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ABSTRACT

The two papers in this document focus on general systems theory. In her paper, Linda Lederman discusses the emergence and evolution of general systems theory, defines its central concepts, and draws some conclusions regarding the nature of the theory and its value as an epistemology. Don Rogers, in his paper, relates some of the important features of general systems theory and of modern organizational theory to organizational communication theory, and he points out that these theories provide a potentially significant analytical model for organizational communication scholars. (JM)

PARALLEL EVOLUTION IN SCIENCE: THE HISTORICAL ROOTS AND CENTRAL CONCEPTS OF GENERAL SYSTEMS THEORY

by

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"A difference which is no difference is not a difference."

William James

Abstract

General Systems Theory has emerged in the last twenty years in part as a reaction to the reductionism predominating the sciences for the last two centuries. This paper discusses those forces which gave rise to General Systems Theory; explores its evolution, including those scholars who contributed to it; and defines its central concepts. On the basis of surveying these questions, the paper draws some conclusions regarding the nature of General Systems Theory and its value and potential as an epistemology.

INTRODUCTION: EXISTENCE AND THEORIES OF KNOWLEDGE

There has always been some interest in global theories about the nature and meaning of human existence.[1] From the beginning of recorded time, humanity has struggled with the nature of existence and its meaning by questioning the relationship of human beings to other forms of animal life, nature, and the supernatural. Institutions such as religion and government have arisen out of the need for clarification of the meaning of things. What Thayer refers to as in-formation[2] and Berger calls internalization[3] in some very important ways are merely manifestations of the human being's need for answers, or, at the very least, definitions of the questions which ought to be addressed.

As can be seen repeatedly in recorded history, one's prerogative as a self-defining, 'symbol-making'[4] being have included the search for some integration of knowledge; some way of understanding the parts in relation to the whole so as to comprehend the totality in some more meaningful way. In each historical period, the solutions to the age old questions have been sought in different ways. The universe that humanity had to question and consider broadened with each new 'discovery' and/or definition of the outer limits of the world and with each new way of probing deeper into one's inner world. One day's science fiction becomes the next day's scientific reality; one day's fictional projections about the future of existence, the next day's living realities. Buck Rogers' comic strip exploits, for example, have been replaced within less than half a century by Neil Armstrong's 'one small step', and America of 1976 echoes with mechanism with fictional counterparts in Orwell's 1984. But political realities and 'outer space' exploration have made advances no greater than 'inner' space exploration, i.e., investigation of human biological and psychological innards. The questions regarding the meaning of existence continue in differing historical contexts. The soothsayer, witch doctor, alchemist, neurosurgeon, have differing answers for the questions of human physical nature which are time- and culture-bound. The classical Greeks' understanding of human psychological make-up are reflected in Freudian usage of Greek literary referents (Oedipus, Electra, etc.) but the methodology for investigation and/or manipulation of innate human drives and needs has changed and changes with the times and the dictates or concerns thereof.

In terms of scientific exploration, it was in the Eithteenth and Nineteenth Centuries that the frontiers of science were laid wide open, and that human beings were first able to map territory previously unknown by means of simple observation and experiment. Discoveries of scientific principles that were observable and manipulable, and instruments to 'extend the senses'[5] made possible the journey into waters that had been before uncharted. These developments resulted in two related phenomena in the scientific research of the era. One, that inevitably there developed a kind of progressive specialization in which theories evolved which were constructed to fit particular disciplines and operations. The result of any such progressive specialization is that the circle of people with whom that knowledge can be shared grows smaller; that there is an inverse relationship between highly specialized technical knowledge and the number of people interested and/or equipped to pursue it. This because the scientist's "personal need for integration of knowledge was satisfied through exploration of many diversified fields and through articulate communication with equally interested minds".[6]

The second phenomenon which developed was that once human beings discovered that what they considered 'reality' was divisible and observable in progressively smaller pieces, it was not unnatural that their preoccupation became the process of dividing up each newly found chunk of matter into more manageable and explainable pieces. During this intellectual and scientific age, "the goal of science was analytical: to split up reality into ever smaller units and to isolate individual strains of causality."[7] The underlying assumption in the process was that each new division of the phenomena into smaller units yielded new information and/or insight into the nature and workings of the greater unit of which the smaller parts were divisions. The discovery that water was composed of hydrogen and oxygen was followed by the investigation of each of those elements and their compositions.

In some very significant ways, then, the thrust of scientific investigation during the past two hundred years was toward increasing specialization in areas of scientific investigation. Its principal concern was reductionism, i.e., reducing an organism to its totality of simplicity as a way of 'knowing' it; as if once it was known in this way, one could add back together the pieces with some greater knowledge of how they worked.[8]

There are two different directions such a state of scientific affairs could and, in fact, did lead. First, for those convinced of the soundness of the approach described above, the direction of their scientific pursuits was toward a greater degree of specialization; pursuing the reduction of known phenomena to smaller knowable units as a means of finding and analyzing the essence of those things. The proliferation of specialities within formerly larger fields, such as embryology, anatomy, microbiology, physiology and genetics within the field of biological science is an example. So too, in medicine, the replacement in the mid Twentieth Century of the family doctor by a series of specialists such as internist, gynecologist, cardiologist, geriatric specialist, etc. In the continuous process of reducing a thing to its more basic elements, the bodies of knowledge about those special parts became so immense that specialization was a necessary and, in many ways, desirable outcome.

Not all scientifically oriented researchers were content with this state of scientific investigation. The second direction, then, came about in direct opposition to the first. It saw reductionism as 'fragmentation', analysis into smaller pieces of matter as "atomism",[9] and in reaction, moved in a direction toward more generalizable, interdisciplinary knowledge. That is, while there were many scientists who felt productive in searching out the answers to the questions about existence in their highly specialized disciplines, working with those of similar interest and ability in their discipline-specific knowledge, others were experiencing a need for a different approach. This second group of scientifically oriented researchers, unhappy with the general tendency toward compartmentalization of the various scientific disciplines, began to search for a body of theory of some utility to the study in their areas which would make available insights and theoretical concepts from the individual disciplines on a widespread basis.[10] To this latter group, the specialists' discipline-specific knowledge and search for the 'essence' of things by reducing them to their least common denominators was viewed as counterproductive to the more global task of understanding human beings and their world. In the view of these thinkers, the physicist, biologist, psychologist and social scientist were "encapsulated in private universe(s)", and to them it seemed that "it became increasingly difficult to get word from one cocoon to another."[11] The aim of this second group of scientists was to redirect the state of scientific affairs by finding a more universally meaningful way of studying man and of making available that which their studies were to yield.

