Systems approaches and communication research: The age of entropy

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Abstract

This essay examines the contemporary approaches to systems theory, the strengths and limitations of these approaches, and how communication researchers can apply them creatively. It points out that using system approaches requires communication scholars to study the mutual interaction of both information inputs and matter/energy inputs. Overloads of these inputs coupled with storage problems could engender positive feedback loops and move the system away from the linear region of stability toward the edge of chaos (bifurcation). It could then self-organize as a more complex system in a new phase space of its trajectory. This complexity approach could be used to trace the trajectory of the global mass communication system or to conduct empirical research on all or any of the information-processing subsystems within the eight hierarchical levels of nested systems ranging from cell to supranational systems. Although systems thinking is writ large in the onto-cosmology of Eastern philosophies, its epistemological and methodological refinements did not occur until quantum physics challenged the 'atomism' of the dominant Newtonian-Cartesian model.

Keywords: autopoiesis, cognition, communications research, dependent co-arising, dissipative structures theory, living systems theories, social entropy theory.

'New' Systems Approaches

The main purpose of this essay is to draw attention to a cluster of 'new' systems approaches (vis-à-vis the 'old' equilibrium approaches), their strengths and weaknesses, and their potential applications in communication science. I shall outline three 'new' systems approaches − Miller's living systems theory, Capra's theory of living systems (a composite of

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dissipative structures theory, and the autopoiesis and cognition theories), and Bailey's social entropy theory. I shall also briefly refer to two other approaches – sociocybernetics theory, and communication networks theories. Finally, I will provide some parallels between systems concepts and the fundamental presumptions of Eastern philosophy, particularly those of Buddhism and Daoism, which are hardly known to Western communication scholars (Gunaratne, 2005a, 2005b).

Bailey (1994) points out many specific strengths of the 'new' systems theory approaches, which, *inter alia*;

- Provide a framework for holistic analysis, macroanalysis, multidisciplinary analysis, and multidimensional analysis.
- Provide needed methodological rigor (e. g., critique of equilibrium, methodological analysis of the micro-macro link, the Q-R distinction, and three-level analysis), as well as an inventory of concepts and new vocabulary (e. g., autopoiesis, structural coupling, three-level model, etc.).
- Provide a more methodological operationalization and theoretical specification of the problem of order; present an analysis of boundary theory; and link matter/energy and information.
- Provide a new approach to see the relations between action/structure, process/structure, or agency/structure.
- Provide a context for the analysis of conflict, interaction, networks, etc.; and a comprehensive specification of salient macro variables.
- Draw attention to hierarchy and levels of analysis (eight system levels each with 20 critical subsystems), and space-time in social systems (diachronic analysis).
- Analyze self-reproduction and self-regulation (autopoiesis), and action and order; deal with complexity reduction through systems; and emphasize change via entropy and nonequilibrium analysis.
- Relate to ideational and empirical levels of analysis, and offer an analysis of systems philosophy and systems technology.
- Offer a comprehensive framework (which does not preclude, exclude, or denigrate any line of inquiry) for diachronic comparison, both between and within groups.
- Provide a foundation for cultural and normative analysis; and deal with issues relating to the observer and the observed.

Moreover, scholars have extended the application of 'new' systems approaches to fields such as semiotics, knowledge and cognition, culture, music, language, and literature (Altmann and Koch, 1998).

Miller's Living Systems Theory

James Grier Miller (1978) wrote a 1,102-page volume to present his theory of living systems. He constructed a general theory of living systems by focusing on concrete systems – nonrandom accumulations of matter-energy in physical space-time organized into interacting, interrelated subsystems or components. Slightly revising the original model a dozen years later, he distinguished eight hierarchical levels in such complex structures: cell, organ, organism, group, organization, community, society, and supranational system (Miller and Miller, 1992). This hierarchy shows the evolutionary principle of 'shred-out' or 'fray-out'. Thus, each level is 'nested' (i. e., each higher level contains the next lower level in a nested fashion).

