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CHAPTER 3

SYSTEM THEORY

One of the most general theoretical approaches to communication is system theory. System theory and two related fields, cybernetics and information theory, offer broad perspectives on how the world operates. System theory deals with the interaction among elements of a larger process, cybernetics deals with control and regulation in systems, and information theory focuses on the measurement and transmission of signals. This group of theories can help us understand a wide variety of physical, biological, social, and behavioral processes.[1]

The roots of system thinking began at least as far back as the nineteenth century with the theory of Georg Hegel. Hegel viewed the world as being in process and controlled by a tension between opposites. For example, a cold war between two superpowers would be followed historically by an antithesis such as the collapse of one of the superpowers and a new world order. The tension experienced between these opposites—the struggle between the forces of the old and new world orders in our example—would be resolved through a synthesis of the two, such as the creation of a plethora of new nation-states and ethnic strife. The synthesis itself becomes a new position, only to be thrown off balance again by a new antithesis, beginning the process all over. Hegel explained historical development in terms of this dynamic process, called *dialectic*.[2]

Karl Marx quickly applied Hegel's thinking to the distribution of power in society, using it to unite labor in opposition to capitalism (see Chapter 11).[3] Charles Darwin, too, relied on the idea that species evolve and adapt to pressures from outside. However, he explained the process differently than did Hegel and Marx. For Darwin, change is brought about by adaptations and accommodations.[4]

1 For excellent discussions of general system theory and other system approaches, see Chang-Gen Bahg, "Major Systems Theories Throughout the World," *Behavioral Science* 35 (1990): 79–107.

2 See, for example, Walter Kaufmann (ed.), *Hegel: Texts and Commentary* (Garden City, NY: Anchor, 1966).

3 See, for example, Anthony Giddens, *Profiles and Critiques in Social Theory* (Berkeley: University of California Press, 1982), especially chaps. 8 and 9.

4 Marjorie Grene, *The Knower and the Known* (Berkeley: University of California Press, 1974), chap. 7. For a more detailed treatment of the influence of Darwin on communication study, see Everett M. Rogers, *A History of Communication Study: A Biographical Approach* (New York: Free Press, 1994), pp. 41–64.

Although system theory is a product of Western intellectual history, it has similarities to certain Eastern philosophies as well. As a group, Eastern philosophies stress patterns and wholes, which are the centerpieces of system theory. Too, system theory and Eastern philosophies avoid simple linear causal reasoning and focus instead on the ways in which many considerations affect one another.[5]

System theory as we know it today was probably best codified by Ludwig von Bertalanffy, a biologist, who established the field of study known as *general system theory*. GST is a broad, multidisciplinary approach to knowledge.[6] Basically, this version of system theory uses system principles to show how things in many different fields are quite similar to one another.[7] For example, the processes that govern economic growth, biological development, and social movements might be viewed in similar terms.

Fundamental System Concepts

What are these qualities that seem to characterize so many different kinds of things? First, let's define a system and then look at the system's qualities.

What Is a System?

Any system can be said to consist of four things.[8] The first is *objects*—the parts, elements, or variables within the system. These may be physical or abstract or both, depending on the nature of the system. Second, a system consists of *attributes*—the qualities or properties of the system and its objects. Third, a system has *internal relationships* among its objects. This characteristic is a crucial aspect, and we will take a closer look at internal relationships throughout this chapter.[9] Fourth, systems also possess an *environment*. They do not exist in a vacuum but are affected by their surroundings. A *system*, then, is a set of things that affect one another within an environment and form a larger pattern that is different from any of the parts.

One of the most common distinctions is between closed and open systems.[10] A *closed system* has no interchange with its environment. It moves toward internal chaos, disintegration, and death. The closed system model most often applies to physical systems like stars, which do not have life-sustaining qualities. An *open system* receives matter and energy from its environment and passes matter and energy to its environment. The open system is oriented toward life and growth.