It is in this context that the times were ripe for an approach to one's knowledge about the existence of things which came to be known as General Systems Theory. The theory has been praised by advocates as a Weltanschauung, a new and unique perspective, a theory of theories. It has been dismissed as superficial and trivial by those embued with specialization. In order to evaluate General Systems Theory and its contributions, potential and otherwise, this essay will explore four questions: (1) how General Systems Theory evolved; (2) what that theory is; (3) who are the people who have helped to fashion it; and finally (4) what are the concepts undergirding it.

EVOLUTION OF GENERAL SYSTEMS THEORY

"Viewed in the context of the history and evolution of social thought, the sciences of unified theories are the products of Twentieth Century thinking, although the rudiments are to be found throughout the history of self-conscious man."[12] While General Systems Theory is a Twentieth Century solution to the age old question of human existence, its roots are traceable as far back as one wishes depending upon how one defines 'system' and 'system thinking'. The view of General Systems Theory as a 'Weltanschauung', a new and unique world view mentioned above, emphasizes its Twentieth Century trappings, and defines systems as new and unique, a discovery of the Twentieth Century. But viewed as a 'perspective', a way of thinking, a way of "organizing and theory of organization"[13] its roots reach back to classical times. An example, as cited by Ruben,[14] is the thinking of Aristotle reflected in his politics, in which he defines a "state as composed of villages, which are in turn made up of households, which contain families". Others include Aristotle's Nicomachean Ethics[15] in which he classifies and categorizes morals and morality in a hierarchy and the Roman definition of the division between the material and spiritual world, "render unto God that which is God's and unto Caesar that which is Caesar's."

Given that the concern of this essay is the emergence of General Systems Theory in mid Twentieth Century as an outgrowth and/or reaction to the sciences and scientific approaches of that time, its roots will be delimited as those which are traceable from the Nineteenth Century scientific climate to the mid Twentieth Century scientific atmosphere in which General Systems Theory was specifically labeled and defined as a 'new' perspective on human knowledge of its condition. General Systems Theory arose in response to four distinct problems in scientific inquiry of the mid Twentieth Century. First, the problem of duplication of scientific investigation and 'discovery'; the work of scientists in several fields unaware of the work of others leading to the same or similar insights. Second, the need for a general theory of organization which could deal with concepts such as wholeness, directiveness, teleology, self-control, regulation, and differentiation. Third, the need for a development of mechanisms for displaying isomorphies which were the consequence of the fact that in certain respects there are corresponding abstractions and conceptual models which can be applied to different phenomena.[16] And finally, as an alternative path of inquiry to the mechanistic, analytic pursuits of reductionism.

There have been more trends toward an integration of knowledge, among them General Semantics[17] in language and communication, Gestalt theory in psychology,[18] and as cited by Bertalanffy, the work of Lotka and Volterra in the dynamics of biological populations and work in quantitative economic and economicrics.[19] General Systems Theory was the name given to this particular approach to scientific questioning by Bertalanffy in 1947.[20] Bertalanffy recounts the history of his own definition of General Systems Theory as dating to a presentation in 1937 in Charles Morris's philosophy seminar at the University of Chicago but concedes that "at that time theory was in bad repute in biology...so I left my drafts in the drawer, and it was only after the war that my first publication on the subject appeared."[21]

There are several references in the literature that date the change in intellectual atmosphere and movement away from reductionism to the time period around World War Two. One explanation is that it was the war effort which caused the government to call the scientists out of their laboratories and into practical endeavors with one another to solve pragmatic defense concerns. Bertalanffy describes it as a "surprising happening, a change in intellectual climate, in which model building and abstract generalizations became fashionable, and General Systems Theory, after all was not isolated, not a personal idiosyncrasy as I had believed, but corresponded to a trend in modern thinking."[22]

Whatever the cause of the changes in intellectual atmosphere, the result was that the times had changed and the pursuit of knowledge had gone far enough in the direction of specialization to permit a return to some more interdependent or interdisciplinary approaches. While a direct cause-effect relationship is impossible to discern in relation to the fostering of General Systems Theory, what is noteworthy is that at the same time similar general views and concepts were appearing in diverse field [23] And it was these concepts and the thinkers involved with their development who can be cited as parenting general systems thinking as a scientifically acceptable alternative to the reductionism of the two hundred years preceding mid Twentieth Century.

FUNCTIONS AND DEFINITION OF GENERAL SYSTEMS THEORY

General Systems Theory is another survey of human knowledge, another search for more global explanations, and reaction to the specialization in scientific knowledge. While in some quarters General Systems Theory is hailed as the "theory of theories" as Ella Fitzgerald is acknowledged by some as the "singer's singer", in others it is criticized as lacking in rigor and superficial in its attempts to draw analogies. General Systems theory has been called a Weltanschauung, a new and unique world view.[24] It has been compared to reductionism as a means of "atoning for our sins...repairing the damage done by breaking up the universe into units and dealing with them as if they were isolated."[25] On the other hand, sentiment and reaction to a theory which calls for serious scientific attention to generalizable principles in an age of specialization is dubious. In the twenty to thirty years since the inception of General Systems Theory, an ability to generalize becomes to many an Agnew describing an urban tour by saying, "Once you've seen one slum you've seen them all."