His central thesis was that the systems in existence at all eight levels are open systems composed of twenty critical subsystems that process inputs, throughputs, and outputs of various forms of matter/energy and information. Miller's theory posits that the mutual interrelationship of the components of a system extends across the hierarchical levels. Examples: Cells and organs of a living system thrive on the food the organism obtains from its suprasystem; the member countries of a supranational system reap the benefits accrued from the communal activities to which each one contributes.

Miller (1978) defines society, which constitutes the seventh hierarchy, as "a large, living, concrete system with [community] and lower levels of living systems as subsystems and components". Society may include small, primitive, totipotential communities; ancient city-states, and kingdoms; as well as modern nation-states and empires that are not supranational systems. Each of the twenty subsystems constituting society has a main component, which he illustrates (in parentheses) as follows:

- Processors of both matter/energy and information: reproducer (constitutional convention that produces the constitution), and boundary (organization of border guards);
- Processors of matter/energy: ingestor (import company), distributor (transportation company), converter (oil refinery), producer (factory), matter-energy storage (warehouse company), extruder (export company), motor (trucking company), and supporter (national officials who operate public buildings and land);
- Processors of information: input transducer (foreign news services), internal transducer (public opinion polling agencies; voters), channel and net (telephone and communication network), timer (legislators who decide on time and zone changes), decoder (cryptographers; language-translation unit), associator (teaching institutions), memory (li-

brary; national archives), decider (voters and government), encoder (press secretary; drafters of treaties), and output transducer (national spokesmen).

A supranational system, in Miller's (1978) view, "is composed of two or more societies, some or all of whose processes are under the control of a decider that is superordinate to their highest echelons". However, he contends that no supranational system with all its twenty subsystems under control of its decider exists today. The absence of a supranational decider precluded the existence of a concrete supranational system.

At the supranational system level, Miller's emphasis was on international organizations, associations, and groups comprising representatives of societies (nation-states). Miller identified the subsystems at this level to suit this emphasis. Thus, for example, the reproducer was "any multipurpose supranational system which creates a single purpose supranational organization"; and the boundary was the "supranational forces, usually located on or near supranational borders, which defend, guard, or police them".

Strengths of Miller's theory

Bailey (1994) says that Miller's theory provides a detailed analysis of types of systems and their roles in social systems theory. Moreover, it analyzes the twenty subsystems and their interrelations while making a clear distinction between matter/energy processing and information-processing subsystems. It also analyzes the eight system levels and their interrelations while showing how social systems link to biological systems. It analyzes the irregularities or 'organizational pathologies' of systems functioning (e. g., system stress and strain, feedback irregularities, information-input overload). It explicates the role of entropy in social research while it equates negentropy with information and order. It is perhaps the 'most integrative' social systems theory. It enables cross-level research and it emphasizes both structure and process, as well as their interrelations.

Limitations

It omits the analysis of subjective phenomena, and it overemphasizes concrete Q-analysis (correlation of objects) to the virtual exclusion of R-analysis (correlation of variables). By asserting that societies (ranging from totipotential communities to nation-states and non-supranational systems) have greater control over their subsystem components than supranational systems have, it dodges the issue of transnational power

over the contemporary social systems. Miller's supranational system bears no resemblance to the modern world-system that Wallerstein (1974) described, although both of them were looking at the same living (dissipative) structure.

Applicability to communication research

Miller's theory provides the most exhaustive integrative framework for communication researchers to investigate the global information flows (e. g., news/advertising/entertainment, digitized information, the Internet, world money) in the context of matter/energy flows (e. g., imports and exports, travel and tourism, immigration and emigration). They could improve on Miller's classic cross-level studies of information-input overload. The system can turn 'dysfunctional' when it is unable to process or store input overloads of information (and matter/energy). If communication researchers venture into the study of negentropy inputs in relation to entropy outputs in living systems, it would not only break down disciplinary barriers but also enhance the qualitative status of communication research.