A family is an excellent example of an open system.[11] The members of a family are the "objects," and their characteristics are attributes. The family system is formed by the interaction among the members. Families also exist in a social and cultural environment, and the family and its environment influence each other. Family members are not isolated, and their relationships must be taken into account to fully understand the family as a unit.

System Qualities

Biological, psychological, and sociocultural systems possess certain common characteristics. You will notice that the following qualities are

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5 See, for example, Joanna Macy, *Mutual Causality in Buddhism and General System Theory* (Albany: SUNY Press, 1991); and Todd Evan Pressman, "A Synthesis of Systems Inquiry and the Eastern Mode of Inquiry," *System Research* 9 (1992): 46–63.

6 For a biographical sketch of Bertalanffy, see "Ludwig von Bertalanffy," *General Systems* 17 (1972): 219–228. For a good general summary of GST, see Macy, *Mutual Causality*, pp. 69–89.

7 For an example of formalized GST, see Masanao Toda and Emir H. Shuford, "Logic of Systems: Introduction to a Formal Theory of Structure," *General Systems* 10 (1965): 3–27.

8 A. D. Hall and R. E. Fagen, "Definition of a System," in *Modern Systems Research for the Behavioral Scientist*, ed. W. Buckley (Chicago: Aldine, 1968), pp. 81–92.

9 Walter Buckley (ed.), "Society as a Complex Adaptive System," in *Modern Systems Research for the Behavioral Scientist* (Chicago: Aldine, 1968), pp. 490–513.

10 Hall and Fagen, "Definition"; Anatol Rapoport, "Foreword," in *Modern Systems Research for the Behavorial Scientist*, ed. W. Buckley (Chicago: Aldine, 1968), pp. xiii–xxv. For an excellent short description of open versus closed systems, see Ludwig von Bertalanffy, *General Systems Theory: Foundations, Development, Applications* (New York: Braziller, 1968).

11 Considerable research has been done over the years on family communication. See, for example, Arthur P. Bochner and Eric M. Eisenberg, "Family Process: System Perspectives," in *Handbook of Communication Science*, eds. C. R. Berger and S. H. Chaffee (Newbury Park, CA: Sage, 1987), pp. 540–563.

not mutually exclusive, but each relates in some way to all the others.[12]

Wholeness and Interdependence. A system is a unique whole.[13] It involves a pattern of relationships that is different from any other system. As the saying goes, the whole is more than the sum of its parts. To understand this idea, examine for a moment the opposite view of *physical summativity*, in which a "whole" is merely a collection of parts with no interaction among them, like a box of stones. But a system is the product of the forces or interactions among the parts. A group of people standing in a row at a bus stop is not much of a system, but a group of people sitting around a table discussing a problem certainly is.

A system is a whole because its parts relate to one another and cannot be understood separately. Any part of the system is always constrained by its dependence on other object parts, and this pattern of interdependence organizes the system itself.[14]

Interdependence is easily illustrated in families. A family is a system of interacting individuals, and each member is influenced by the actions of the others. Although each person has some freedom, no one is completely free because of family bonds. The behaviors of a family are patterned and structured, somewhat predictable. What one family member does or says follows from other family behaviors and leads to further behaviors. Because interdependence is the most important characteristic of systems, it is worth exploring in some detail here.

The interdependence among the variables of a system is *correlations*.[15] In a correlation, two or more variables change together. In a family, for example, anger and yelling might be correlated. Correlations are rarely pure or perfect but are a matter of degree. Some associations are very strong, others quite weak. In a complex system, many variables interrelate with one another in a web of influences that vary in strength. For example, anger, loudness, frustration, withdrawal, and remorse might be tied together in a family. But variables can be related to one another in different ways.

One variable sometimes causes change in another one. For example, use of power by one family member may cause another to give in. Here, power is directly correlated causally with compliance. Traditionally, causality is considered one-way: variable A affects variable B. In systems, however, causality often runs both ways, such that variable A and variable B influence each other.

