CYBERNETICS

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Cybernetics

The term cybernetics comes from the Greek word for steersman or the helmsman on a ship. Words with the same root mean govern and governor. Norbert Wiener, who first used the term in English, defined it as "control and communication in animal and machine." The term was subsequently extended to social systems. Numerous other definitions have been proposed. Stafford Beer defined cybernetics as the "science of effective organization." Gregory Bateson said cybernetics deals with form rather than substance. Gordon Pask defined cybernetics as "the art of manipulating defensible metaphors." Organization theorists may regard cybernetics as a science of information processing, decision-making, learning, adaptation, and organization, whether these occur in individuals, groups, organizations, nations, or machines.

Conceptual Overview

The field of cybernetics was created after World War II by a group of people who were discussing "circular causal and feedback mechanisms in biological and social systems." A series of ten conferences on this topic between 1946 and 1953 were supported by the Josiah Macy Jr. Foundation. The field was named cybernetics after Norbert Wiener (1948) published his book titled cybernetics. In his book Wiener distinguished three revolutions in human society. The agricultural revolution was a transition from hunting and gathering to settled cultivation of the land. Consequences included the growth of cities, specialization in employment, and legal systems. The second revolution Wiener called the "first industrial revolution" which was brought about by new forms of energy, such as steam and electricity. Consequences included larger, more integrated social units, further specialization of labor, and a great increase in the number of people employed by bureaucratic organizations. The third revolution Wiener called the "second industrial revolution" which the world was just entering in the late 1940s. It was brought about by information machines – computers and computer networks. Consequences include the focus of human effort on creativity rather than repetition, the globalization of economic activity, and the sharing of ideas almost instantaneously around the world. The three types of society distinguished by Wiener were repeated by Daniel Bell in his book *The Coming of Post-Industrial Society* and in Alvin Toffler's more popular book *The Third Wave* in 1981.

Cybernetics is the science that best explains the "second industrial revolution." It has influenced many fields, including computer science, robotics, management, sociology, political science, economics, psychology, and philosophy, particularly epistemology, the theory of knowledge. Cybernetics offers to organization studies general theories which not only explain organizational phenomena but also reveal similarities between processes in organizations and processes in other fields of study. Since it is a general theory of the regulation of systems, it can be regarded as a general theory of management and organization, encompassing adaptation, self-organization, and reflexivity. Currently many people in developed societies spend several hours a day in "cyberspace," but few people are familiar with the basic principles of cybernetics.

Process Improvement and Adaptive Systems

In the years since World War II quality improvement or process improvement methods have played a key role in determining the relative competitiveness of nations. The success of these methods can be explained using Ross Ashby's theory of adaptation. Process improvement methods are based on a distinction between working IN a process and working ON a process. An organization is envisioned as a collection of processes. The people who work in a process constitute the process improvement team. Work IN the process is the work they do to make the process function. Work ON the process is the work they do when they meet as a team to discuss how to improve the process. This conception of how to improve processes within an organization, and hence how to improve the organization, is an example of Ashby's theory of adaptive behavior. Ashby showed that any system having two nested feedback loops, one inside the other, would be able to display adaptive behavior. The inner feedback loop operates frequently and makes small adjustments. The outer feedback loop operates infrequently and initiates the learning of a new pattern of behavior. Adaptation encompasses learning. Learning can be defined as a change in behavior in the direction of improvement. To learn means to acquire a pattern of behavior that is suitable for a particular environment. However, when the environment changes, the pattern of behavior may need to change. A system that can change its behavior when the environment changes is said to be adaptive.

Incentives and Self-Organizing Systems

Ashby's conception of self-organizing systems also provides a general theory for organization studies. Ashby defines a self-organizing system as consisting of interacting elements whose behavior does not change during a specific period. He states the principle of self-organization as follows: every isolated, determinate, dynamic system obeying unchanging laws will develop organisms that are adapted to their environments. This principle is a more general statement of learning theory, Darwin's theory of natural selection, and the basic concept underlying incentive systems whether in organizations or in government regulations. When a manager creates an incentive, such as a sales commission, the manager assumes that salesmen will strive to achieve the reward. In terms of Ashby's theory a new set of interaction rules has been defined and the people in the organization change their behavior accordingly. Similarly, if the government wants to reduce energy consumption, it can create a tax deduction for expenditures intended to reduce energy consumption, for example by adding insulation in an attic or installing storm windows. Each homeowner or business can decide where the energy savings would be greatest relative to cost. The government's purpose – reducing energy consumption – is achieved not by directing people to make particular changes but rather by creating an incentive for people to change. The principle of self-organization leads to a general design rule: in order to modify any object, organism, or organization, expose it to an environment such that the interaction between the object and its environment moves the object in the direction you want it to go.

Managing Complex Systems

In recent years there has been increasing discussion of "complex systems." However, much of the discussion of "complexity" assumes that it is an inherent property of the system observed. Cybernetics, on the other hand, takes the view that complexity is observer dependent. What one person sees as being very complex can appear simple or not problematic to another. For example, fixing an automobile, debugging a computer, performing brain surgery, or managing a corporation may seem overwhelmingly complex to a lay person but not an unmanageable task for a specialist.