Thus, communication researchers who use the world-systems framework could adapt Miller's twenty subsystems for more comprehensive analyses of the impact of matter/energy and information inputs on the world-system as a single unit. Although positivist testing of the theory of living systems at the supranational level might be a formidable task, the idea of focusing on the components of the twenty subsystems constituting the structure of the supranational (or world) system would allow world-system analysts to widen their scope of analysis. Arrighi and Silver (1999) and their collaborators, who have used the world-system as the unit of analysis to interpret the transition of hegemonic power in the modern world-economy − from the Dutch to the British to the Americans − using four perspectives at the supranational level, could have produced a more comprehensive history had they paid attention to all or most of the twenty subsystems, however they chose to define them. In Miller's terminology, the center and the semiperiphery (pertinent to world systems analysis) might also be looked at as higher echelons at the society [nation] level.

Researchers who aspire to write horizontally integrative macro histories of mass communication could adopt Miller's comprehensive framework. Moreover, researchers engaged in studying organizational communication or group communication could refer to the twenty subsystems at the levels of organization and group to examine the impact of the interactions between information inputs and matter/energy inputs on organizational or group dynamics.

Communication scholars can also test some of the 173 cross-level (applicable to systems at each of the eight levels) hypotheses Miller (1978) presented, particularly those related to information theory. Examples:

- In a channel there is always a progressive degradation of information and decrease in negative entropy or increase in noise or entropy. The output information per unit time is always less than it was at the input.
- Two-way channels which permit feedback improve performance by facilitating processes that reduce error.
- If messages are so coded that they are transmitted twice, errors can be detected by comparing every part of the first message with every part of the second, but which of the two alternative transmissions is correct cannot be determined. If they are transmitted three times, they can be both detected and corrected, by accepting the alternative on which two of the three transmissions agree.

Miller (1978) asserts that a researcher "can measure precisely not only the matter-energy characteristics of a system but also, using the Shannon information statistic, its complexity, patterning, or organization". He says that information is the patterning of matter-energy in systems.

Capra's theory of living systems

Fritjof Capra (1996) has proposed a theory of living systems by synthesizing the theories of autopoiesis and cognition attributed to biologists Humberto Maturana and Francisco Varela (Santiago School) with Ilya Prigogine's theory of dissipative structures. Therefore, this theory combines thermodynamics/physics, bioscience, and cognitive science. Gunaratne (2005a, 2005b) has further conflated it with world-systems analysis and Eastern philosophy.

More recently, Capra (2005) has backed up his hybrid theory of living systems with evidence from morphology. He has, it appears, subsumed the tripartite autopoiesis-cognition-structure synthesis under the umbrella concept of metabolism. Capra asserts that the basic process of life is metabolism, which was known as the 'breath of life' throughout the ages. Metabolism "is the ceaseless flow of energy and matter through a network of chemical reactions, which enables a living organism to continually generate, repair and perpetuate itself". The new scientific understanding of life recognizes that networks are the basic pattern of organization of living systems. These are functional networks, a key characteristic of which is their capacity to self-generate. Capra's idea of metabolism has much in common with Miller's idea of the processing of matter-energy and information by the twenty critical subsystems of a system.

Autopoiesis theory

The concept of spontaneous emergence in the theory of dissipative structures is very similar to the concept of autopoiesis in the biosciences. A biological autopoietic system, Maturana (1980) says, is a dynamic system; a composite unity or a network of productions of components that "(a) through their interactions recursively regenerate the network of productions that produced them, and (b) realize this network as a unity in the space in which they exist by constituting and specifying its boundaries as surfaces of cleavage from the background through their preferential interactions within the network".

Autopoiesis, the pattern of life, means 'self-making'. The autopoietic organization of a living system includes the creation of a boundary that specifies the domain of the network's operation and defines the system as a unit (Capra, 1996). Because "all components of an autopoietic network are produced by other components of the network, the entire system is *operationally closed* even though it is open with regard to the flow of energy and matter". Capra (2002) further explains that all biological life consists of cells, each of which is a complex network of metabolic processes that enable self-maintenance (or autopoiesis). The cell's membrane is its boundary. All cellular structures exist far from thermodynamic equilibrium. When the energy flow increases, the structure may engender a 'bifurcation point' at which it may transform itself into an entirely new state (technically known as emergence).