Take nagging and withdrawing, for example. As the father nags, the son withdraws, and as the son withdraws, the father nags. Each affects the other. Actual causation in communication is difficult to confirm, although establishing how the participants in a system *perceive* the causes is often useful. For example, the father may perceive that the son's withdrawal causes him to nag, whereas the son perceives that the father's nagging causes him to withdraw.

Variables also may be associated indirectly. In such a relationship, the two variables are correlated but do not cause each other directly; they are both caused by a third variable. For example, performance in school and in doing housework could be connected. Children who get their jobs done at home also seem to do well in school, and children who do not do very well at school are also remiss in getting house chores done. If this correlation were discovered, the researcher might uncover a third variable—perhaps the amount of time parents spend with children. Spending more time with children may bring about greater cooperation at home and school.

A more complex form of indirect relationship occurs in a chain of influence. Variable A causes B, which causes C, which causes D, which causes E, which causes A, in a causal ring.

For example, a father's dominance could cause the mother to withdraw, which causes the

12 Bahg, "Major System Theories."

13 Rapoport, "Foreword"; Hall and Fagen, "Definition."

14 For a sophisticated discussion of the various ways in which people can think about interdependence in systems, see Magoroh Maruyama's theory of mindscapes, summarized in Michael T. Caley and Daiyo Sawada (eds.), *Mindscapes: The Epistemology of Magoroh Maruyama* (Amsterdam: Gordon and Breach, 1994).

15 Bahg, "Major System Theories," p. 104.

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child to get depressed, which prevents her from going to school, which creates problems with the teacher. The teacher calls the parents, and the father gets mad. In his domineering style, he tells the mother to get the kid to school, and she withdraws.

Complex systems consist of a network of relationships. A variable is related not just to one other variable but to a potentially large number of other variables, to the point that it becomes difficult to study. Researchers deal with this problem by taking the system apart and examining relationships one at a time. There are several ways of doing this; these methods together are known as *multivariate analysis*.[16]

An example is multiple regression analysis, in which one variable—the *dependent variable*—is correlated with several other *independent variables*. An equation is used to reveal the strength of the correlation between the dependent variable and the group of independent variables. In a family, for example, you might discover that adolescent rebellion (the dependent variable) is predicted by three independent variables: parental authoritarianism, strength of peer group, and age.

Hierarchy. Systems tend to be embedded within one another. In other words, one system is part of a larger system.[17] Arthur Koestler expresses this idea in the following tale:

> There were once two Swiss watchmakers named Bios and Mekhos, who made very fine and expensive watches. Their names may sound a little strange, but their fathers had a smattering of Greek and were fond of riddles. Although their watches were in equal demand, Bios prospered, while Mekhos just struggled along; in the end he had to close his shop and take a job as a mechanic with Bios. The people in the town argued for a long time over the reasons for this development and each had a different theory to offer, until the true explanation leaked out and proved to be both simple and surprising.
>
> The watches they made consisted of about one thousand parts each, but the two rivals had used different methods to put them together. Mekhos had assembled his watches bit by bit—rather like making a mosaic floor out of small coloured stones. Thus each time when he was disturbed in his work and had to put down a partly assembled watch, it fell to pieces and he had to start again from scratch.
>
> Bios, on the other hand, had designed a method of making watches by constructing, for a start, sub-assemblies of about ten components, each of which held together as an independent unit. Ten of these sub-assemblies could then be fitted together into a sub-system of a higher order; and ten of these sub-systems constituted the whole watch. . . .
>
> Now it is easy to show mathematically that if a watch consists of a thousand bits, and if some disturbance occurs at an average of once in every hundred assembling operations—then Mekhos will take four thousand times longer to assemble a watch than Bios. Instead of a single day, it will take him eleven years. And if for mechanical bits, we substitute amino acids, protein molecules, organelles, and so on, the ratio between time-scales becomes astronomical; some calculations indicate that the whole life-time of the earth would be insufficient for producing even an amoeba—unless he [Mekhos] becomes converted to Bios' method and proceeds hierarchically, from simple sub-assemblies to more complex ones.[18]

A system, then, is a series of levels of increasing complexity. The larger system of which a system is a part is called the *suprasystem*, and the smaller system contained within a system is called the *subsystem*. Figure 3.1 illustrates the idea of system hierarchy with a tree model.

