Systems Theories: Toward a Meta-Perspective

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Abstract:

In this paper I will outline only some of the focal points in the evolution of systems theories in the sciences as well as some of the debates around the systems concepts which emerged. I will then speculate briefly on some of the implications of the paradigm shift introduced by the system perspective. While some of the systems theories appear to be steeped in mutually incompatible basic assumptions, I will use Mc Whinney's work to argue how these different theories derive from different and supplementary worldviews that co-exist comfortably from a meta-perspective. I suggest that such a meta-perspective offers an understanding of the paradoxical co-existence and complementarity of separation and holism, individuality and community, the atomistic and the field perspectives. It offers new opportunities for inter-fertilization and where relevant integration of different systems perspectives and may provide a deeply human extension of the until now seemingly disparate theories.

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"....I thence concluded that I was a substance whose whole essence or nature consists only in thinking, and which , that it may exist, has need of no place, nor is dependent on any material thing; so that "I", that is to say, the mind by which I am what I am, is wholly distinct from the body, and is even more easily known than the latter, and is such, that although the latter were not, it would still continue to be all that it is."

(Descartes, from "Discourse on Method)

"Blood is necessary to lungs, so blood belongs to lungs. In the same way we can say lungs belong to heart, liver belongs to lungs, and so forth, and we see that every organ in the body implies the existence of all others. This is called, "the interdependence of all things," or "interbeing" in the Avatamsaka Sutra. Cause and effect are no longer perceived as linear, but as a net, not a two-dimensional one, but a system of countless nets interwoven in all directions in multi-dimensional space. Not only do the organs contain in themselves the existence of all the other organs, but each cell contains in itself all the other cells. One is present in all and all are present in each one. This is expressed clearly in the Avatamsaka Sutra as, "One is all, all is one."

(Thich Nhat Hanh p.64)

Say not 'I have found the truth,' but rather "I have found a truth.'
Say not, 'I have found the path of the soul.; Say rather, 'I have met the soul
walking upon my path.'
For the soul walks upon all paths.
The soul walks not upon a line, neither does it grow like a reed.
The soul unfolds itself, like a lotus of countless petals.

Gibran Khalil Gibran

The challenge to grasp the variety of theories and concepts embraced by the term "Systems theories" confronts one with the very issues the systemic approach raises. What are the boundaries of "systems theories" as a system? What are the patterns of organization and relationships of the different systems theories and between these and the historical environment within which they are developing? The very framing of these questions in terms of "boundaries" and "environment" indicates assumptions which are challenged by "field theories".

A linear historical account of systems theories may imply a causal link between significant events in the development of systemic concepts, or perhaps a cyclical causal relationship with feedback loops between the related theories. On the other hand, the chronological approach may express a teleological perspective where the evolution of systemic knowledge is seen as gradually unfolding itself according to its innate ordered laws and inherent purpose? Where would such a linear picture begin? "Systems theories" as such were born in Western society in the twentieth century but their roots can be traced back to the beginning of culture. What would be "inside" and "outside" the system from a temporal perspective? The linear perspective does not reflect the complex "network of relations", "interdependence" and "structural coupling" between the different concepts, disciplines and events which are constantly giving rise to the multiplicity and diversity evident in the emergent "species of systems theories" today. Questions of self-organization, autonomy, hierarchy and constraints, interdependence, complexity, communication, information, dynamic balance, bifurcation points, resonance and iteration are all concepts which can enhance our understanding of the complex network which can be considered as 'systems theories'.

As a meta-field which touches on almost every aspect of our lives from biology to engineering, organizational theories to consciousness, it is not possible to provide a comprehensive or exhaustive history of the field of systems thinking or an account of the many applications in different disciplines. In this paper I will outline only some of the focal points in the evolution of systems theories in the sciences as well as some of the debates around the systems concepts which emerged. I will then speculate briefly on some of the implications of the paradigm shift introduced by the systemic perspective. While some of the systems theories appear to be steeped in mutually incompatible basic assumptions, I will use Mc Whinney's model to argue how these different theories stem derive from different and supplementary world views which co-exist comfortably from a meta-perspective. When one world view predominates in a society - the danger exists that there is an attempt to explain all phenomena from a limited perspective and to deny knowledge derived from differing worldviews. In a sense, this is what happened during the last three centuries with the prevalence of the atomistic, mechanistic perspective in Western Society. In some of the modern popular "systems' literature one may note a reactive tendency which invalidates much of what came before it. While people and disciplines tend to view the world from particular prisms, in this paper I suggest that the meta-perspective described by Mc Whinney is a step towards discovering optimal opportunities for exploring the inter-fertilization and even where relevant of the integration of different systems perspectives. A meta-perspective which offers an understanding of the paradoxical co-existence and complementarity of separation and holism, individuality and community, the atomistic and the field perspectives may provide a deeply human extension of the different systems theories.

The concept of "system"

Senge notes that the word system "descends from the Greek verb sunistanai, which originally meant 'to cause to stand together' "(Senge p. 91) and thus emphasizes the interconnectedness between the different parts of the system, and between the system and the environment. The shift to a systems view coincided with a growing recognition of the scientist as being a part of the "system" of observer and observed and thus not a neutral or objective factor in the research process.

The concept of "system" embodies a significant paradigm shift from a scientific focus on studying the matter and behavior of isolated phenomena, to exploring the nature of integrated wholes, and their complex patterns of organization. Systems theories evolved simultaneously in different disciplines, in reaction to the perceived limitations of atomistic and mechanistic reasoning in explaining complex living phenomena. Thus while a holistic understanding has existed throughout the centuries in a variety of cultural and spiritual practices, the specific concept of systems as I use it here, was born in reaction to the reductionist scientific approach which had been dominant in the Western world since the 17th century.