Maturana (2002) identifies human beings as living systems. They exist in structural coupling with all other living and non-living entities that compose the biosphere. Just like all living systems, human beings are both autopoietic and dissipative.

Cognition theory

Cognition, the process of life, is inextricably linked to autopoiesis. "All living systems are cognitive systems and cognition always implies the existence of an autopoietic network" (Capra, 1996). Cognition is the process of knowing in a living system. Cognition involves the entire process of life; including perception, emotion, and behavior. Mind is not a thing, but a process, according to the Santiago theory of cognition (Maturana and Varela, 1980). The entire dissipative structure of the organism participates in the process of cognition. A living system couples with its environment structurally. Thus, all living systems go through continual structural changes in response to the environment. However, the system specifies the extent of its cognitive domain by selecting the pertinent perturbations from the environment that would 'bring forth' the

changes. The interactions of a living organism with its environment are cognitive. Mind is manifest in social systems and ecosystems as well. Capra says that mind and consciousness have always been the primary objects of Buddhist contemplative investigations.

Dissipative structures theory

Prigogine established the crucial link between 'far from equilibrium' and 'nonlinearity' in open systems.(dissipative structures). He demonstrated that living organisms are far-from-equilibrium open systems, which generally exhibited deterministic (steady state) characteristics between bifurcations:

> Far from equilibrium, the system may still evolve to some steady state … Indeed, as long as the attractor state is defined by the minimum of a potential such as the entropy production, its stability is guaranteed. It is true that fluctuations may shift the system away from this minimum. The second law of thermodynamics, however, imposes the return toward the attractor. The system is thus 'immune' with respect to fluctuations. (Prigogine and Stengers, 1984)

Prigogine showed that the farther a dissipative structure was from (thermodynamic) equilibrium, the greater was its complexity and the higher its degree of nonlinearity. And the system might engender critical points of instability (or bifurcation points) because of amplified fluctuations in energy flow (positive feedback loops) when stability was no longer the consequence of the general laws of physics. Prigogine explained how such a situation would lead toward spontaneous emergence of order:

> When the thermodynamic forces acting on a system become such that the linear region is exceeded … the stability of the stationary state, or its independence from fluctuations [produced by the system or its environment], can no longer be taken for granted. … In some cases … certain fluctuations, instead of regressing, may be amplified and invade the entire system, compelling it to evolve toward a new regime that may be qualitatively quite different from the stationary state corresponding to minimum entropy production. (Prigogine and Stengers, 1984)

Capra (2002) added a fourth strand, meaning, to the three strands discussed above − life process (cognition), form (autopoiesis or pattern of organization), and matter (dissipative structure) − to derive his theory

of living systems. Capra asserted that meaning was the link that enabled the autopoiesis of social systems, which comprised both physical and nonphysical aspects. For instance, culture is an outcome of meaning recursively produced from one generation to another.

Strengths of Capra's theory

This theory rests behind the power of four interdisciplinary notions on living systems. The Santiago School version of autopoiesis places heavy emphasis on epistemology. It employs the role of the observer in the process of systems analysis. Bailey (1994) adds the following strengths of autopoietic theory: the jargon of autopoiesis is complex, rich, and challenging. The notion of an open system with organizational closure is potentially valuable and fascinating. The concept of recursive self-production is rich and challenging. And the concept of structural coupling makes a significant contribution to social theory. Moreover, the dissipative-structures theory not only backs up autopoiesis but also brings clarity to our understanding of entropy – that entropy in open systems can, in fact, decrease without violating the second law. In addition, Prigogine's theory provides a solid basis for nonequilibrium analysis of open systems.