Families illustrate hierarchy very well. The suprasystem is the extended family, which itself is part of the larger system of society. Several nuclear family units are part of the extended family, and each family unit may have subsystems such as spouses, children, and parent–child units.

Koestler calls system hierarchy the *Janus effect:*

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16 See, for example, Peter R. Monge and Joseph N. Cappella, *Multivariate Techniques in Human Communication Research* (New York: Academic, 1980).

17 For excellent discussions of hierarchy, see Arthur Koestler, *The Ghost in the Machine* (New York: Macmillan, 1967); W. Ross Ashby, "Principles of the Self-Organizing System," in *Principles of Self-Organization*, eds. H. von Foerster and G. Zopf (New York: Pergamon, 1962), pp. 255–278.

18 Koestler, *Ghost*, pp. 45–47.

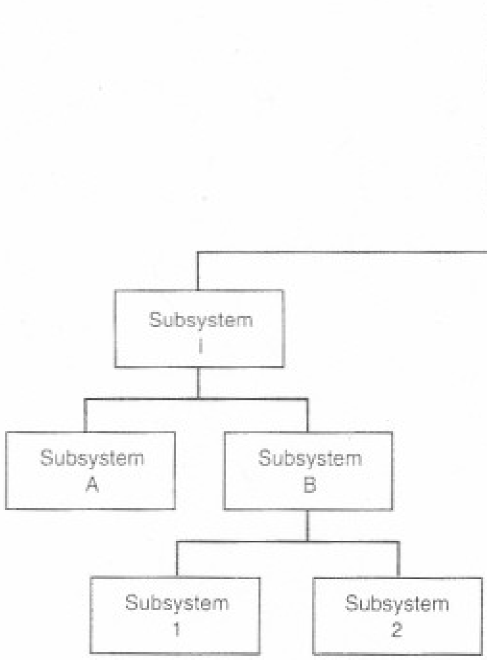

FIGURE **3.1**

System Hierarchy

> The members of a hierarchy, like the Roman god Janus, all have two faces looking in opposite directions: the face turned toward the subordinate levels is that of a self-contained whole; the face turned upward toward the apex, that of a dependent part. One is the face of the master, the other the face of the servant.[19]

The natural question at this point is where a system ends and its environment begins. Because systems are part of other systems, boundaries are arbitrary and can only be established by the observer. We can take a very broad view by observing a number of systems that interact with one another in a large suprasystem, or we can take a narrower view by observing a smaller subsystem where the larger system is the environment. For example, you could look at a large extended family (a suprasystem) or two siblings in a nuclear family (a subsystem).

Self-Regulation and Control. Many systems are goal-oriented, and such systems regulate their behavior to achieve certain aims. The parts of a system must behave in certain ways and must respond to feedback. Families illustrate this. A family can have a variety of control mechanisms. For example, it may rely on one dominant member for making decisions and providing guidance. This person monitors the family and asserts control as necessary whenever signs (feedback) of deviation from family standards are detected. Other families may handle control very differently, as is the case for those families with strict role divisions that permit members to exert control over certain kinds of decisions and not others. We'll take a closer look at this aspect of systems in the section on cybernetics.

Interchange with the Environment. Remember that open systems interact with their environment. They take in and let out matter and energy,

19 Koestler, *Ghost*, p. 48.

having *inputs* and *outputs*.[20] For example, parents must adjust constantly to their children's relationships outside the family and deal with influences from friends, teachers, and television.