A less abrasive way of looking at General Systems Theory is as a way of thinking about things rather than as a neat set of propositions.[26] While the thinking of the Nineteenth and early Twentieth Century scientists was to unify science by the reduction of all science to physics, and the final resolution of all phenomena into physical events, General Systems Theory at its most basic level looks at science not to reduce all phenomena to some essence but to find isomorphies. Viewing systems in this way, its thrust emerges as 'perspectivism' rather than 'reductionism'. The triumphs of reductionism were the identification of the units out of which complex structures grow, and analysis rather than synthesis.[27] While no serious scientist can quarrel with the value of analysis in terms of one's understanding of the working of things, general systems thinking seeks to take a step back up what the General Semanticists call the 'ladder of abstraction', to draw on the possible generalizability of such insights. Ashby[28] cites Fisher as perhaps the first worker to "face squarely the fact that not all systems need by analyzed into parts to be studied" and as the initiator of a "new science strategy, the acceptance of complexity as an essential, non-ignorable property". The general systems movement away from reductionism was in reaction to a scientific situation in which the scientist in looking for the ultimate essence of things, failed to acknowledge complexity and difference, indivisibility at some basic level, as part and parcel of the nature of things. Bertalanffy cites an analogy used by Huxley in which he compares a Neopolitan ice cream cake to science. The physical, biological, and social/moral universe are compared to the vanilla, chocolate and strawberry layers. And the pitfall of reductionism as opposed to perspectivism is pinpointed by analogizing that one cannot reduce chocolate to strawberry.[29]

While analysis of things and the nature of things is undisputedly of value, General Systems Theory places more emphasis on synthesis than analysis. In general systems thinking it is through synthesis that we can combine the contributions from many fields in order to achieve advances which can be communicated back to the special fields.[30] In the pursuit of knowledge about existence and its essence, the general systems thinker raises questions and offers approaches regarding the pooling of scientific accomplishments and methodologies rather than the continued pursuit of the ultimate essence of things. The systems approach allows for the difference between chocolate and strawberry by questioning the way in which knowledge about the similarities and differences between the two can lead to understanding the nature of things. In this way the systems theorist questions the methods and intentions of science. The scientist may belong formally to any one of the substantive disciplines but first attention must be given to "epistomological predicates of science in general".[31] It is in this sense that general systems is not really a theory, but a fundamental approach to science, standing in both "logical and procedural opposition to the more traditional schemes such as strict empiricism, positivism, intuitionalism, and phenomenonology".[32]

In some important way, then, while systems is a reaction on the part of some scientific researchers to a sense of ultimate fallacy in reductionism, it could only emerge with a serious foundation at a time in scientific history in which reductionism had lead to substantial insight into the nature and function of things. In espousing synthesis, the systems thinker needed something to synthesize. Rather than dismissing the findings of the several sciences, systems is a methodology which suggests what its proponents consider a more significant approach to further inquiry into knowledge of self and the universe. While physics, chemistry, biology, psychology, etc., all "carve out for themselves certain elements of the experience of man and develop theories and patterns of activity (research) which yield satisfaction in understanding appropriate to their special segments,"[33] systems theory is a search for a systematic body of theoretical constructs which deal with the general relationships of the empirical world.

A systems approach to knowledge, then, is concerned with the specifics to which one can reduce more complex organisms, but is mindful of the danger of loss of generalizability and applicability in so doing. It is an approach which is concerned with the bath water as much as with the baby. It seeks to utilize the knowledge of the specific without the loss of the sense of implication and application. "Somewhere between the specific that has no meaning and the general that has no content, there must be, for each purpose and at each level of abstraction, an optimum of generality."[34] Systems is concerned with the optimum of generality without the loss of the specifics necessary to anchor that generalizability. These being its concerns, systems can be defined on two levels of analysis. First, it can be defined as an approach, an epistomology rather than a discipline unto itself. It is a way of viewing things and perspective rather than a discipline. It is thereby of value to the scientist regardless of discipline-specific concern. On a second level of analysis, it can be defined by its objectives. Boulding[35] cites systems as an approach with two objectives; the first, more attainable and less ambitious, the second more ambitious but perhaps less readily attainable. One objective is to point out the similarities in the theoretical construction of the different disciplines, and where these exist, to develop theoretical models having applicability to at least two different fields of study. The second is to develop something like a 'spectrum' of theories, a 'system of systems' to function as a 'Gestalt' in theoretical constructions.

CONTRIBUTORS TO GENERAL SYSTEMS THEORY

Besides Bertalanffy, whose definition of the field has already been discussed, other contributors to the emergence of General Systems Theory were those scientifically oriented researchers, unhappy with the trend toward compartmentalization of the various scientific disciplines, who began to search for a body of theory of some utility to the study in their areas which would make available insights and theoretical concepts from the individual disciplines on a widespread basis.[36] Ruben[37] cites as the direct ancestors of today's General Systems Theory Bertalanffy, Norbert Weiner, Shannon and Weaver, and von Newman and Morgenstern. "Of these, only Bertalanffy was directly concerned with systems theory per se, but all shared an interdisciplinary orientation and concern for organization and communication."[38]

The more recent history of general systems thinking and its contributors dates back to the 1950's, during which the Society for General Systems Research (1954) was founded and at which time it began publishing its journal, General Systems (1956). Membership in the society and contributions to the yearbook are vastly interdisciplinary. Among the contributors and disciplines from which systems theory is drawn are Weiss, Rosen, Miller in biology;

Allport, Piaget, Maslow, Bruner, in psychology; Menninger, Grinker, Rizzo, Gray, Frank in psychiatry; Klir, Hall and Fagen, Weiner, Shannon and Weaver in engineering; Boulding in economics; Buckley, Merton, Parsons, Berger and Luckmann, Blumer, Mead in sociology; Ackoff, Churchman, Lasswell, Vickers in political science; Laszlo, Tillich in philosophy; Trist, Koestler, Katz, Kahn in behavioral sciences; Rapoport, Johnson, Korzybski in general semantics; Smith in anthropology; Dubos, and Ashby.

Contributions of these men can be described along three lines, none of them mutually exclusive. First, as contributing seminal works, artifacts which could be used and on which other thinkers could. Among these one could include the works of Rapoport,[39] Grinker,[40] Gray and Rizzo,[41] Laszlo,[42] Bertalanffy,[43] Buckley[44] and Churchman[45]. Their works consist of selected and edited writings of other systems thinkers, thereby committing to print presentations and exchanges between presenters and those audiencing them which would otherwise have been lost to those not present; or, as in the cases of Bertalanffy and Laszlo, works in which the author's own explorations of the systems thinking are cornerstones.