Limitations

The synthesis of the theory of living systems needs further refinement. Controversy prevails over the applicability of autopoiesis to social systems (Dougall, 2001; Little 2001). Autopoietic theorists and sociologists often define structure in the opposite sense. The sophisticated theories subsumed under the theory of living systems "lead to complex models that cannot, or only with great difficulty, be treated empirically" (van der Zouwen and van Dijkum, 2001).

Applicability to communication research

Gunaratne (2005a) used Capra's theory of living systems as the metaphorical framework for deriving a humanocentric theory of communication-outlets and free expression. To do so, he incorporated systems concepts from world-systems analysis – using Baker's (1993) model linking it to dissipative structures theory – and Eastern philosophy. Gunaratne conceptualized nations as autopoietic units of the world-system. Because nations are operationally closed but are cognitively and structurally open to their environment, they may choose to input only those perturbations from the environment that are consistent with their socio-cultural condi-

tions. Thus, the notion of mass media freedom and responsibility can vary from nation to nation along a spiral-like continuum ranging from libertarianism (*yin*) to authoritarianism (*yang*), the two antinomies, which must co-exist within the unity of the world-system (*Taiji* or *Dao*), a far-from-equilibrium dissipative structure that turns more and more complex as it moves from one phase space to another along its trajectory with each bifurcation. Synchronic mass media freedom scores are misleading without diachronic mapping of the evolutionary trajectory of each nation's media system in the context of the comparable trajectory for the world system as a single unit. Gunaratne (2005b) also used this framework to analyze public diplomacy, global communication, and world order.

The metaphorical use of the theory of living systems or its components has become increasingly popular in sociology following Luhmann's highly abstracted but theoretically exquisite theory of autopoietic social systems comprising communication events *sans* people. Luhmann has conceded that his social systems are "not tied to life," but has argued that autopoiesis cannot aspire to become a general theory if it is coupled with cognition (Dougall, 2001). Among the sociologists who have recently applied the concepts of the theory of living systems are Chesters and Welsh (2005), who studied the process and emergence of social movements; Cetina (2005), who studied the terrorist societies as complex, global microstructures; and Urry (2005), who has focused on global complexities. Nowotny (2005) has analyzed the contradictions involved in the increase of complexity and its reduction.

Communication researchers can apply this theory to numerous situations at any one or more of the hierarchy of eight system levels. Hallin and Mancini (2004), who studied the mass media in the United States, Canada, and most of Western Europe, constructed three models of media and politics − polarized pluralist model, democratic corporatist model, and liberal model − which they hope can "be of some use to scholars of other regions not only as an example of how to conduct comparative research but also because these models have actually influenced other systems". Although their painstaking effort is laudatory, their approach to the study of systems goes against the emphasis on world as the unit of analysis (in world-systems analysis), the hierarchical analysis of systems in relation to both information inputs and matter/energy inputs (in Miller's living systems theory) or the autopoietic and nonlinear behavior of systems (in Capra's theory of living systems). What determines the boundaries of these systems? What is the nature of their structural coupling or interpenetration? These doubts give an indication of the challenges that systems theory provides for communication researchers.

Bailey's social entropy theory

Bailey (1994) says that social entropy theory is based on two critiques of functionalism (over-reliance on equilibrium, and inability to analyze complex society) plus several other considerations: It uses the structure-process analysis throughout via the three-level model and the Q-R distinction. It postulates a set of structural variables with the social system *sui generis* as the basic unit of analysis. As such, a system is not a 'set of individuals' but a concrete entity comprising a population of individuals interacting over physical space-time within boundaries. This perspective generates a set of supra-individual or global macro variables: population, information, level of living, organization, technology, and space (PILOTS). These six variables, Bailey (2006) says, apply to systems at all of Miller's eight levels. S.E.T. also makes a distinction between mutable distributions (macro variables) and immutable or micro variables.

This model includes both equilibrium and nonequilibrium analyses. It applies the three-level measurement technique to analyze systems with X = perception of the system; X' = actual empirical system, and X" = model of system. Model X" is formed as a combination of X and X'. Bailey says because we can never simultaneously observe the empirical system X' in its entirety, our perceptions of X are crucial to derive the final model X".