Balance. Balance, sometimes referred to as *homeostasis*, is self-maintenance.[21] The system must somehow detect when it is off kilter and make adjustments to get back on track. Deviation and change do occur and can be tolerated by a system, but only for so long. Eventually, the system will fall apart if it does not maintain itself.

The need for balance explains why families seem to struggle so hard to keep things on an even keel. For example, why do parents keep nagging children to behave? Why do couples who are having serious marital difficulties frequently try to get back together? From a system perspective, these efforts are natural attempts to maintain homeostasis. Indeed, many families have trouble maintaining balance in a complex social environment and do not survive. Often uncomfortable patterns such as anger and blame become part of the family system itself, and these patterns get repeated over and over in the system's attempt to maintain itself. You can see from this example that balance is not necessarily a comfortable state of affairs.

Change and Adaptability. Because it exists in a dynamic environment, a system must be adaptable.[22] Paradoxically, to survive a system must have balance, but it must also change. Complex systems sometimes have to change structurally to adapt to the environment, and that kind of change means getting off balance for a time. Advanced systems actually reorganize themselves to adjust to environmental pressures. The technical term for system change is *morphogenesis*.

To continue our example, families do change. As members age and develop, as new members come and old members leave, and as the family faces new challenges from the environment, it must adapt.

Equifinality. Finality is the goal achievement or task accomplishment of a system. *Equifinality* means that a particular final state may be accomplished in different ways and from different starting points. The adaptable system can achieve that goal under a variety of environmental conditions. The system is capable of processing inputs in different ways to produce its output.[23] If one pathway fails, another one can take its place. If one process gets cut off, another process steps in. Smart parents, for example, know that children's behavior can be affected by a variety of techniques, that family decision making can occur in more than one way, and that children learn several methods for securing the compliance of the adults in their world.

We have seen in this section that systems are dynamic wholes in which parts relate to one another in complex patterns of interaction. Something happens in a system to make it more than the sum of its parts. What is the currency of system interactions? What is the medium by which system influences occur? We turn now to a kindred field that attempts to answer these questions—information theory.

Information Theory

Information theory, which grew out of the boom in the telecommunications industry after World War II, is the area of study most concerned with communication in systems. *Information theory* involves the quantitative study of signals. It has practical applications in the electronic sciences that design transmitters, receivers, and codes to facilitate efficient handling of information. It has also been used widely in the behavioral and social sciences.[24]

Information theory developed from investigations in physics, engineering, and mathematics, which were concerned with the organization of

20 Gordon Allport, "The Open System in Personality Theory," in *Modern Systems Research for the Behavioral Scientist*, ed. W. Buckley (Chicago: Aldine, 1968), pp. 343–350; Hall and Fagen, "Definition."

21 Ashby, "Principles."

22 Hall and Fagen, "Definition"; Buckley, "Adaptive System"; Koestler, *Ghost*.

23 Von Bertalanffy, *General Systems Theory*, chap. 3.

24 Several brief histories of the movement are available. See, for example, Rogers, *A History*, pp. 411–444.

events. Claude Shannon, a telecommunications engineer at Bell Telephone Laboratories, synthesized the early work in information theory. His book with Warren Weaver, *The Mathematical Theory of Communication,* is now a classic.[25]

Basic Concepts

Information can be understood by starting with entropy, a related concept borrowed from thermodynamics. *Entropy* is randomness, or lack of organization in a situation. A totally entropic situation is unpredictable. Because most of the situations we are confronted with are partially and not completely predictable, entropy is a variable. If dark clouds come over the sky, you could predict rain, and you might be right or wrong. Because weather is an organized system, predictions are never certain. You cannot predict rain conclusively. The entropy existing in the situation causes some uncertainty. In short, the more entropy, the less organization and predictability.