In 1981 Checkland wrote that the fact that "the systems movement is, even on a jaundiced view, at least a loose federation of similar concerns - linked by the concept "system" is the main achievement of Ludwig von Bertalanffy."(Checkland p. 92) At the turn of the 20th century, scientists began to turn more attention towards exploring the properties of wholes, and the organizing patterns within the whole. In the 1940's Bertalanffy initiated the generalization of organismic thinking into a broader concept of systems in general, and in 1954 was influential in founding the Society for General System Theory together with Boulding an economist, Gerard, a physiologist and Rappaport, a mathematician. The aim of the society was to stimulate interdisciplinary research and the development of a General Systems Theory. It was hoped that the society would enable investigation of the cross disciplinary isomorphy of concepts and laws and promote communication of knowledge and the unity of science. While the stimulation of interdisciplinary thinking was accomplished, as was the promotion of the concept of systems, Bertalannfy’s vision of a unified and encompassing mathematical General Systems Theory has not been achieved. The establishment of the society can be seen as a crucial “bifurcation point” in the history of systems thinking, one which gave public form and articulation to ideas emergent within a particular cultural and historical context.

History

Like many concepts revitalized today, ideas central to systems thinking can be traced back to early history in the thinking of the Greek philosophers, and many of the ancient spiritual traditions. These ideas need also to be explored within the context of the evolution of modern scientific thinking. In describing aspects of the different theories, it becomes clear how concepts that evolved in one field are integrated into the work of other disciplines in a process of mutual fertilization or perhaps of ‘structural coupling’ or ‘co-dependent arising’.

As early as the sixth century BC one finds sparks of debates continuing until today between a structure as opposed to a process view of the world, between those who advocated observation as the path to truth and those who advocated logical reasoning, between the concept of the whole being more than the sum of the parts and a more atomistic vision of the universe comprising building blocks and between a search for truth based on observation and experimentation as opposed to a metaphysical search for truth.

The Ionian philosophers, around the 6th century BC formulated cosmologies that speculated on the basic material element common to all of nature. Heraclitus on the other hand saw the basic unit of nature as the process of flux. The dichotomy, between sense and reason (observation and logical argument) as the path to the truth was the center of a debate between Parmenides and Empidocles in the fifth century BC. Hippocrates insisted on an empirical approach based on observation and testing, especially in the field of medicine. Socrates used the dialectic method to study metaphysical questions concerned with man's relation to the afterlife. While Democritus put forward the idea of the world comprising physical atoms with void between them, Parmenedis held that space is not a void but a plenum. Pythagoras developed the use of the abstract atoms of number to describe universal principles.

While Plato saw the manifest world to be deceptive and truth to lie in the world of ideas, his pupil, Aristotle did not believe that ideas could exist separately from their embodiment in the world of nature. He saw science as the discovery and classification of the teleological nature of objects, the purpose and evolution inherent in the form. This concept of an ordered and purposeful universe, in which objects evolve towards expressing their true nature and purpose, and where the whole is more than the sum of the parts, was to dominate Western thinking for 2000 years, until it was eclipsed by the mechanistic approach initiated by Galileo in the 17th century.

During the medieval period, Grosseteste, and later Roger Bacon and William of Ockham developed the use of experiments for testing hypotheses and formulated rules for inductive reasoning about phenomena. There was a debate between the realists who argued that qualities have independent existences and the nominalists who believed that qualities are only meaningful when embodied in an object. These developments were precursors of the scientific revolution, however medieval science according to Checkland was based on both reason and faith and its main goal was understanding the significance of things. The medieval notion of the universe was an organic, living and spiritual one and medieval scientists were concerned with questions relating to God, the human soul and ethics.

In the 16th century, the heliocentric picture of the universe put forward by Copernicus challenged the thinking of the time. Experimental science developed by Gilbert and Bacon was designed to provide answers to practical problems, and to provide opportunities for "control" over nature. This concept of control over nature was a departure from the previous spirit of a science that looked to explore and understand the natural laws as a means of connecting with the metaphysical nature of man and the universe. Galileo's work on mechanics using observation, measurement and mathematics was particularly revolutionary in that it investigated questions of cause and effect beyond the teleological Aristotelian view.

It was Descartes who articulated most comprehensively the reductionistic, mechanical view of a mathematically ordered universe. Believing that he could discover the nature of the whole by studying the parts, Descartes used analytic thinking to study the basic component parts of complex phenomena. The “Cartesian” differentiation between mind and matter and reductionist approach to the discovery of truth, was to exercise a powerful effect on the evolution of modern science. The scientific revolution was characterized by this Cartesian vision, an experimental approach based on observation and quantification, a search for the basic universal elements of nature, the laws which regulate their interactions and a drive towards practical discoveries which would provide ways to master nature. Newtonian mechanics offered a powerful foundation for the scientific worldview that went almost unquestioned until three hundred years later when Einstein put forward his theory of relativity.

Metaphysical speculation regarding issues of teleology and the relationship of the parts to the whole continued on the fringes of intellectual discussion and at the end of the eighteenth century political, economic and ethical theory began to explore the relationships of the parts to the whole. It was only in the early 20th century that questions of the nature of order and the relationship of the whole to the parts became central in scientific research.

In the 1890’s, the biologist Driesch cut the embryo of a sea urchin in half and noted that it nevertheless evolved into a whole sea urchin. This finding seemed to contradict the premises of the mechanistic worldview in which a final state is determined by its initial conditions. Driesch proposed a law of equifinality where the same goal can be reached from different starting points in different ways. He believed however that this could only be explained by a soul-like vitalistic factor or a higher intelligence that governed the processes. A debate ensued between the ‘vitalists’ who held the view of a higher intelligence that explained the evolution of form and purpose and the ‘mechanists’. According to Gray and Rizzo, the push towards a general systems theory was influenced by the debate between the mechanists and the vitalists; the development of organismic theories; the contradiction between the thermodynamic law of entropy which would indicate a trend towards maximum disorder and leveling down of differences and the law of evolution in biology which indicated movement towards higher levels of order; and the push towards a unification of science.

Von Bertalanffy however, resolved the apparent contradiction between the law of entropy and the law of evolution by distinguishing between inanimate and animate and closed and open systems.   “He emphasized that living organisms are essentially open systems, maintaining themselves in a continuous state of inflow and outflow, building up and breaking down components, never being, so long as they are alive, in a state of chemical or thermodynamic equilibrium, but rather in a steady state of balanced tension."(Gray & Rizzo p. 12) Open systems produce entropy as do closed systems but also import negentropic complex molecules thus off-setting entropy and allowing the development to higher states of order. This 'organismic' approach challenged the teleological assumptions of the vitalists, and sought to explain the evolution of form in living organisms by the patterns of relationship within a whole.

