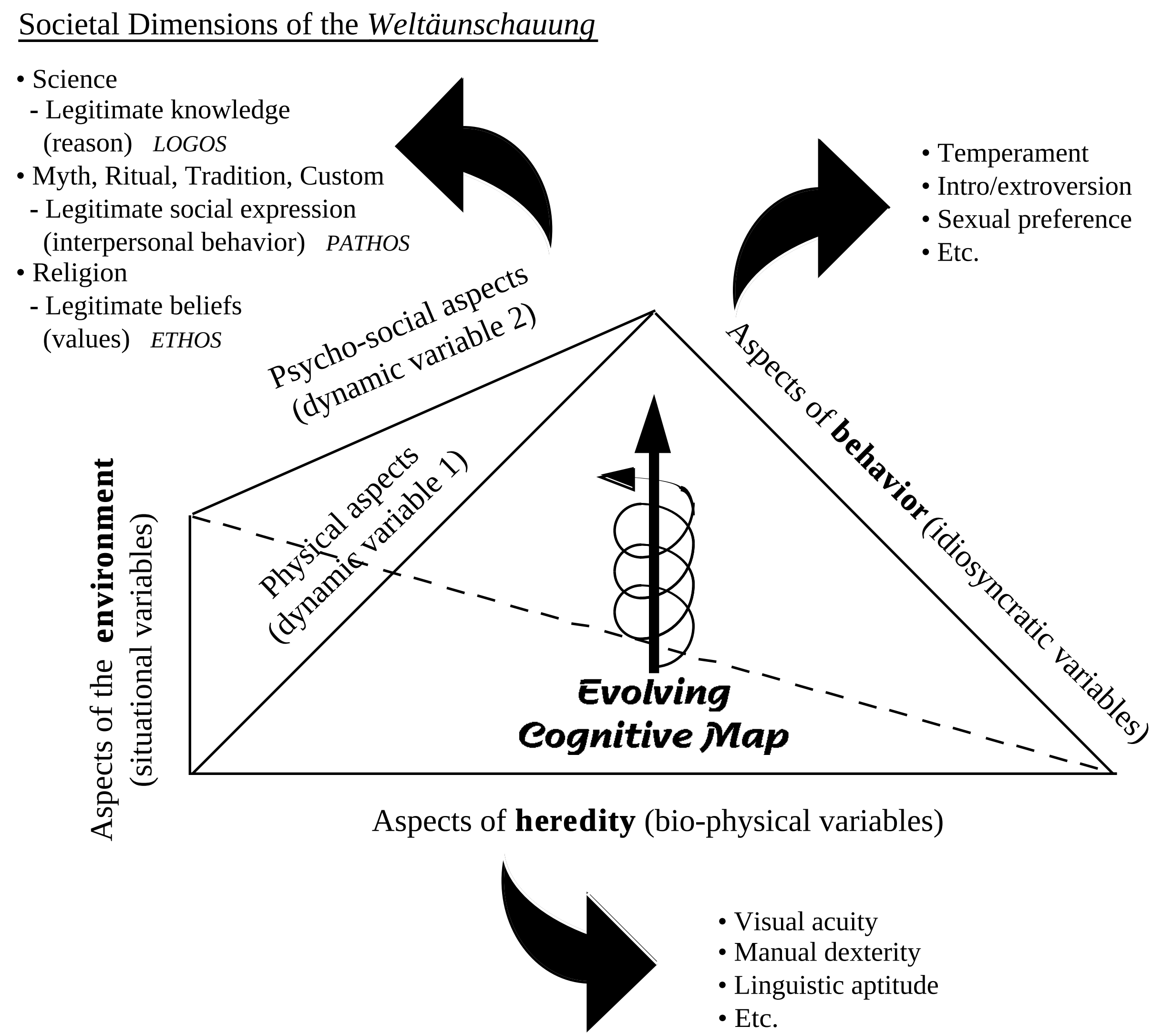

Figure 2. **Heuristic representation of evolving individual cognitive map**