A second way in which the contributors can be described is in terms of conceptual contributions; uncovering concepts basic to systems thinking or coining the terminology for describing such concepts. Included among these contributors are Shannon and Weaver,[46] Hall and Fagen,[47] Maruyama,[48] Weiner,[49] Miller,[50] Rapoport,[51] Frank,[52] Ashby,[53] and Klir.[54]

A third way in which to classify contributors to systems thinking is in terms of their cognitive style, their perspective or intellectual bent. Some scientists contributed directly to systems thinking or exemplified it. Those who work directly related to systems theory include, as mentioned above, Weiner, Bertalanffy, Rapoport, Frank and others, such as Boulding,[55] Vickers.[56] Those whose approach contributed as models of interdisciplinary knowledge-seeking include Korzybski,[57] Berger and Luckmann,[58] Smith, Dubos, Piaget, Menninger and Weiss.[59]

One of the problems of tracing the evolution of systems thinking manifests itself as one attempts to sort out the contributors and their contributions. It becomes clear that attention must be paid to those concepts central to systems thinking, and thereby the undergirdings of it as an epistomology; that systems thinking is based on more than an interdisciplinary approach and desire for generalizability.

CENTRAL CONCEPTS IN GENERAL SYSTEMS THINKING

In order to deal with the concepts central to systems thinking, it is necessary to define what is meant by 'systems' and then proceed to elaborate upon those elements and dynamics inherent in systems as defined. A sampling of the literature reveals that the word 'system' is used with divergent meanings.

The following are among the significant definitions of systems found in the literature: Hall and Fagen define systems as "a set of objects together with relationships between the objects and between the attributes".[60] Parsons' use of the word, system, is "that which is made up of units or parts and which we deal with as entities."[61] Howland defines a system as "an organization comprising man and machine components, engaged in coordinated goal-directed activity, linked by information channels, and influenced by external environment."[62] Miller defines systems as a "set of units with relations among them."[63] Kuhn deals with defining systems by offering what he labels a "Tentative Classification Scheme with Special Reference to the Behavioral Sciences" in which he divides systems into action and non-action or pattern systems, and subdivides the former into controlled (cybernetic) systems and uncontrolled (noncybernetic) systems, and the latter into real pattern systems and analytical or conceptual pattern systems, with definitions and examples of each.[64] Beer defines a system by warning that when we talk of systems we speak of our lives, that research into systems is "research into self, bounded by self."[65]

Compounding the differences in usage, Grinker notes that one may be bewildered by the notion of a term such as 'system' which is "applicable to the biological, psychological, cultural/social aspects of life-in-process."[66] A synthesis of the word's usage in light of this broad-based application is to consider a system, after Grinker,[67] as "some whole form in structure or operation, concepts or functions, composed of united and integrated parts". With this as a baseline definition, it can be said that a system thinker is anyone concerned with any whole in terms of its structure and/or operation, concepts and/or functions, whose work deals with it as a composition of united and/or integrated parts, and whose thrust of investigation has any direct or analogizable application to any other structure, operation, function, concept, etc.

Having established a working definition of systems and some criteria on which to evaluate systems thinkers, some parameters are set for exploring central concepts in systems thinking. These can be discussed along two dimensions. First, the elements and dynamics inherent in systems. Secondly, the functioning of these elements and dynamics which differentiates kinds of systems.

Elements and Dynamics Inherent in Systems

In the 1964 volume of the General Systems Yearbook, Young presents a survey of the literature of the field to establish its common concerns and divergencies; to establish the dimension of the field.[68] He divides the concerns of contributors to general systems thinking into four categories: (1) systematic and descriptive factors, (2) regulatory and maintenance, (3) dynamics and change, and (4) decline and breakdown phenomena.[69] In each category he specifies concepts and terms of those concepts found in the literature and cites them. Under the first category, systematic and descriptive factors, he locates such terms as open and closed systems; organismic and non-organismic; subsystems; state-determining systems; equifinality; boundaries; environment, etc.; category two, regulatory and maintenance includes controls; neg entrophy, etc. In the category of dynamics and change, he cites change: response; adaptation; goal seeking feedback; learning; growth; teleology; goal; dynamics, etc. And in the decline and breakdown category, he lists stress, disturbance; overload; positive entrophy; and decay.

An historical update of Young's findings would include in the lists of those elements and dynamics he cites, important terms added by Bertalanffy in his General Systems Theory (1968) (wholeness; hierarchy of order; dynamic interaction);[70] and Ruben's work in 1972[71] and 1975[72] in which he discusses metabolism; communication; and multifinality as central to systems thinking. These additional terms can be worked into Young's paradigm. The notions of wholeness, hierarchy of order, and multifinality fit within the scope of Young's first category, systematic and descriptive factors. Those of dynamic interaction, metabolism, and communication can be added to category two, regulatory and maintenance factors. In terms of an exploration of the elements and dynamics inherent in systems thinking, Young's paradigm is as useful and significant as those phenomena he cites and categorizes. As the field grows and expands new terminology is added to its developing taxonomy. Young's classifications provide a paradigm for incorporating them; a skeleton on which to flesh out systems thinking.

Functioning of Elements and Dynamics in Different Systems

The second dimension along which central concepts in systems thinking is to be discussed is the functioning of those elements and dynamics in different kinds of systems. On this dimension comparisons can be made between different kinds of systems and how they function rather than by classification and categorization. The two aspects of differences which need to be discussed have to do with (1) openness/closedness, and (2) the nature of feedback mechanisms.

The most basic distinction which one can make between an open and closed system is to establish an open system as one which is in interaction with its environment. While a closed system, too, has an environment, all those things outside of that system, and may indeed be affected by that environment, it is not in interaction with that environment. Interaction implies a giving and taking as opposed to being acted upon. The open system continually interacts and exchanges with its environment. It ingests, consumes, metabolizes that which it needs in exchange for that of which it has no need. One open system's output is another's input.[73] The human being, for example, ingests oxygen and gives off nitrogen; the houseplant ingests the nitrogen in exchange for oxygen. In this sense, the open system is in a constant state of being and becoming, and characterized by other such traits as organization and communication. Living systems are the most apparent models of open system. Animals, plants and humans exist in environments, physical and social, in which they are continually interacting. The living system must be capable of metabolizing those inputs and excreting the by-products to continue to function. Darwin's theory of survival of the fittest can be discussed in systems thinking as an indication that those living systems most highly perfected and adaptive to their physical (and social) environments were those most likely to survive. The dinosaur's mammoth body and pea-sized brain made it a less adaptive system that that of the ape.