It was in this milieu that von Bertalanffy in the 1940's began to envision a general science of wholeness, and the establishment of a meta-discipline or common conceptual framework that would allow for inter-fertilization between the different sciences and would work towards finding a common interdisciplinary language of systems.

Years later, in 1967 Bertalanffy suggested that it was possible to identify two main trends which had developed in systems theories: the mechanistic trend and the organismic trend. These directions reflect many differences and even contradictions but also similarities and resonances. As these directions developed in parallel within a relatively short space of time it is difficult to identify specific causal links and direct influences between them. A field metaphor is perhaps most evocative here with "ideas being in the air", gaining more and more coherence and resonance as they were articulated on the background of different disciplines.

The mechanistic trend according to Bertalannfy " is grounded in technological, industrial, and social developments such as control techniques, automation, servomechanisms, computerization and so forth. Cybernetics, operations research, linear programming, theory of automata, and systems engineering may be named as characteristic examples. This trend finds its main expression in the theory and practice of self-regulating mechanisms governed by the principles of cybernetics. In the terms mentioned above linear causality was supplemented by circular causality, introducing feedback of output into input and so making the system self regulating with respect to maintenance of a desired variable or a target to be reached. (Bertalannfy p. 37)

Cybernetics

Cybernetics emerged as a separate science within this trend and was prominent in the future development of systems theories. Cybernetics reintroduced the concept of purposive systems but free of the previous Aristotelian teleological connotations. It explored how the living organism maintains and develops its organized state in the context of a tendency in the system toward disorganization. Cybernetics is concerned with questions of communication and control within systems and postulates mechanistic, mathematical models of systems with feedback mechanisms that mediate between actual and expected performance. The feedback mechanisms, involving self balancing ('negative') and self-reinforcing ('positive') feedback, assess and provide information relating to the deviation from the expected outcome and thus creates the possibility of purposeful self regulating systems. The field was influenced by the ideas of Walter Cannon who in 1939 wrote about the homeostatic principle that he identified in organisms.

Cybernetics introduced many new concepts in to the systems world, such as inputs, outputs, feedback mechanisms and comparators, and a movement from classical localized rules to one of global coherence in networks. Developments in cybernetics stimulated work in other fields, such as that of Ashby on set theory and others on game theory, decision theory organization theory, systems science, as well as new ways of looking at cognitive science.

At the first of the interdisciplinary Macy conferences, John von Neumann presented analogies between the as yet unbuilt computer and the brain. Cyberneticists, many of whom were mathematicians (most notably Norbert Wiener) and engineers were concerned with patterns of communication of information or signals. They examined patterns of organization common to machines, humans, organizations, disciplines and cultures. Wieners relationship with Gregory Bateson led to thinking about communication models within human systems and about applications of systems theories to family therapy. Wiener, Bateson and Mead looked to exploring the way in which cybernetic processes are integral not only to the individual, but also to social systems. Bateson also formulated a concept of the mind based on cybernetic principles and used cybernetic principles to explain human and societal phenomena in general.

Systems engineering developed alongside cybernetics. The role of systems engineers was primarily to design, implement and evaluate specific activity systems within organizations. Systems engineers were also concerned with creating optimal models specifying the steps and sequences involved in their task.

Systems analysis evolved primarily within the context of the research and development of the non-profit RAND Corporation in the United States that initially was involved during the Second World War in planning military operations. Whereas systems engineering deals with the set of activities of a human activity system and the information flow within the system, systems analysis is a systematic appraisal of the costs and consequences of alternative models for meeting a specific objective. The attempt of both systems engineering and systems analysis to apply systematic procedures often defined in terms of mathematical formulas to real-world problems, was both its strength and limitation. While contributing rational methods, clarity of definition, purpose, structure and processes to industrial problems, the richness, complexity and multi-dimensionality of the human aspect of the systems was greatly oversimplified or neglected.

Socio Technical Systems

Rice, Miller, Emery and Trist developed the concept of socio-technical systems. They emphasized that in industry the concept of the open system cannot refer to the technological component independent of the social system. In his study of the coal mining industry, Trist and his colleagues explored the way in which the consideration of human needs, or lack of it, impacts task performance.

The technological and human components mutually bound the design of the optimal working system where the human needs and the "primary task" of the whole system are taken into account. Enterprises were seen as "open socio-technical systems" which were concerned with the three-way influence of the socio-technical aspects of the system and the environment. This implies that management is concerned both with managing all three relations and especially the "boundary conditions" between them.

When it was applied to practical organizational problems, in particular to situations in which either social or technical changes had to be accommodated, this conception inevitably led to solutions that compromised between the technical requirements of the task and the human needs of those performing it. The assumption was made that the "right" organization would satisfy both task and social needs. (Miller and Rice, 1967, p.xi)

This approach provided the earliest applications of systems theories to industry. Since then there has been much work done on using systems theory for organizations which reflect both the mechanistic and organismic approaches as well as the spectrum in between.

The organismic trend

The organismic trend in contrast to the mechanistic, take a more gestalt view of the organizing patterns of the organism. The dynamic regulation of the system is seen as a property of the system as a whole which is beyond the aggregate of the parts. Structural arrangements allow the organism to carry out the necessary processes for survival. Rather than resting with the concept of causal loops, the organismic view looked to identifying the general principles and laws concerning "multi-variable interaction" within the organism and between the organism and the environment. "Wholeness", "growth" "competition", and "negentropy" were some of the earlier concepts to evolve. With recent work in biology, micro-biology, cognitive science, mathematics, and ecology the "systems vocabulary" has been supplemented with a vast evocative repertoire of new terms which describe a new vision of inter-dependence, co-creation and co-evolution of organism and environment. The new concepts are gradually being integrated into the human sciences as metaphors explaining human behavior in social systems.

With the advent of technology for the study of microbiology and ecology there was an intensified exploration of the organizational patterning of living organisms and the implication of the findings for understanding all living systems, as well as for evolutionary theories. Developments in the realm of quantum physics went beyond familiar mechanical concepts to new visions of energy, time, space and human consciousness. All these developments generated ripple effects within the scientific world which continue to spread outwards to other disciplines and cultural arenas. New metaphors for understanding the world ranging from 'feedback loops' to 'the uncertainty principle' and 'Gaia' have become part of the common pool of systems thinking today.