Moreover, this theory is based on the premise that it is necessary to analyze *both* roles/relationships (R analysis) and persons (Q analysis). Bailey (1994) explains that "the basis of the system is a set of persons acting and interacting in physical space to process matter/energy and information". The synchronic R analysis indicates *structure*; and the diachronic Q analysis indicates process. Human actors maintain the system over space-time to achieve set goals. The structure-process interaction is an endless cycle.

The six globals (mutables) are not single variables but factors or components. Bailey (1994) says they "can be split into sets of variables and can be operationalized in myriad alternative ways". The globals are sum totals of the amount of the entity in each case. Bailey claims that this general model is applicable to all societies in the world. All six globals can be written as interrelated synchronic variables (R analysis) to provide the system's structure. They also can be analyzed diachronically in terms of process. Moreover, they apply to different levels within the society and to supranational systems as well.

The immutables are micro properties with the individual as the unit of analysis (e. g., ascribed characteristics such as race, ethnicity, gender, age). Each individual possesses a set of micro mutable characteristics, as well as a set of micro immutable characteristics (e. g., education, income,

occupation, residence). Bailey (1994) explains: "While the mutable micro characteristic is a property of an individual …, the mutable macro distribution is a property of the society".

The allocation of individuals into structural positions entails Q-relations on decision based upon R-variables. The three-level model guides the mechanics of allocation. The theory identifies two principal types of organizational formation: agglomerative and divisive. Each organization has a set of globals, just as in society. Each individual within the organization is constrained by the six globals and five mutables operating at the society/world level, as well as by the six globals and five mutables of the organization and by the workgroup within it.

What organizational administrators are actually doing is managing entropy levels, by "balancing the constant increase of internal entropy through decay of physical plant … use of materials, obsolescence of information, etc. The internal entropy increase is offset through inputs of new raw materials (matter-energy), information, new technology, etc." (Bailey, 1994). Thus, proper regulation of globals and mutables enables the maintenance of social order.

Strengths of Bailey's theory

As Bailey (1994) claims, this theory utilizes the macro, micro, and organizational levels of analysis. It explicates the link between process and structure. It develops the global mutable-immutable distinction. It uses the three-level model to analyze the deviations of perceived phenomena from the empirical phenomena. It shows the virtues of both concrete and abstracted systems via the Q-R distinction. It explicates social entropy, both qualitatively and quantitatively.

Limitations

It is not as detailed as the living systems theory. It is not a true general systems theory but an application of several system principles to the study of society. It omits salient issues such as feedback loops, autopoiesis, and self-steering. It does not test hypotheses but presents a set of testable hypotheses.

Applicability to communication research

Communication researchers can use this theory as a framework to analyze the negentropy-entropy levels of mass media organizations, and public-relations/advertising agencies. They can use the three-level model and Q-R analyses to develop models that incorporate the perceived and empirical status of issues related to news and entertainment.

Sociocybernetics approach

Sociocybernetics is a special branch of systems theory that applies first-order and specially second-order cybernetics to the social sciences and their further development within the social sciences. Second-order cybernetics, which emerged in the early 1970s, explicitly includes the observer(s) in the living systems, ranging from cells to human beings, to be studied in contrast to the focus of first-order cybernetics on control systems for inanimate technological devices.

A central issue of sociocybernetics is the question of social steering; i. e., the extent to which governments can steer societies. Little (2001) points out that the application of self-reference to Luhmann's autopoietic social subsystems can never avoid paradox. The political system's three subsystems − public, politics, and government − are operationally closed and are only structurally coupled to each other. The public or the politics subsystems, however, cannot exert direct control over government for they can only perturb or irritate it. Hejl's (1997) "synreferential" social systems theory asserts that it is never communication that communicates but individuals in social systems. Synreferentiality refers to shared reality constructs. Little says it is not possible to control Luhmann's social systems but it is possible to control Hejl's synreferential systems. Therefore, Little suggests a reconciling of Luhmannian and Hejlian approaches. Political communication researchers can apply such a synthesized theory for empirical studies.