Because the closed system is incapable of metabolizing, it moves toward disorder and chaos as its environment introduces new inputs. The open system's ability to metabolize leads it to states of equal or greater degrees of organization and results in 'equifinality', that is, the ability to reach the same state from different initial conditions and in different ways. The closed system, acted upon by an environment that it cannot incorporate or introduce in any ordering sense, behaves according to the second law of thermodynamics, and moves toward 'entropy', chaos, deterioration, randomness, maximum disorder. An example is a burning cigarette. It is a system in that its structure consists of parts in relation to the whole. Because it is acted on by its environment and incapable of metabolizing, it moves to disorder, ashes.

In this comparison between open and closed systems, distinctions have been made between them in terms of reaction to the environment, metabolism, organization, and final states. Other concepts central to systems thinking have been used to describe rather than distinguish between these kinds of systems and are thereby important to both open and closed systems. These are wholeness, parts in relation to that whole, ordering. Each is central to systems thinking and explicit in either the definition presented above, the classification paradigm, or the comparisons of open and closed systems and examples previously cited.

The distinction between open and closed systems is valuable as a means of sorting out central systems concepts, including those which apply to all systems, and those germaine to one kind or the other. There remain some other important systems concepts to explain. A comparison of systems in terms of feedback can accomplish this. Ruben[74] calls this classification common, "due to the widespread application of feedback systems in electronics, biology, and the social sciences." Feedback in a generic sense refers to a portion of a system's output which is fed back or recycled to the system as input, thereby affecting the system's ability to regulate itself.[75] Contemporary systems theory adds some more specialized concepts to the feedback notion, including such things as input and output, control, goal, and deviation.[76]

> "Input and output refer to directions of flow to and from a system across its boundaries; goal refers to a desired state of a system...control is the consequence of the comparison performed between the actual output level and desired level...."[77]

Understanding of the nature of feedback and the self-regulation in which it results enables scientists concerned with things as apparently divergent to have some common concerns. Once systems are understood as having feedback elements, it is possible to discuss such things as regulation and self-regulation; steering and self-steering, and the abilities of divergent systems to deal with deviation, error and differences. One of the goals of systems thinking is to take the insights of diverse disciplines and utilize their discipline-specific knowledge as it applies to other sciences. The notions of openness, closedness, environment, wholeness and parts in relation thereto, metabolism, entropy, equifinality, organization, feedback are all central to systems thinking and to its interdisciplinary thrust.

The Study of 'Intact' Systems

Given these central concepts and the basic elements of systems and systems concern, there are three methods for the study of 'intact' systems. One method is to take the world where one finds it, examine the various systems that occur in it, and draw up some statements about the regularities observed. A second approach is to arrange the empirical fields in a hierarchy of complexity of organization of their basic individual or unit behavior and to try to develop a level of abstraction appropriate to each.[78] A third, Ashby's method,[79] is to start at the other end, to consider the set of all possible systems and to reduce to more reasonable size. The significance of the method of exploring systems lies in attempting to develop a logic of mechanism; of using what we can observe or that which might be possible to exist, as a way of formulating hypotheses about the working of the system, specific enough to be of value, but generalizable enough to have an interdisciplinary yield.

As noted in an earlier section of this essay, systems thinking has not met with universal acceptance or even with consensus to its thrust. Even some among those who have contributed to systems thinking raise questions about the direction in which it is headed and the cautions with which it must proceed. One of these is Stafford Beer who cautions that systems research stands in the "twilight of a subject inhabited by shadowy concepts from the past" and that unless we "confront our myths" it is not possible to press ahead.[80] The basic myth he sees has to do with chaos and order; the assumption that the raw state of nature is chaos and that order is introduced to and imposed on chaos. Whether one takes this as significantly questionable or not, these kinds of considerations lead to an evaluation of general systems theory and thinking as a Twentieth Century attempt to answer the age old questions of existence.

CONCLUSION: EVALUATION OF SYSTEMS THEORY AND ITS CONTRIBUTIONS

The contributions of General Systems Theory can be discussed in at least three senses.[81] First, as a supradiscipline including the special systems disciplines such as mathematic systems, systems engineering, cybernetics, control and automata theories. Second, one can attribute to systems thinking the development of a taxonomy of terms and concepts applicable to systems of all types, drawn from the different disciplines in which isomorphies and/or analogies can be found or made. Third, one can conceive of General Systems Theory as a new epistomology of special significance to the social and behavioral sciences. In this last sense, General Systems Theory would serve to contribute the necessary mechanisms for isomorphies of scientific utility and the means of postulating critical models in complex areas of knowledge.

Which conclusion one selects depends on the frame of reference from which systems theory and its utility are viewed. To consider General Systems Theory as a suprasystem including the special systems disciplines also precludes it in some important senses from being truly interdisciplinary in thrust and applicable to the widest range of disciplines. Those who have helped fashion systems thinking and the disciplines from which they come seem to preclude this first sense of systems theory as too narrow in its definition. It would be a broader definition to conclude that systems theory develops a taxonomy of terms and concepts applicable to the different disciplines. But viewed in light of the definitions offered in this essay, that system theory is a 'perspective', a way of looking at things rather than a specific set of propositions, this second sense of the meaning and value of systems theory is also limited. Taxonomies are tools and as such are necessary but not sufficient in the determination of an approach to knowledge. Finally, it has been suggested that General Systems Theory can be considered a new epistomology of special significance to the social and behavioral sciences.