Self-organizing systems

One of the central concepts that bridged the mechanical and organismic trends of systems thinking was that of self-organizing systems. While cybernetics contributed to the understanding of self organizing systems with the work on feedback loops, and incorporated ideas of open as opposed to closed systems, the conceptualization of causality nevertheless remained logical and somewhat reductionist. This is reflected in the basic mechanistic computer model with its binary positions that determine the nature of the interrelations of the network. The organismic approach focused on the organizing patterns that are beyond the separate elements - on the wholeness of the system as something beyond the different parts.

" ...the organismic trend starts with the trite consideration that organisms are organized things; we have to look for general principles and laws concerning "organization", "wholeness', "order of parts and processes", "multivariable interaction", "growth", "competition,", negentropy; and others. These traits are common to biological, behavioral, psychological, and social phenomena; there are, as it is called, isomorphisms between biological, behavioral and social phenomena and sciences. Therefore, we should try to develop a general theory of systems. Interaction among many variables and free dynamic order may be indicated as central notions." (Bertalannfy in Gray pg. 37)

While the work on self-organizing systems took place already in the United States and Great Britain in the 1940's and 50s it came to the fore in different disciplines and different countries in the 1960's. Among the key figures in conducting research were Prigogine in Belgium, Haken and Eigen in Germany, Lovelock in England, Margulis in the United States and Maturana and Varela in Chile. The models of self-organization they developed share certain basic ideas including the ability of living systems to learn and to create new structures and modes of behavior, the emergence of new structures and forms of behavior which occur when the system is far from equilibrium, and the non-linear relations within the system.

In the theories of Prigogine, Haken and Eigen, self-organization was seen as the spontaneous emergence of new structures and forms of behavior and higher levels of complexity in systems far from equilibrium brought about by instabilities and the amplification of feedback loops. The new theories went beyond focusing on the existing structures within systems. Patterns of organization were discovered which revealed possibilities of generativity, learning and evolution of new structures and modes of behavior within living systems.

Prigogines work on non-equilibrium systems was a pivotal point in the evolution of systems thinking. One of his major contributions was in a further resolution of the apparent contradiction between the thermo-dynamic law of entropy that pointed to the dissipation and waste of energy in systems and the theory of evolution that indicated a movement in systems towards higher levels of structure and order. In the sixties Prigogine following on earlier work by Bernard on heat convection in water, developed a new, non-linear thermo-dynamics. As opposed to classical thermodynamics in closed systems where the dissipation of energy in heat transfer was associated with waste, Prigogine showed how dissipation in non-equilibrium, systems open to energy from external sources can become the source of order. When the flow of energy and matter through dissipative structures is maintained or increases, the systems may maintain themselves or evolve into new structures of increased complexity.

Prigogine showed that "while dissipative structures receive energy from outside - the instabilities and jumps to new forms of organization are the result of fluctuations amplified by positive feedback loops. Thus amplifying 'runaway' feedback, which had always been regarded as destructive in cybernetics, appears as a source of new order and complexity in the theory of dissipative structures". (Capra 1996 p.89)

Haken suggested that the transition from normal light to laser light is an example of order emerging when a non-eqilibrium system of light is pumped with energy from the outside. He used the term synergetics to indicate study of processes in which the combined actions of many individual parts in systems far from equilibrium produce a coherent behavior of the whole.

The concept of self-organizing living systems was being studied in the field of geology as well. In 1972 James Lovelock first put forward the idea known as the "Gaia theory" which stated that the planet earth is a whole is a self-organizing system. His theory, which he expanded upon later with the microbiologist Lyn Margulis, postulates that life on earth and the environment both create each other and adapt to each other.

By 1990, the theory had evolved and incorporated the systemic concepts developed in the other sciences.

"The nearest I can reach is to call Gaia the theory of an evolving system - a system made from the living organisms of the Earth, and from their material environment, the two parts being tightly coupled and indivisible. This evolutionary theory views the self-regulation of climate and chemical composition as emergent properties of the system. The emergence is entirely automatic; no teleology is invoked. Gaia evolves as a system, gradually, during long periods of homeostasis that are punctuated by sudden simultaneous changes in both organisms and environment. Such changes move the system to new and different homeostatic states; a significant jump of this kind occurred between the anaerobic Archaean and the oxygenated Proterozoic 2.5 thousand million years ago. Gaia offers a resolution of the long debate over whether evolution was gradual or punctuated by suggesting that it was both." (Lovelock, 1990 p. 101)

Lovelock, together with Lynn Margulis speculated that there is a tight interlinking between the planet's living parts, plants, microorganisms, and animals and its nonliving parts- rocks, oceans and the atmosphere. They describe a giant feedback loop "linking volcanoes to rock weathering, to soil bacteria, to oceanic algae to limestone sediments and back to volcanoes" (Capra, 1996 p. 105) that contributes to the regulation of the earth's temperature. The Gaia theory brings together a variety of disciplines including geology, microbiology and atmospheric chemistry. Capra quotes Margolis as saying "It is the growth, metabolism and gas-exchanging properties of microbes…that form the complex physical and chemical feedback systems which modulate the biosphere in which we live." (Ibid p. 216)

Margulis proposed another key concept, symbiogenesis. She used this term to describe her discovery of how independent microorganisms create a permanent functional and structural symbiosis with each other. This symbiosis indicated relations of partnerships and cooperation on the level of microorganisms that allowed for the evolution of higher organisms to take place. This theory of cooperation and partnership among organisms leading to higher levels of complexity challenged the classical evolutionary theories that were based on primarily on competition.

In the seventies, Eigen researched catalytic processes involving enzymes in biochemical self-organizing systems that are far from equilibrium. He argued that molecular self-organization is based on "hypercycles" of multiple feedback loops. These cycles are self-replicating and with time and a continuing flow of energy tend to interlock to form closed loops in which the enzymes produced in one cycle act as catalysts in the subsequent cycles.

Maturana and Varela also addressed the self-making nature of living systems for which they coined the term autopoietic. Every living organism continually renews itself, its structure, cells, tissues and organs while maintaining its organizing patterns. They saw the key characteristic of a living network as its continual self-production. This view of the process of life as the activity involved in the continual embodiment of the systems pattern of organization, bridged the dialectic between process (organization) and structure oriented theories. Unlike the classical mechanical theories or cybernetics, the autopoietic network refers to the network of relations among processes rather than to the relations among the components.