The approach that cyberneticians take to the management of complex systems is based on Ashby's law of requisite variety. First published in 1952, this law states that the amount of selection that can be performed is limited by the amount of information available, or the variety in a regulator must be at least as great as the variety in the system being regulated. For example, if a university is selecting students for admission to a graduate program but does not have information on some of the applicants, no rational decision can be made about those applicants. A second example is buying a computer. In order to know which computer to buy, one first estimates the size of the task in speed and memory. One then buys a computer at least that big. It would not be rational to buy a smaller one. Although these examples may seem obvious or trivial, this law is the starting point for any analysis intending to amplify intelligence (defined as appropriate selection) or regulatory capability. Organizations amplify appropriate selection in the same way that a hydraulic lift in a service station lifts a car or the way a stereo system at a rock concert amplifies the music on the stage. In each case a pattern is imposed on a larger flow or capability.

The control of variety is the central problem in organization studies. Consider the subject of span of control. If we assume that all human beings have approximately the same cognitive capability, for example the number of pages that can be read in a day, then a manager who supervises seven or more subordinates is at a hopeless disadvantage and is confronted with an impossible task. Of course, the problem rarely arises because the subordinates are not trying to outwit or defeat the manager. Generally subordinates do as they are trained to do and managers only need to deal with exceptional cases. Also, the manager chooses to regulate very little of each subordinate's behavior.

Here we begin to see the power in the idea that complexity is observer dependent. Ashby (1956) defined a system as a set of variables selected by an observer. There are two assumptions. First, the variables are related, otherwise there would be no reason to treat them as a system. Second, the observer has a purpose in mind that guides the selection. Consider the different disciplines involved in managing a corporation. People in the finance department are concerned with dividends, interest rates, stock price, and return on investment. People in marketing are concerned with market share and customer loyalty. The personnel department is concerned with training, salaries, pensions, and health insurance. Engineers are concerned with new technology, production schedules, and defects. Hence, the people who work for a corporation think in very different terms. The variables each person pays attention to depend on his or her tasks or purposes.

If one seeks to manage a large, complex system, such as a corporation or the global economy, one must think in abstractions and rely on others to implement policies at several levels of organization. Managing through conceptualizations is another way of saying that complexity is observer dependent. However, cyberneticians do not stop there. Selecting the features of a system to pay attention to is not merely a matter of convenience. Selection and interpretation is inherent in the perceptual process. Usually people speak of a system and a model of the system. What they have in mind is a real system in the external world and a mathematical or conceptual model, which is a simpler representation. However, by studying the operation of the brain cyberneticians came to the conclusion that even our knowledge of the external world is a conceptualization. Our knowledge of the world depends on our senses. Recall that human beings and other animals, such as dogs and insects, live in different perceptual worlds. Different organisms see and hear different light and sound frequencies. Furthermore, from what we are able to perceive, we focus our attention differently depending on our purposes. Through the study of neurophysiology cyberneticians came to the conclusion that "the world as we perceive it is our own invention."

Reflexivity

Because of their interest in communication and control, cyberneticians are interested in reflexivity or the mutual influence between the observer and the system observed. In the natural sciences we assume that our theories do not alter the phenomenon described. For example, we assume that atoms did not change when theories of atomic structure changed. The same cannot be said of social systems. When economic theories change, and people act on the new theories, the behavior of an economic system changes. In social systems, particularly organizations, there is an interaction between cognition and participation. This phenomenon is called reflexivity.

Reflexivity is a particularly difficult problem for organizational science because social scientists are still working with the philosophy of science, which was developed to guide theory construction in the natural sciences. In response to this dilemma cyberneticians have undertaken to expand the philosophy of science so that it can include reflexive phenomena. One approach has been to focus attention on the importance of methods in addition to theories. Whereas theories are descriptive, methods tell managers how to act. A second approach to dealing with the problem of reflexivity is to include the observer in the domain of science. Historically scientists have sought to remove the observer from science. Their goal was to create theories that were independent of the person conducting the experiment. But for reflexive phenomena including the observer within the domain of science yields a conception of science as a social activity involving mutual influence and experimentation and the construction of successive descriptions.

Critical Commentary & Future Directions

The original goal of creating a common language for discussing communication and regulatory activities in a wide range of systems has been achieved and is on-going. But the lack of formal programs in universities means that this area of research tends to be reinvented about every two decades. There have been waves of interest in cybernetics in the 1940s and 1950s, control systems in the 1960s, chaos theory in the 1970s and 1980s, and complexity theory in the 1990s and 2000s. Why has there not been more continuity in the development of ideas? There are several reasons.

The interdisciplinary character of the field has impeded its taking root in universities. Many existing fields feel they currently cover the subject matter of cybernetics and resist encroachment. Furthermore, most people who have heard the term "cybernetics" associate it with computers and engineering. Few people outside the field are aware of its general theories, which could be helpful to fields, including organization studies, that are still struggling to create general theories or are using a multiplicity of more specific theories.

The term "cybernetics" has been used more often in Europe than in the U.S. The reason no doubt is that continental Europeans tend to look for meaning in more general categories whereas Americans focus on applications.

The potential for future research is great since cybernetics deals with information, cognition, organization, selection, emergence, adaptation, and participation. These are relatively new areas of investigation in the history of science. Work to date has shown the great productivity of dealing with communication and control, management and organization in the most general way, that is, attempting to develop theories that explain these processes in language that is applicable to systems independent of their material embodiment – individuals, groups, organizations, nations, or machines.

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See also Viable System Model, Autopoiesis, Structured Design Process

Further Readings and References

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