Viewed as an epistomology, general systems thinking appears to be replete with the mechanisms for developing isomorphies and analogies which can be utilized across disciplinary boundaries in serious and non-superficial ways. It seems capable of developing adequate theoretical models where they are absent at present, and of minimizing the duplication of intellectual exploration in different fields. Most profoundly, it may be capable of promoting a sharing of knowledge; a unity of science based on definition and investigation of significant similarities in the nature of things without loss of sight of differences that make a difference. In this sense it can be viewed as an alternative to the reductionism of earlier times; a way of explaining the meaning of existence without attempting to reduce all flavors to strawberry. Intellectual curiosity about the meaning of existence has been central to the cerebral pursuits of humanity from the beginnings of recorded time. It runs through the thinking of classical philosophers, the intellectual endeavors of the Renaissance, and contemporary human scientific and quasi-scientific exploration. The scientific discoveries of the Eighteenth and Nineteenth Centuries which led to the methodology of reductionism produced and continue to provide certain kinds of answers to certain kinds of questions about the nature of things. But the human race is as intellectually insatiable as curious; a trend in any direction is countered by investigation along other avenues. Reductionism made way for attempts at synthesis provided in theories like systems thinking; just as more global theories of earlier times were responded to by reductionism.

In contemporary scientific thought there is room, and indeed, need for both kinds of analysis one can achieve by reductionism and the kinds of synthesis which prevent it from splintering into fragmentation. As an epistomology, General Systems Theory provides the mechanisms for the pooling of knowledge without dousing the pursuit of the specific. In approaching knowledge by fostering the sharing of those discipline-specific insights which have interdisciplinary ramifications, it is capable of increasing rather than reducing the ways in which the scientist can explore the nature and essence of things. At the very least it provides those of us in distinct disciplines such as mathematics, communication, biology, anthropology, engineering, with the understanding that we do indeed have some things to say to one another. If General Systems Theory can provide the mechanism for doing so fruitfully, it has provided roads back to ancient Rome and Athens while permitting us to travel with the intellectual goods purchased during the intervening centuries.

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"General Systems Theory," "Modern Organizational Theory," and Organizational Communication

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Because of the recent interest of communication scholars in "General Systems Theory" and "Modern Organizational Theory" this paper is an attempt to relate some of the significant features of these approaches to theory building to organizational communication theory.

"Something called 'modern organizational theory' has recently emerged," wrote Scott (1961), "raising the wrath of some traditionalists, but also capturing the imagination of a rather elite avantegarde" (p. 8). In little more than ten years, however, Scott's "rather elite avantegarde" has become a major movement united by the premise that "the only meaningful way to study organization is to study it as a system" (Scott, 1961, p. 17). Indeed, according to Sadler and Barry (1970), "The classical and human relations approaches to the study of organizations have been succeeded by new approaches concerned with the study of organizations as systems" (p. 57). These new approaches to the study of organizations are especially significant to researchers, theorists, and practioners of organizational communication. As Johnson, Kast, and Rosenzweig (1964) noted, "Communication plays a vital role in the implementation of the systems concept. It is the connecting and integrating link among the systems network" (p. 378). For just this reason Steil (1971) argued, "an understanding of modern organization theory should profitably enhance the speech-communication scholar's understanding of the organization and in turn--organizational communication" (p. 84). In "modern organizational theory" communication is the focal point for the application of systems analysis to the functioning of organization.

Ehling (1966) was quite definite in his assessment of the potential of systems approaches to problems of organizational communication theory:

> The point of my comments is that there are some new approaches in researching the behavior of individuals and social groups.

> Ludwig van Bertalanffy, Kenneth Boulding, and Anatol Rapoport, among others, have shown the significance of applying these new notions made clear in general systems theory....It is my contention that much of the variability found in recent industrial communications research can be more effectively handled and controlled by the newer methods of analysis than through the traditional social psychological and sociological approaches which have dominated much of communications research during the last three decades (p. 88).

Redding (1968) was no less equivocal when he wrote that, "there is no substitute for systems-thinking in any serious study of organizational communication" (p. 105). In the broadest sense, therefore, our problem as students of organizational communication is the implementation of the observations of Steil (1971), Ehling (1966), and Redding (1968) concerning "modern organizational theory," and the use of a "systems approach" to examine specific problems of information diffusion networks in organizations.

Systems Approaches

Emery (1969) suggested that there are two primary trends of thought from which the systems concept emerges: 1) a concern with the design of complex engineering systems, and 2) concern that progresses from theorizing about biological systems in general to specific social systems (p. 7). The first approach arose from work in such areas as operations research, man-machine systems, and computer simulation. According to Dearden and McFarlan (1966) this approach to the systems concept consists of "freeing ourselves from restraints inherent in manual methods of problem solving" (p. 105). It is essentially a decision-making approach based on mathematical and logical (usually computer oriented) models. While much of the current literature on organizational functioning has focused on the techniques of this approach for solving complex multi-variable problems, this is not what has been generally included under the label "modern organization theory" and this is probably not the approach most useful to the study of organizational communication.

The more applicable, second approach is best exemplified in the works of Bertalanffy (1962, 1968), Boulding (1953, 1956a, 1956b), and James Miller (1965, 1971a, 1971b). This approach, generally referred to as General Systems Theory, was pioneered by Bertalanffy in his work on an organismic theory of biology in the 1930's. Bertalanffy (1968) defined systems as "sets of elements standing in interaction" (p. 38). If the interaction is entirely internal, the system is closed. If the interaction of elements is both internal and with elements of the environment (external), the system is open. This distinction between open and closed systems provides the most provocative of the systems concepts. Classical and human relations theories of organization were based on the concept of internal regularity. Whether the nature of the regularity was mechanistic as in bureaucratic theory or cyclic as in flow theory, the organization was an entity or identity independent of its social environment. While this mode of analysis is possible in General Systems Theory, through the examination of closed systems, a second mode is possible through open systems analysis (popularly) referred to as Open Systems Theory). This second mode is significant since, as Johnson, Kast, and Rosenzweig (1967) noted, "Such a description of a system adequately fits the typical social organization" (p. 12).

A qualification is necessary, as Katz and Kahn (1966) argued:

> Open systems theory is not a theory at all; it does not pretend to specific sequences of cause and effect, the specific hypotheses and tests of hypotheses which are the basic elements of theory.... Open systems theory is an approach and a conceptual language for understanding and describing many kinds and levels of phenomena (p. 452).