The living organism is in constant interaction with the environment through a process of structural coupling through which the structure of the system changes. The organism is a learning system whose history of structural coupling will influence the way in which it later interacts with the environment. The cell is defined by its membrane as a distinct system while being an active part of its environment. Like in a cell, all components of an autopoietic network are produced by other components in the network. Autopoeietic networks were described as organizationally closed, but structurally open to the flow of energy and matter, and as autonomous but not isolated from their environment.

"The systems structure is the physical embodiment of its organization. Autopoiesis is a network of production processes in which the function of each component is to participate in the production or transformation of other components in the network. In this way the entire network continually makes itself. It is produced by its components and in turn produces those components. In a living system the product of its operation its own organization." (Capra 1996 p. 208)

Cognitive Science

Maturana and Varela developed their theories in the field of cognitive science. With the advent of computers, the computer metaphor of the brain had dominated cognitive science until the 1970's. Following cybernetic principles, cognition was explored in terms of computer intelligence which involves the manipulation of symbols that represent certain features of the word according to sequential rules. The limitations of this theory were evident in biological research where the speed of simple tasks could not be explained by sequential information processing and neither could the resilience of the brain's functioning despite localized damage. This led to models of neural networks with complex possibilities of interconnectivity.

Over the last two decades, the developments in the organismic trend in cognitive science, especially in the work of Maturana and Varela "brought forth" a completely new approach. Bateson, a pioneer in the field writing in the 50's and 60's described cognition as mind and saw mind not as a thing but as a process - the very process of life, including perception, emotion and behavior. The concept of mind and matter as inseparable challenged the Cartesian separation of the two.

In the Santiago theory Maturana and Varela proposed that the process of cognition is one of development and learning. They introduced the concept of "structural coupling" and saw cognition as the structural coupling of the organism with the environment. In this process, the organism does not represent some external reality but rather "brings forth a world". While structural changes in the system are triggered by perturbations in the environment, the patterns of organization of the system are maintained. The living system is seen as flexible, dynamic and autonomous in that it seems to specify the structural changes, as well as the environmental perturbations that trigger them. The perturbations trigger in a distributive way rearrangements in the patterns of connectivity throughout the network. Cognition is thus not a representation of an independently existing world. It is the very process of living, through which worlds are continually "brought forth". The process of cognition consists of all the activities involved in the continual embodiment of the systems autopoietic pattern of organization and physical dissipative structure. The entire dissipative structure of the organism participates in the process. The process occurs even in bacteria. The brain and nervous system are structures through which the process occurs in more complex organisms.

"There are many disturbances that do not cause structural changes because they are foreign to the system. In this way each living system builds up its own distinctive world according to its own distinctive structure. "Mind and world arise together" However, through mutual structural coupling individual living systems are part of each other's worlds. They communicate with one another and coordinate their behavior. There is an ecology of worlds brought forth by mutually coherent acts of cognition." (Capra, 1996 p. 269)

The process of bringing forth worlds by structural coupling is a process of making distinctions. While Bateson saw these distinctions as part of the objective external world, Maturana saw them as part of the process itself. For him there was no independently existing world outside of the process of cognition.

For human beings cognition involves language, abstract thinking and symbolic concepts that are not available to other species. In Bateson's view, verbal language is only one small aspect of a wider behavioral form of communication that exists in humans and other organisms.

"Communication, according to Maturana , is not a transmission of information, but rather a coordination of behavior among living organisms through structural coupling." (Capra, 1996 p. 287)

The question is raised as to the relevance of concepts derived from research in the physical domain, to the realm of abstract thought, language, consciousness and social systems? Maturana did not see human social systems as being autopoietic in themselves but rather as the medium in which human beings realize their biological autopoiesis through 'languaging'.

In the forward to Luhmanns book Social Systems, Eva Knodt writes:

"If one accepts the proposition that the basic components of social systems consist in living systems (i.e. people), it is unclear how such systems can fulfill the fundamental condition of autopoiesis, namely, recursive self-(re)production. While social systems may be described in terms of functionally interrelated components, they do not, as Maturana points out, literally produce "the network of production of (their) components.

In a brilliant move, Luhmann resolves this apparent dilemma by reconceptualizing the social in such a way that it does meet the condition of autopoietic closure. All we have to do, he proposes is to give up the Aristotelian premise that social systems are living systems, and think of them instead as systems whose basic elements of communications, vanishing events in time that, in producing the networks that produce them, constitute emergent orders of temporalized complexity. ....But the features that distinguish these different types of autopoietic systems come into focus only when the concept of autopoiesis is abstracted from its biological connotations. The reproduction of cells is based on chemical processes, the brain works with neurophysiological impulses. By contrast, systems that operate on the basis of consciousness (psychic systems) or communication (social systems) require meaning (Sinn) for their reproduction." (Luhmann p. xxiii)

In writing about the theories that deal with meaning and communication as the basis of social systems Capra says that:

"A family system for example can be defined as a network of conversations exhibiting inherent circularity. The results of conversations give rise to further conversations so that self-amplifying feedback loops are formed. The closure of the network results in a shared system of beliefs, explanations and values - a context of meaning - that is continually sustained by further conversations.

The communicative acts of the network of conversations include the self-production of the roles by which the various family members are defined and of the family systems boundary. Since all these processes take place in the symbolic domain, the boundary cannot be a physical boundary. It is a boundary of expectations, confidentiality, loyalty and so on. Both the family roles and boundaries are continually maintained and renegotiated by the autopoietic network of conversations.(Capra 1996 p. 213)

Varela emphasizes that while mental space is composed of different brain functions, and perceptions, memories and emotions, it is experienced as a single coherent experience, with a dominant sensation. He suggests that there exists a neural mechanism which gives rise to "phase locking", a transitory phenomenon of resonance and synchrony of neural activity in widely dispersed neural circuits.

In his book *The Embodied mind*, Varela links the latest findings in cognitive science to Buddhist knowledge especially with regard to the concept that there is no objective lasting object that can be regarded as self. The self is brought forth just as any object is brought forth in the process of cognition.