Another concern of sociocybernetics is the methodology for empirical testing of complex social cybernetic models. Van der Zouwen and van Dijkum (2001) say:

> Sophisticated sociocybernetic theories no longer generate hypotheses about bivariate distributions, which can easily be tested. The theories involved have to be translated into simulation models and run on a computer in order to see which predictions can be derived from the theory. Insofar as the predictions concern social processes, the output of the computer will consist of generated time-series, or trajectories. These computed trajectories have to be compared with the observed time-series, and the degree of fit between the trajectories has to be established.

Van der Zouwen and van Dijkum (2001) hint that those who desire to explore nonlinear dynamics should turn towards nonlinear mathematics. They point out that as soon as the researchers introduce the notion of feedback loop into their models, the usual assumptions behind the use of linear equations and unidirectional causality no longer hold. They

argue that classical procedures, which use regression equations, or linear structural models, differential equations and survival analysis, only fit with models of systems that do not take into account that systems anticipate their future state and change their goals, behavior, or structure. They go on to say that social sciences require new procedures to validate more complex models involving feedback and nonlinearity.

Communication networks theories

Monge and Contractor (2003) "have argued for a multi-theoretical, multilevel approach to the study of communication and other forms of organizational and social networks". This scheme fits in with the middle range of the eight levels of system hierarchy in Miller's theory, particularly at the levels of community and organization. The three-tiered MTML model "decomposes networks into their multilevel component parts, examines the attributes of nodes, and explores their relations with other multiplex and/or autoregressive networks; p* techniques provide the basis for statistical analysis of network data, providing an inferential basis for similar to more traditional analyses of social attribute data". This model treats communication networks as complex adaptive self-organizing systems. "The essential idea of complex systems is that *rule-governed interaction* among a set of interconnected individuals can generate emergent structures".

ϑMonge and Contractor have highlighted the following social theories to identify theoretical mechanisms relevant to network realizations: theories of self and mutual interest; contagion, semantic, and cognitive theories; exchange and dependency theories; homophily, physical proximity, electronic proximity, and social support theories; evolutionary and co evolutionary theory; and small world networks. The MTML is not a general systems theory although it uses several signposts of systems theory such as wholeness (of the network), interdependence, hierarchy, self-regulation, environment, change and adaptability.

Parallels with Eastern thought

DeFleur and Ball-Rokeach (1989) lament that contemporary social scientists "often seem unaware of major insights into the human condition that have accumulated over several centuries of social thought and are directly relevant to the topics they are currently studying". This is the case with many systems theorists who appear to be unaware that the principles of systems theory are writ large on Eastern philosophy,

The main concepts of the general systems theory can be found in Buddhist philosophy and Chinese onto-cosmology although Dougall (2001)

has attempted to trace them to ancient Greece. Dougall has done so by claiming that the *leitmotif* of Aristotle's two key figures, form and matter, are by analogy the same as Maturana and Varela's organization and structure within the framework of autopoiesis, according to which an autopoietic unity can maintain its identity following a structural perturbation. Dougall argues that a similar *leitmotif* runs through the work of Touraine, Bourdieu, and Giddens.

However, von Bertalanffy was more influenced by the work of 15th-century cardinal Nicholas of Cusa, the central theme of whose philosophy was the unity of the opposites, which is central to Chinese ontocosmology. Nicholas saw God as an infinite circle, and held the view that "any part of the world contains in a limited way, the infinite whole" (Macy, 1991). The Buddhist *cakra* and the Chinese *Taiji* symbolize the circular flow of all matter/energy and information within the infinite whole.

Much of the general systems theory is summarized in the following simple stanza, which expresses the essence of Buddhist philosophy (Kalupahana, 1976)

> When this is present, that comes to be;
> From the arising of this, that arises.
> When this is absent, that does not come to be;
> On the cessation of this, that ceases.

