LIVING SYSTEMS THEORY

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Summary

National, international, and environmental problems require multi-disciplinary solutions. Living systems theory is an evolutionary scientific theory that justifies well-defined research across multiple disciplines. Its connection to the zeitgeist of a new millennium of human aspiration is expressed in the last paragraph of the chapter on supranational systems in the seminal work by James Grier Miller:

When general living systems theory dissects Europe or the EEC, the world or the United Nations, into subsystems and uses computer simulations to analyze the perturbed nations with their vibrating cities and distressed peoples, it may seem to be aloof and dispassionate. But the earth's crises are too real for that. If we examine formal identities between supranational systems and other, better-understood levels of life, it must be with the fervent hope that such analyses can help relieve some of this planet's ominous pathologies.

1. Introduction

The universe of all things that exist may be understood as a universe of systems where a *system* is defined as any set of related and interacting elements. This concept is primitive and powerful and has been used increasingly over the last half-century to organize knowledge in virtually all domains of interest to investigators. As human inventions and social interactions grow more complex, general conceptual frameworks that integrate knowledge among different disciplines studying those emerging systems grow more important. Living systems theory (LST) instructs integrative research among biological and social sciences and related academic disciplines.

LST is a comprehensive conceptual framework of related definitions, assumptions, and propositions for investigating life. It views existence, from the perspective of living systems, as an integrated, evolving hierarchy of matter, energy, and information. Living systems are defined within a scheme of all systems as concrete open systems, with purposes and goals, and ranging in a hierarchy from cells to supranational systems. They are composed of subsystems integrated to process inputs, throughputs, and outputs of various forms of matter, energy, and information.

Such systems exist in physical space-time and evolve both concrete and conceptual systems by internal dynamic interactions and exchanges with their environments. LST identifies eight levels of life. Systems at all of these levels have similar critical subsystems whose processes are essential for life—even though many emergent characteristics distinguish the systems at different levels. Twenty critical subsystems have been identified.

The similarity of critical subsystems at all levels of living systems is explained by the evolutionary principle of fray-out—a progressive specialization of functions (a sort of division of labor) that causes higher-level living systems to emerge from lower-level ones. Living systems are continually (though often erratically) evolving, by this process, generally towards greater complexity. The fray-out principle explains why it is possible to discover, observe, and measure formal identities across levels of life.

LST is intended to provide a theoretical basis for integrating scientific research from various disciplines to solve social problems. The theory emphasizes extending scientific methodologies from the physical and biological sciences to the social sciences. Insights drawn from the physical and biological sciences, however, are rigorous methodological extensions that take into consideration the emergent characteristics of higher-level living systems. They are not loose analogies drawn from casual observation.

To this end, LST identifies structure and process that may be formally assessed and measured at each of the eight levels of living systems. Different scientific and academic disciplines and specialties have developed to investigate systems and components at these different levels. They usually developed independently of each other and, consequently, integration of knowledge across disciplines is difficult. LST instructs the integration of knowledge from these disciplines through the discovery, observation, and measurement of cross-level formal identities.

Measurement is a central function in the integration prescribed by LST. Measurement requires that observations be made in a common space, or in different spaces with known transformations. Physical space is common to all sciences since it is shared by all investigators and data must be processed in it. Many useful conceptual spaces exist as well, such as pecking order in birds and other animals, and social distance among ethnic and racial groups. LST requires that methodological extensions include restatements of assessments made in such conceptual spaces to measurements in physical space. Such restatements are generally complex. For example, a restatement of ethnic distance is not a simple function of physical proximity (although that contributes) but also includes such elements as genetic coding, family income, available communication channels, and so on. If cross-level (inter-disciplinary) hypotheses are to be confirmed or disconfirmed, both restatements of this nature and physical measurements of systems at different levels are required.

The following exposition of elements of LST explains its central ideas, providing examples to clarify them. The discussion is divided into basic concepts, characteristics of living systems, the fray-out thesis, levels of living systems, critical subsystems, observable structures and processes, and a summary.

2. Basic Concepts

In the final analysis, science composes conceptual systems to study concrete systems. In doing so, it studies many previously introduced conceptual systems and often formulates abstracted systems as well. How these information systems are used becomes an important epistomological consideration. How LST draws these systems together is discussed in this section.