What does this have to do with information? *Information* is a measure of the uncertainty, or entropy, in a situation. The greater the uncertainty, the more the information. When a situation is completely predictable, no information is present. This is a condition known as *negentropy.*

This definition of information is confusing because most people associate information with certainty or knowledge. As used by the information theorist, however, the concept does not refer to meaning but only refers to the quantification of stimuli or signals.

On closer examination, this idea of information is not as nonsensical as it first appears, if you consider information as the number of signals required to reduce completely the uncertainty in the situation. For example, your friend is about to flip a coin. Will it land heads up or tails up? You are uncertain; you cannot predict. This uncertainty will be eliminated by seeing the result of the flip. Now suppose that you have received a tip that your friend's coin is two-headed. The flip is fixed, resulting in no uncertainty and no information. In other words, you could not receive any more signals that would help you predict any better than you already can. In short, a situation with which you are completely familiar has no new information for you.

There is yet a third way to understand this concept. Information can be thought of as the number of choices, or alternatives, available to a person in predicting an outcome. In a complex situation with many possible outcomes, more information is available than in a simple situation with few outcomes. In other words, a person would need more facts to predict the outcome of a complex situation than to predict the outcome of a simple one. For example, there is more information in a two-dice toss than in the toss of a single die and more information in a single-die toss than in a coin flip. Because information is a function of the number of alternatives, it reflects the degree of freedom in making choices within a situation. The more information in a situation, the more choices you can make within that situation.

Language and Information

Many messages consist of a series of stimuli received sequentially, or one at a time. In written language, for example, one letter follows another, and words flow one at a time. Information theory can be applied to this kind of situation. If the letters in a sentence were arranged randomly, you could never predict what letter might follow any other letter. Decoding would be difficult because of the great amount of information in the message. But letters (or sounds in speech) are not organized randomly. There are various predictable patterns. These patterns make decoding easier because there is less information, or greater predictability. For example, in English an adjective has a high probability of being followed by a noun. A *q* is always followed by a *u*

25 Claude Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana: University of Illinois Press, 1949). Two sources were particularly helpful in the preparation of this section: Allan R. Broadhurst and Donald K. Darnell, "An Introduction to Cybernetics and Information Theory," *Quarterly Journal of Speech* 51 (1965): 442–453; Klaus Krippendorff, "Information Theory," in *Communication and Behavior,* eds. G. Hanneman and W. McEwen (Reading, MA: Addison-Wesley, 1975), pp. 351–389.

in English. Thus, the overall arrangement of a sentence is patterned and partially predictable. This is called *redundancy*.

On the other hand, a sentence does contain some uncertainty because you can never predict with complete accuracy. If you could, there would be no freedom of choice. Once the first letter was written, all the other letters would follow automatically. Language is blessed with moderate redundancy, allowing ease of decoding with freedom of encoding.

Language information is an example of a *Markov process*, in which certain things follow other things in a chain. A Markov process is a series of events, one happening after another in time, such that the occurrence of one element in the chain establishes a probability that another particular element will follow. Language is an example of a Markov process. Many other phenomena follow the same pattern, for example, a workday consists of a series of somewhat predictable tasks and driving from one city to another requires following a sequence of turns.

Markov processes like language must be discussed in terms of *average* redundancy because the actual amount varies from point to point in the chain. For example, the average redundancy in English is about 50 percent.

Information Transmission

Information theory is not concerned with the meaning of messages, only with their transmission and reception. This is particularly important in electronic communication, where signals are transmitted along a line or through a medium.

The basic model of transmission developed by Shannon and Weaver is shown in Figure 3.2.[26] In this model the *source* formulates or selects a *message*, consisting of signs to be transmitted. The *transmitter* converts the message into a set of *signals* that are sent over a *channel* to a *receiver*. The receiver converts the signals into a message. This model can be applied to a variety of situations. A television message is a good example in the electronic arena: The producers, directors, and announcers are the source; the message is transmitted by airwaves (channel) to the TV set, which converts electromagnetic waves back into a visual impression for the viewer.