The concept of the open system is not itself a theory, but with its focus on universal phenomena it can provide a foundation for future organizational theories. Typical phenomena for analysis include, according to Bertalanffy (1968), wholeness, growth, differentation, hierarchy, dominance, control, and competition (p. 47).

Sadler and Barry (1970) presented three characteristics which generally are included in "modern organizational theories":

1. Concern with the organization as a whole.
2. Concern with the organization in relation to its environment.
3. Concern with the dynamics of organizational life and organizational development.

Thus the key concepts of "modern organization theory" would be: 1) wholenss, 2) openess, and 3) process. "The systems approach," noted Churchman (1969), "is simply a way of thinking about these total systems and their components" (p. 11).

Systems Thinking

Perhaps the most succinct statement of the characteristics and demands of systems thinking is Chin's (1961):

> The analytic model of system demands that we treat the pnenomena and the concepts for organizing the pnenomena as if there existed organization, interaction, interdependency, and integration of parts and elements. Systems analysis assumes structure and stability within some arbitrarily sliced and frozen time period (p. 202).

The conceptual language for examining organizational wholeness, openness, and process includes, therefore, organization (the arrangement of complete and functioning wholes), interaction (mutual or reciprocal activity--the primary mode of which is communication), interdependency (transfer of effect--so that a change in one part of a system is felt eventually throughout the system), and integration (the formation rule of the whole--such that synergistically the whole is not "more" than the sum of the parts, but the whole is "different" from the sum of the parts).

Boulding (1956b) elaborated the notion of analysis by levels, noting that there exists a hierarchy of complexity, "roughly corresponding to the complexity of 'individuals' of the various empirical fields" (p. 201). Each level of complexity incorporates the lower levels and consequently, "much valuable information and insight can be obtained by applying low-level systems to high-level subject matter" (p. 206). Each level of complexity reflects systems which are both complete (on that level) and parts/elements/components of systems on higher levels. Thus, Koestler (1967) noted that any living system must be analyzed in terms of hierarchy, "wherever there is life, it must be hierarchically organized" (p. 47). Koestler coined the word HOLON (from the Greek holos or whole, and the suffix on suggesting a part or a particle) to be used to analyze the system which is both a complete system with sub-systems, and a subsystem of some larger system. His analysis, therefore, would include the subsystem, the system, and the supra-system (which in other formulations could be considered as the environment of the system).

Katz and Kahn (1966) have developed more fully the notion of organizations as open systems dependent on their environments. They isolated nine characteristics to define all open systems:

1. The importation of energy. Resources (people, materials, information, etc.) are drawn from the environment into the system. No open system is self-sufficient.

2. The through-put. The input is somehow transformed.

3. The output. The system exports some kind of matter/energy into the environment. The output includes both the final products of the through-put and the waste products.

4. Systems as cycles of events. The products sent into the environment furnish the sources of energy for the repetition of the cycle of events. Goods are sold to produce revenue to purchase raw materials to be transformed into goods to be sold to produce revenue, etc.

5. Negative entrophy. Not only does the system import enough energy to maintain itself, but it imports extra energy as a

safety margin to prevent the system from exporting more energy than it imports (death).
6. Information input, negative feedback, and the coding process. Open systems operate and control operations by gathering information from the environment, and from its own operations coding the information, and using it to determine problem areas.
7. The steady-state and dynamic homeostasis. Open systems tend to maintain their basic character by either resisting changes, offsetting changes, incorporating the changes into its basic character, or by developing new characteristics.
8. Differentiation. Crude patterns become more sophisticated and specialized by function. A division of labor occurs.
9. Equifinality. A single end state (goal) can be reached in a variety of ways. Note: as the specialization of function increases, the options available to the system may decrease (paraphrase, pp. 10-26).

These characteristics reflect the creative and constantly emerging nature of open systems. As French (1963) note, "A system is a particular linking of events which has a facilitating effect, or an intended facilitating effect, on the carrying out of a process" (p. 49). In this concept of process, the organization as a human system (unlike the biological system) exists. "Organizations possess no physical structure," wrote Collins (1968), "Structure is given to social systems by the arrangement of events rather than the arrangements of things" (p. 15).

Churchman (1969) put many of the notions of this conceptual language in perspective by considering four major way in which systems thinking is utilized:

> (1) The advocates of efficiency; they claim that the best approach to a system is to identify the trouble spots, and especially the places where there is waste....and then proceed to remove the inefficiency. (2) The advocates of the use of science in approaching a system; they claim that there is an objective way to look at a system and to build a 'model' of the system that describes how it works. The science used is sometimes mathematics, sometimes economics, sometimes 'behavioral' (e.g., psychology and sociology). (3) The advocates of human feeling, i.e., the humanists; they claim that systems are people and the fundamental approach to systems consists of first looking at the human values: freedom, dignity, privacy....(4) The anti-planners, who believe any attempt to lay out specific and 'rational' plans is either foolish or dangerous or downright evil. The correct 'approach' to systems is to live in them, react to one's experience, and not try to change them...(pp. 13-14).

It is the scientific version of systems thinking that Chin (1961), Emery (1969), Boulding (1956b), Koestler (1967), Katz and Kahn (1966), French (1963), and Colins (1968) presented. They presented models (conceptual languages) for understanding the functioning of organizations. In general, the models recognized organizations as given, identifiable, structures of events with the inherent ability to change. Thus the organization as supra-system (environment) is necessary to provide energy for the survival of its members as systems; and the members as sub-systems are necessary to carry out the processes (events) which give the organization its form and existance.

At this point the efficiency, humanistic, and anti-planning versions of systems thinking become significant by virtue of their focus on value criteria. People and organizations depend upon each other for survival; at the same time they influence each other. It is theoretically probably that people can help create organizations which maximize their personal potential for survival, while the organization can help create people which maximize its potential for survival. Therefore, the criteria for ultimate survival and immediate influence become significant. Churchman's efficiency version of systems-thinking considers inefficiency as the primary threat to survival, accepts the axiom that, "All waste is bad," and gears its actions to the elimination of waste--despite the recognition by the scientific version that negative entrophy demands excess energy as safety margin against death. The humanistic version considers exploitation as the primary threat, accepts the axiom that, "The individual is inviolate," and aims its actions at maximizing individual freedom of choice--despite the scientific version's realization that a system as a cycle of events demands regularity and predictability of behavior. The anti-planning version considers change as the primary threat to sruvival, accepts the axiom, "Work within the status quo," and acts for the preservation of the current system--despite the scientific version's contention that change is inevitable and equifinality suggests that many different systems could be equally desirable.