Like in Buddhist philosophy he believes that all fixed forms, things, events, people or ideas are not things. It is out of ignorance that we separate the world into objects that we see as solid and permanent but which are really dynamic, transient and constantly changing. "There is no abstract knower of an experience that is separate from the experience itself. " (Varela p. 26)

With this idea, he addresses the limitations of scientific knowledge. “If science is to continue to maintain its position of de facto authority in a responsible and enlightened manner, then it must enlarge its horizon to include mindful, open-ended analyses of experience.” (Varela 81) The types of open-ended analyses he works with in his book are the mindful meditation practice of Buddhism and the exploration of experience in psychoanalysis.

Varela’s ideas on cognitive science contributed to evolutionary theory. He suggested that evolutionary logic was proscriptive rather than prescriptive, and this explains the diversity and complexity in nature. “Histories of coupling are not optimal, they are, rather, simply viable...... any action undertaken by the system is permitted as long as it does not violate the constraint of having to maintain the integrity of the system and/or its lineage.” (Varela p. 205)

Field Theories

In the realm of physics, Einstein put forward an idea of a ‘unified field theory’ with non-linear equations. The ‘particle’ could be understood as a “form of localized pulses, consisting of a region of intense fields that could move through space stably as a whole....These pulses do not end abruptly but spread out to arbitrarily large distances with decreasing intensity.” (Bohm p. 174) Bohm says that Einstein’s field theory maintains the essential features of the mechanistic order as fields are considered to be fundamental entities existing separate from each other.

Bohm on the other hand proposes that it is wholeness that is real and that any separation into entities is illusory and shaped by mans’ fragmentary thought. He looked at the world “as an undivided whole, in which all parts of the universe, including the observer and his instruments, merge and unite in one totality.” (Bohm p. 11) With regard to man’s atomistic view he says:

“Nevertheless, we can comprehend that aspect of atomism which still provides a correct and valid form of insight; i.e. that in spite of the undivided wholeness in flowing movement, the various patterns that can be abstracted from it have a certain relative autonomy and stability, which is indeed provided for by the universal law of the flowing movement” (Ibid p. 11).

He emphasises that even the apparent separateness of human beings in their interactions with each other and with nature is misleading.

In his theory of the enfolding-unfolding universe and consciousness, he proposes that “what we call empty space contains an immense background of energy, and that matter as we know it is a small ‘quantized’ wavelike excitation on top of this background, rather like a tiny ripple on a vast sea.” (Bohm p. 191) This notion is reminiscent of Parmenides of Greece who saw space as a plenum.

In his theory of the implicate order, Bohm argues, “everything is enfolded into everything.” He uses the metaphor of a hologram to reflect the idea that what is made manifest as separate are reflections projected by a wholeness which exists in a higher dimensional ground where the implicate order prevails.

Like Bateson, Varela and Maturana, Bohm also links inextricably mind and matter, saying “that mind enfolds matter in general and therefore the body in particular”.

The new mathematics has developed alongside the theories of complex self-organizing systems and the new physics. This mathematics has evolved non-linear equations, and ways of describing processes of feedback and iterations. The new mathematics “is qualitative rather than quantitative and thus embodies the shift of emphasis that is characteristic of systems thinking - from objects to relationships, from quantity to quality, from substance to pattern.” (Capra 1996 p. 113) In the 19th century, Poincare developed a visual mathematics designed to depict organizational patterns of complex dynamical problems. Over the last few decades, with the help of high-speed computers, these ideas have been revitalized, and a “phase space” technique for mapping complex trajectories in a multidimensional space has been developed.

This led to the discovery of “strange attractors” around which the seemingly erratic motion moves in a somewhat ordered way without ever repeating itself exactly. All trajectories starting within a certain region of phase space will lead sooner or later to the same attractor. This region is called the “basin of attraction”. In chaos theory, systems known as chaotic systems are highly sensitive to minute changes that lead over time to large-scale effects. This has been commonly referred to as “the butterfly effect”.

“In many nonlinear systems, however, small changes of certain parameters may produce dramatic changes in the basic characteristics of the phase portrait. Attractors may disappear or change into one another, or new attractors may suddenly appear.

Such systems are said to be structurally unstable, and the critical points of instability are called bifurcation points because they are points in the systems evolution where a fork suddenly appears and the system branches off in a new direction.” (Capra 1996 p. 136)

The development of fractal geometry based on iteration and the development of complex numbers developed by Mandelbrot in the 1960’s and 70’s provided a mathematical language which was able to describe the complexity of irregular shapes found in nature. In fractal shapes, the same patterns are found repeatedly at descending scales. This property appears in strange attractors and in certain natural phenomena for instance in cauliflower, mountain rocks, borders of clouds and coastlines, where every part is similar in pattern to the whole.

The meta “Realities” model of Mc Whinney

What has been described thus far is only a narrow window into some of the key people concepts and developments in the diverse world of theories about systems. McWhinney emphasizes that systems theories are determined by the prism of realities with which one views the world. He has created a model of existing systems paradigms based on his model of the different realities he describes in *Paths of Change.*

With the rise of the anti-positivist school of thought, much work has been done both in the natural and human sciences on investigating the influence of the researcher’s perspective on the methodology and results of research. Mc Whinney offers a meta-look at systems theories, and argues that the way in which we build theories of systems in our minds is based on the way in which we view reality. Cultures, disciplines and individuals have predominant prisms through which reality is viewed, and the paradigms are a way of understanding these complementary prisms from a more integrative perspective. Systems theories are thus embedded in specific worldviews of the particular theoreticians who developed them and the social, historical context in which they work. He proposes a model that characterizes these worldviews and looks at how these determine the nature of a particular system theory.

By showing how different systems theories arise from the different archetypal worldviews which he describes in his book Paths of Change, McWhinney provides a meta-perspective which indicates the place of each theory within a larger context and reveals their particular biases, contributions, limitations and applications. He suggests that it is more helpful to see the seemingly contradictory theories as mutually complementary. Each may be useful in tackling particular areas of practice and taken together they provide a more complete picture of our multi-faceted reality in which we continually face the paradoxical coexistence of apparently mutually exclusive ideas and phenomena. Meta-theories about systems theories create a multi-leveled prism where the worldview of the theoretician of the meta-theory interacts with the reality in which the specific systems theory concerned is embedded.

Mc Whinney suggests that “for each theory there are processes for: establishing the boundaries of a whole, establishing the elements of the system, distinguishing the system elements from those of its environment and identifying the relationships that connect the parts into a whole system”. (Mc Whinney, Praxis, p. 85**)** Each systems theory also concerns itself with the type of relations between a system and its environment and will have central criteria by which to determine “systemness”.