2.1 Concrete Systems

A concrete system is a nonrandom accumulation of matter-energy in a region of physical space, which is organized into interacting inter-related subsystems or components. Living systems are composed of concrete systems as well as conceptual ones and, consequently, are subject to physical space-time constraints. How many bits of information can be stored by a DNA molecule is determined by how it is configured in space, by its different nucleotide bases. The rate of advance toward Berlin by the US Third Army in World War II was determined by the amount of friction the fuel lines that supplied General Patton's equipment exerted upon the fuel pumped through them—limiting the amount available. Examples of such constraints are everywhere. Notwithstanding their concrete system composition, however, living systems include conceptual systems and are often controlled by them.

2.2 Matter-Energy

Matter is anything that has mass, and energy is the ability to do work. Mass and energy are equivalent but different qualities of the energy conserved in the universe. LST uses the term matter-energy for this complex of physical substance. Matter-energy is always in flux. All changes in the states of matter-energy and movements in space are termed actions. The concepts of information and entropy are especially useful for studying actions in living systems.

2.3 Information

Information is the amount of formal patterning or complexity in any system. LST uses the term in the technical sense of Shannon's mathematical theory of communication. Thus, the amount of information in a well-defined system or part thereof can be measured.
In concrete systems, information is the arrangement of a system's matter-energy elements in space-time. Observable bundles, units, or changes of matter-energy (termed markers), the patterning of which conveys information, are required for information to be moved in space or retained in time. Matter-energy actions that occur primarily to convey information, as opposed to functioning directly for things such as growth or repair, are termed communication or information flow. Information markers have evolved (and continue to do so) towards less mass. Cuneiform tablets conveyed approximately 10^{-2} bits of information per gram, while magnetic tape can store up to 10^{12} bits per gram. It has been estimated that no living or nonliving system can process information at a rate greater than 2×10^{47} bits per second per gram of its mass. This constraint on the ability of living systems to process information becomes apparent when it is realized that a system the size (6×10^{27}) and age (10^{10} years) of the earth can process no more than 10^{93} bits of information while the number of all possible moves in a single chess game is about 10^{120}. So while the measurement of the quantity of information is important for scientific precision, it is equally important to develop precise methods for assessing meaning in particular situations.

Evolutionary studies of the interactions among conceptual and concrete systems as they relate to interactions among living systems and nonliving cybernetic systems have revealed the need to recognize different types of informational processes. Recently, information-as-action has been termed referential information, with information-as-knowledge termed non-referential, to distinguish, respectively, between information that has meaning within a system and that which reflects the observation of a system. These types are augmented by state-referential information, which includes both referential and non-referential information that is confined to a priori state-spaces and raises the question of whether evolution and emergence can be accounted for in such a closed and deterministic space.

2.4 Meaning

Meaning is the significance a system gives information—how a system's process and structure are changed by information. Information can be measured rigorously in the structure and process of different sorts of living systems, whereas rigorous and objective methods for quantifying meaning in different types of living systems have not yet been developed. Nevertheless, certain systems for measuring meaning (as it is defined in LST) are emerging and being developed in living systems. For example, modern generally accepted accounting principles (GAAP) instruct financial information disclosure in such a way that analysts and other users may determine the effects of quantities of money-information marker flows into, through, and out of organizations. Those effects are the meaning of certain quantities of money flows to certain entities.

2.5 Conceptual Systems

The units of conceptual systems are terms such as words, numbers, and other symbols. Relationships in these systems are expressed by verbs or by mathematical symbols that represent operations such as inclusion, subtraction, and multiplication. Conceptual systems are borne on information markers. Scientific conceptual systems exist in observers, theorists, experimenters, books, articles, computers, and so on. Observers form conceptual systems by selecting sets of units to study from an infinite number of units and relationships. The units selected may be purely logical or mathematical, or may be intended to have a formal identity or isomorphism to empirically determined units and relationships in concrete systems. Because observers can never be certain they have selected all units and relationships in any concrete system being studied, such selected systems are termed abstracted systems to distinguish them from the concrete systems as they actually exist. Science advances as the isomorphism increases between a theoretical conceptual system and the empirical objective discoveries about concrete systems. For this reason, it is important to distinguish between conceptual and concrete systems even though both are integrated into living systems.

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Biographical Sketches

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James Grier Miller, M. D., Ph.D., Harvard University, is past President of the University of Louisville and a pioneer of system science. He has served on the faculties of Harvard, the University of Chicago, the University of Michigan, John Hopkins University, and the University of California. He edited the journal *Behavioral Science* for more than forty years, originating the modern use of the term “behavioral science”. He was a founder and first President of EDUCOM and has been a fellow of the International Institute of Applied Systems Analysis in Vienna. He has written or co-authored ten books and more than 100 scientific and scholarly articles.