Clearly the systems approach to "modern organization theory" provides a conceptual language for understanding the organization as a dynamic and purposeful entity. But simply knowing and understanding the language of the systems concept does not allow us to handle the variability of past research mentioned by Ehling (1966) nor conduct the serious study mentioned by Redding (1968). Therefore, the systems approach of "modern organization theory" must be applied specifically to organizational communication.

Organizational Communication

"In an exhaustive theory of organization," wrote Barnard (1938), "communication would occupy a central place, because the structure, extensiveness, and scope of organization are almost entirely determined by communication techniques" (p. 91). In "modern organization theory" the communicative process does, in fact, occupy a central place. As noted earlier, Johnson, Kast, and Rosenzweig (1964) wrote that "It (the communicative process) is the connecting and integrating link among the systems network" (p. 378). In their influential analysis of the organization as an open system Katz and Kahn (1966) devoted considerable space to communication as the essence of organization.

> In this sense, communication--the exchange of information and the transmission of meaning--is the very essence of a social system or an organization. The input of physical energy is dependent on information about it, and the input of human energy is made possible through communicative acts. Similarly the transformation of energy (the accomplishment of work) depends upon communication between people in each organizational sub-system and upon communication between sub-systems. The product carries meaning as it meets needs and wants, and its use is further influenced by the advertising and public relations material about it. The amount of support which an organization receives from its social environment

> is also affected by the information which elite groups and wider publics have acquired about its goals, activities, and accomplishments.
>
> Communication is thus a social process of the broadest relevance in the functioning of any group, organization, or society. It is possible to subsume under it such forms of social interaction as the exertion of influence, cooperation social contagion or imitation, and leadership (pp. 223-224).

Although Katz and Kahn were operating from an unsophisticated and incomplete definition of communication, they none the less apprehended the significance of the communicative process in human systems. Scott (1961) summarized this view by describing the communicative process as "a mechanism which links the segments of the system together" (p. 20). Thus, in human organizations, communication is the central process integrating the human, physical, financial, and informational elements. Through the acts of communicating the organization is formed and maintained.

Recognizing the creative power of humans communicating, Thayer (1968) observed:

> It is the communication which occurs within it, and the communication that occurs between the organization and its environment, which both defines the organization and determines the conditions of its existence and the direction of its movement (pp. 101-102).

Simon (1957) established that the communicative process is a necessary characteristic of organization. "It is obvious that without communication there can be no organization" (p. 154). Cherry (1957) went a step further, noting that the communicative process is not just a necessary condition for organization, but a sufficient condition. "Communication renders true social life practicable, for communication means organization" (p. 5). Thus there is evidence that an understanding of organizations from a systems perspective requires an understanding of the communicative processes within the organization.

Organizational communication as a field of study attempts to investigate the behaviors and their consequences which constitute communicative processes within an organization. As Smith, Richetto, and Zima (1972) argued, ". . . organizational communication is conceived of as a general area of empirical research conducted by scholars from a number of fields, all of whom are concerned with the way in which people communicate within their organizations" (p. 270). Within organizations, MacDonald and Farace (1970) observed that ". . . relatively stable and regular patterns of work and communication activities can be observed; the purview of scholars of organizational communication is to describe and analyze these communication and information patterns" (p. 2). These patterns to a large extent determine the functioning of an organization. As Bavelas and Barrett (1951) suggested:

> It is entirely possible to view an organization as an elaborate system for gathering, evaluating, recombining, and disseminating information. It is not surprising, in these terms, that the effectiveness of an organization with respect to achievement of its goals should be so closely related to its effectiveness in handling information. In an enterprise whose success depends on the coordination of the efforts of all its members, the managers depend completely on the quality, the amount, and the rate at which relevant information reaches them. The rest of the organization, in turn, depends on the efficiency with which the managers can deal with this information and reach conclusions, decisions, etc. (p. 368).

This same recognition of the significance of the information diffusion networks within the organization that prompted Barnard (1938) to contend that, "the first executive function is to develop and maintain a system of communication" (p. 226). Scott (1961) elaborated:

> Communication is viewed as the method by which action is evoked from parts of the system. Communication acts not only as a stimuli resulting in action, but also as a control and coordination mechanism linking the decision centers in the system into a synchronized pattern (p. 20).

What is significant is not that patterns and networks do emerge, but that they are constantly emerging. Unrestricted channels of communication in most organizations would be completely unworkable. No manager would be able to keep up with the myriad of changing inputs: such a system would be chaos. Moreover, such a system would not be "organized." There would be neither structure, nor control, nor hierarchy. The events would be either completely random, or dependent upon organizationally irrelevant factors (e.g., geography). Katz and Kahn (1966) noted that the selection or designation of communication channels is the first step to establishing the organization as a structure of events:

> To move from an unorganized state to an organized state requires the introduction of constraints and restrictions to reduce diffuse and random communication to channels appropriate for the accomplishment of organizational objectives (p. 225).

Moreover, according to French and Bell (1973), the designation of communication channels is a significant step in maintaining the organization as a structure of events:

> A central issue in organizational life, then, is the degree to which members of the organization are permitted to communicate fully with each other about the various organizational subsystems and the degree to which such communication is facilitated (p. 82).

Conclusion

The above discussion suggests two major conclusions. First, "modern organizational theory" through the application of "open systems" concepts provides a potentially significant analytical model for organizational communication scholars. This analytic model is incorporated in the possibility of adopting various perspectives (scientific, humanistic, efficiency, and anti-planning) for utilizing the conceptual language of systems thinking (focusing on openness, wholeness, process, interaction, interdependency, integration, etc.). Second, from this perspective, organizational communication as a field of study would be devoted to the investigation of the regular (formal, informal, task, social, upward, downward, lateral, horizontal, etc.) patterns, networks, and/or channels of information diffusion and experience sharing through which the activities of persons in organizations are coordinated, controlled, and evaluated.

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