This is the Buddhist doctrine of *paticca samuppāda* (dependent co-arising), which explains all physical, psychological, moral, and spiritual in the entire universe. All signposts of general systems theory are implicit in it: wholeness, interdependence, hierarchy, self-regulation and control, balance, environmental interchange and adaptability, and equifinality.

One can interpret *paticca samuppāda* to fit 'concrete' or 'abstracted' systems at any of the eight levels in Miller's systems model, and go further to encompass the domain of subatomic systems, as well as the domains of planetary and galactic systems. In the Buddhist view, both 'concrete' systems (as in the Miller model) and 'abstracted' systems (as in Parsons' model) cannot maintain equilibrium in the classical sense because of mutual interdependence of 'this' and 'that', which means ongoing change. Therefore, the Buddhist perspective accommodates the living systems to be far from equilibrium. The reciprocity of causal process is integral to the process of dependent co-arising. Nothing can exist independently or autonomously (cf. autopoiesis theory, which asserts that living systems are operationally closed but cognitively and structurally open to their environment). Moreover, the mutual interdependence

means the intermingling of cause and effect (as in feedback loops), which produces equifinality.

Buddhist philosophy asserts that as a holon, a "person's existence is intimately, intricately and inextricably interwoven with other forms of life. No freewheeling monad, his life is a tapestry of biological and sociocultural relationships, from the organic subsystems which shape his body to the larger social and natural systems in which he functions" (Macy, 1991). The 'holon perspective' shows that the Buddhist view is compatible with the notion of hierarchical levels.

Macy (1991) asserts that one cannot apprehend the meaning of *paticca samuppāda* aside from the doctrine of *anicca* (impermanence), which, together with *dukkha* (suffering) and *anatta* ('no self'), characterize our existence. All that we perceive, feel, and think is *anicca*. *Paticca samuppāda*, as a regulative principle, is the pattern of change that produces change (chaos and bifurcation) and order (steady state in a new phase space), or order within change. This evolutionary process is clearly nonlinear.

In Buddhist philosophy, there is no first cause, and no creation *ex nihilo* of the universe. Matter and consciousness are mutually interdependent, and have co-existed, co-exists, and will co-exist for all time. Thus, consciousness extends well beyond the human species to encompass all flora and fauna. Mind and body cannot be separated, as some systems theorists (e. g., Luhmann) have attempted to do. The world is not substance but process. The cyclic universe has no beginning or end. It rises from pure potentiality and goes through cycles of birth, evolution and death as everything else, and returns to pure potentiality (Gunaratne, 2006b). Macy (1991) provides a thorough comparison of the parallels between Buddhism and systems theory.

The ancient *Yijing* (*I Ching*) model of the Book of Changes also illustrates the fundamentals of systems theory. This model illustrates the interconnection between the Dao (the Supreme Reality) and everything else in the universe that Dao created through its agents *yin* and *yang* − the two antinomic energy forces (Gunaratne, 2004, 2006a).

The hierarchical arrangement of the bigrams, trigrams and hexagrams in the *Yijing* model is very much in tune with systems theory. The *Yijing* model can be interpreted to illustrate both equilibrium or far-from-equilibrium conditions of a system. The binary values of each hexagram comprising unique combinations of six lines denoting *yin* (split) and *yang* (non-split) illustrate a homeostatic system model whereas the fractal values of the same lines illustrate a far-from-equilibrium model with the line arrangement signifying strange attractors (Walter, 1994). The model illustrates how bifurcation creates more complex systems, and how all systems are related to one another, and how diversity is tied to unity.

Conclusion

Systems approaches are generally antithetical to Occidental cosmology, which upholds individualism and atomism. An obvious deterrent for the ready acceptance of 'new' systems approaches by communication scholars is their lack of expertise with nonlinear mathematics. Communication research cannot make much headway without adopting systems approaches to complement the traditional methods. However, the advent of quantum computing, which can quickly determine complex interactions among myriad variables, bodes well for the future of 'new' systems approaches.

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