One of the main contributions of this paradigm model is in offering an ordering and classifying language through which the different paradigms can be examined and compared. The proposed parameters cut through many of the formal classifications and highlight similarities and differences between the different systems models being proposed. The main parameters used to distinguish between the systems are: the way the theories explain systemic structure, cause and processes and the significant omissions of the theories.

The map which McWhinney draws of the archetypal ways in which humans perceive reality is based on two axes; plurality, which relates to whether change in that reality moves towards things being more holistic (monistic) or more distinct (pluralistic), and agency which relates to whether the cause of change is perceived as due to an external natural condition (determinism) or whether change can occur through intentional acts (free will).

The following diagram of the Dimensions of Reality is taken from *Paths of Change*.

Plurality

monistic **pluralistic**

determined

Agency

free will

UNITARY	SENSORY
MYTHIC	SOCIAL

(Mc Whinney, 1997 p. 28)

While the above scheme refers to ideal types, most people function with a combination of the sources of reality, but their dominant beliefs will determine the way in which they relate to explanations of phenomena and causality, ethics and rules of evidence.

Mc Whinney's meta view of systems emphasizes that the different systems theories are embedded in different worldviews based on the encounter of at least two archetypal "ideal" "realities" which he describes in his book *Paths of Change*. This means that one reality can only be 'realized' through an encounter with another reality. The act of observing and describing one reality - can thus paradoxically only be done from the perspective and in juxtaposition with another reality.

In his paper *Praxis: Beyond Theory and Practice*, Mc Whinney puts forward the hypothesis that one's view of reality stems from a combination of different reality encounters and thus does one's choice of systems thinking. The following table from this paper sets out the different systems theories from the perspective of the different meetings of worldviews from which they derive.

SYSTEMS	**REALITY**	**PROCESS**	**CAUSALITY**	**CRITERION**
CLASSIC Formal Logic Nominalism	U-M	Ordering (law, accounting, mathematics)	Formal	Consistency & Pervasiveness

DYNAMIC Science (realism)	SE-U	Moving (production system mechanics	Efficient	Validity
POLITICAL Moral Theory	U-SO	Contracting (claiming policies and mediating values)	Interpenetration	Agreeability Morality
COMMUNICATIVE	SE-SO	Signaling (social exchange, economics, management)	Functional final	Fairness
EVOLUTIONARY Creativity	M-SE	Becoming (visions, inventions)	Morphogenic	Freshness & Doability
POIETIC Narrative Theories	M-SO	Constructing elements of meaning (culture)	Coupling (emploting)	Coherence

The Classic Paradigm for instance, exemplified in the Aristotelian worldview described above, reflects the predominance of the encounter between the Unitary and Mythic realities. In this view of a highly ordered universe, the whole 'system' with its underlying hierarchical order is greater than the sum of its parts. Causality, in this paradigm, is determined by the form of the elements and by the form of the system. There is thus no explanation of the concept of change other than the unfolding of the integral or teleological purpose innate within the form.

The Dynamic Paradigm derives from the Sensory and Unitary realities. It is exemplified in what is commonly referred to as the Newtonian, scientific or mechanistic worldviews. In this paradigm, the concept of causality is no longer due to form but rather to concepts of cause and effect, primarily with a linear temporal framework of necessary antecedent conditions. The influence of this paradigm within the developing scientific methodologies of observation, experimentation, measurement and quantification of the 17th century spread and had a profound affect on the prevalent worldview. It led to a transition from a predominantly metaphysical exploration of the world to one that looked to finding and explaining the laws of nature in order to be able to manipulate, control and predict nature. The mode of research was analytical, focusing on identifying the basic units of nature in order to be able to understand the whole. The focus on the parts of the whole (form and structure rather than process) as the objects of exploration, and the linear model of causality denied to a large extent the complex inter-relations between the parts and between the parts and the whole. And it was in reaction to this that the concept of systems was born in order to reinstate the emphasis on process, flux, patterns and interrelations neglected in this paradigm. Some of the earliest paradigms that were the forerunners of the current systems theories were nevertheless strongly influenced by the dynamic model.

The Communication paradigm is based primarily on the sensory and social realities. This paradigm focuses on informational systems. The earliest development was the cybernetic model, a statistical theory of communication derived from the study of thermodynamics. Cybernetics like many other theories does not fall solely under this paradigm but can be understood by using multiple paradigms. This statistical model using probability theory allows for the prediction of the behavior of complex systems having an intentional guidance mechanism. The placing of the communciation model within the sensory-social combination, reflects that the signaling of information in human beings occurs out of a result of choice of data to be sent according to certain values and this information impacts the receiver of the message also in terms of her own values and preferences which determines the meaning which she attributes to the communication and the accompanying feelings about it. This is not a question of cause and effect as much as it is one of intention, control, and change on the part of the sender as well as of the receiver.

Summary

The emergence of systems theory in the twentieth century has thus reawakened age-old debates. Systems thinking in itself is not new but with scientific research much age old wisdom which has reemerged with new terminology. This is reflected for instance in the attitude that the whole is more than the aggregate of the parts, and the fact that reseach into process and its relationship to structure is receiving the scientific “blessing”, (an appropriate oxymoron). With research in the areas of biology, physics, ecology, and mathematics, age old debates are receiving new color and our vocabulary has been augmented with powerful metaphors for understanding our everyday world. The current situation is one where there is still a strong tension between the atomistic reductionist view of reality and the systemic view. The challenge that faces us is perhaps to explore the optimal way in which these views can live side by side, allowing each to contribute in the appropriate place while finding the areas of synthesis and integration where those are helpful. Meta-perspectives such as that of Mc Whinney are contributions towards this. Fields such as cybernetics can be seen as a complex synthesis of numerous worldviews where multi-variable principles are integrated. In many areas however, the systemic view has not yet been allowed to find its place and the atomistic, fragmenting view has its historic rather than relevance hold. Much of public policies in the areas of politics, economics, healthcare, ecology etc. are based on looking for causal relations between split off elements in the puzzles which face the world and on a hierarchical, competitive and fragmented conceptualization of global and societal issues.

While science has provided some breakthroughs in moving beyond the mechanistic approach there is the paradoxical situation where the social sciences are still trapped in their struggle to prove themselves a science by adopting methodologies from the natural sciences. “... we arrive at the very odd result that in the study of life and mind, which are just the fields in which formative cause acting in undivided and unbroken flowing movement is most evident to experience and observation, there is now the strongest belief in the fragmentary atomistic approach to reality. “ (Bohm p. 15)

In the field of medicine, scientific research has penetrated mysteries of life way beyond what the naked eye can reveal and developed sophisticated technolgies for intervening in the human system form heart transplants to genetic manipulation. Paradoxically, with the expanding knowledge, came the by-product of very focused specializations that created a fragmented and symptom oriented approach to healing. While a holistic view of healing is a vital part of Eastern traditions, this approach has been developed in the West over the last few centuries as fringe disciplines broadly categorized as “alternative medicine”. With the development of systems thinking as well as global trends towards a “new age” spiritual revitalization movement, there is growing dissatisfaction with conventional medicine and a search for alternative approaches. Today, the two worlds are still far apart, yet there is a gradual process of growing recognition within governmental health-care systems of alternative, holistic practices which focus on the person and his/her environment rather than the specific symptom. Perhaps we are witnessing a significant move towards the inter-fertilization of system paradigms. When cognitive scientist Varela, looks to Buddhist ways of knowing as a necessary inspiration for scientific technique, and the medical establishment begins to do research into long distance healing techniques and other spiritual healing practices we are perhaps seeing the sparks of a new way of being, where the systems of science and spirituality may "couple structurally" and new patterns of organization and structures can emerge.

As we have seen, systems theories have challenged twentieth century Western society in powerful ways, questioning issues fundamental to the prevalent Cartesian worldviews and belief systems. With the evolution of the theories we have witnessed a movement from thinking based essentially on parts of a whole, to viewing phenomena in terms of system and environment; from a search for fundamental building blocks of matter to the exploration of the organizing patterns of a whole considered as an entity beyond the aggregate of its parts. The emphasis has moved from one of quantity to one of quality, from a view of causality as linear to one which is non-linear and even to the idea of co-dependent arising. Whereas atoms were seen as existing independently in empty space there was a shift to viewing space as full, as force fields with transitory areas of coherence, entrainment and pulses with relatively stable manifestations. The view of disorder and dissipation of energy as destructive and leading ultimately to entropy was replaced an understanding of the necessity of disorder and chaos in bringing about higher levels of order. Living systems were no longer seen to be predictable or to function according to deterministic laws, with change being somewhat reversible. Instead specific events in open systems were seen as unpredictable and there evolved a new idea of the possibility of creativity and generativity within the system unavailable in previous models. A separation between form and meaning and between structure and process allowed other conceptualizations to take form. Systems were understood to be energetically open while organizationally closed and the holographic model was put forth as an alternative to a hierarchical one. An either /or conflict between opposing theories was replaced with the view that opposites are essential and integral to systems, and paradox is an inevitable aspect of human beings' necessarily partial view of nature. Even the notion of boundaries, so fundamental to the view of systems was dramatically reframed by field theory. In biology and physics the concept of global coherence due to iterating patterns across networks emerged as did the idea of non-local causality based on the whole being more than the parts and structure as an ongoing embodiment of the organizing patterns.

It is not that the system approach eclipsed the previous mechanical one - it provided new insights relevant for viewing and working with different aspects of the world. Bohm emphasizes that new worldviews do not falsify old ones, they are neither true nor false and that they are "are ever-changing forms of insight, giving shape and form to experience in general" (Bohm p. 6) It is interesting for instance to speculate about future developments. Behavior of self organizing systems which are described by researchers today as "spontaneous" or "random" may reflect our present inability to grasp the depths of the implicate order. Perhaps we use "random" and "spontaneous" to describe what to us appears without clear cause or coherent structure.

The system perspective has had tremendous implications for all aspects of societal life and has influenced the development of academic disciplines and practical fields. Cybernetic concepts were adopted in a broad range of areas from systems engineering, and socio-technical systems in organizational theory to cognitive science and family therapy. With the evolution of systems theories in the different sciences, Laslo, Jantsch, and others have been influential in applying systems thinking to different aspects of human existence. Boulding in his book *The world as a total system* explored the world as a physical, biological, social, economic, political communication and evaluation system. In 1987 Thompson edited a book called Gaia, a way of knowing which is a collection of articles investigating the political implications of "the new biology". The evocative new concepts have been integrated for instance into the popularized works of Peter Senge on learning organizations and in Margaret Wheatley's recent book on Leadership and the New Science which explores the relevance of the new systems thinking in nature to organizational systems and leadership.

Many systems theorists today have a strong belief that systems theories and systems thinking will trigger a new consciousness about the interdependence between people, cultures, societies and ecology which will be the basis of a process leading to the healing of the current alienation between man and man and between man and nature. The danger lies in a simplistic utopian vision of peace and harmony based on a concept of interconnectedness and lack of differentiation alone. The challenge in many ways is to hold the paradoxical co-existence of separation and holism, community and individuality, the atom - and the wave, and to hold in our consciousness this meta-perspective in which the different worldviews complement each other and together form a larger picture.

In many ways, systems theories are still in the early phases of development and have not penetrated much of the institutionalized thinking in the Western world. Nevertheless, it seems that whereas initially, the reactive stance of early systems theories emphasized what was neglected in the Cartesian worldview, such as relationships rather than structure, or circular rather than linear causality, today there is more interest in a meta-perspective which takes a pluralistic and integrative stance. This stance advocates exploring why all these paradigms emerge, what is the meaning of their simultaneous co-existence and their apparent contradictions, how can they function side by side in an optimal way, in what areas of application are they are most helpful and what kind of inter-fertilization between them can be developed? Rabbi Zalman Shachter suggests that we will need to supplement our language with grammar and vocabulary which reflects the relational aspects of life. He says for instance that there is currently no way of expressing ideas such as “The chair and I are intersitting”[1], and is concerned that human thought processes are limited by the fragmentary way in which we use language. Ultimately these multiple paradigms are reflections of the diversity in human beings , as well as of their interdependence and perhaps even their “interbeing”[2].

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[1] From a lecture at “Kol Haneshama” in Jerusalem, June 1998

[2] Concept used by Thich Nhat Hanh - see opening quote.

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