In interpersonal communication the speaker's brain is the source, the vocal system the transmitter, and the air medium the channel. The listener's ear is the receiver, and the listener's brain the destination. The final element in this model, *noise*, is any disturbance in the channel that distorts or otherwise masks the signal.

Whether the message is coded into regular language, electronic signals, or some other verbal or nonverbal code, the problem of transmission is the same: to reconstruct the message accurately at the destination, as any television viewer with a snowy screen can testify.

Now you can begin to see the role of redundancy in a message. Redundancy compensates for noise. As noise distorts, masks, or replaces signals, redundancy allows the receiver to correct or fill in missing or distorted data. For example, suppose you receive from a friend a letter that has been smeared by rain. The first sentences might look like this: "How - - - yo-? I a-fine." Or perhaps because of static, a sentence of radio news comes across as, "The Pres- - - -ed States has - clared. . . ." You can make some sense out of these distorted sentences because of the predictability or redundancy in the language.

Another factor limiting accurate transmission is channel capacity. *Channel capacity* is usually defined in terms of the maximum amount of information that can be transmitted over a channel in a given time period (per millisecond, perhaps). The actual amount of information in the channel is *throughput*. If throughput exceeds channel capacity, distortion will occur or transmission will slow down, as when you set your amplifier too high, beyond the capacity of the speakers.

If you do much Web surfing, you know firsthand the limitations of channel capacity. You may be frustrated downloading a file with a 28.8 modem because you have a channel capacity problem. One answer is to increase the size of the channel by going to a 33.3 or higher modem. On

26 Shannon and Weaver, *Mathematical Theory*, p. 5.

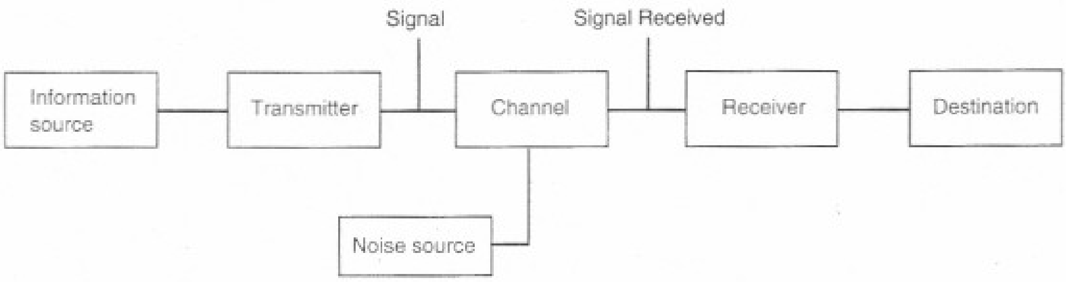

FIGURE 3.2

Shannon and Weaver's Model of Communication

From *Mathematical Theory of Communication* by Claude Shannon and Warren Weaver. Copyright © 1949 by the Board of Trustees of the University of Illinois. Reprinted by permission of the University of Illinois Press.

Sunday mornings, you can zoom from one site on the Web to another pretty quickly, but by Sunday evening, the Internet is like mud—thick and slow. What's the difference? Not channel capacity, but throughput demand. Hardly anyone is on the Web on Sunday morning, but by evening, everyone wants to get on.

What, then, is necessary for efficient transmission? Efficient transmission involves coding at a maximum rate that will not exceed channel capacity. It also means using a code with sufficient redundancy to compensate for the amount of noise present in the channel. Too much redundancy means transmission will be inefficient; too little means it will be inaccurate.

Cybernetics

Cybernetics is the study of regulation and control in systems.[27] An important feature of open systems, as we saw earlier, is that they are regulated, seek goals, and are purposeful. This is the subject of cybernetics.

Feedback Processes

Cybernetics deals with the ways a system gauges its effect and makes necessary adjustments. The simplest cybernetic device consists of a sensor, a comparator, and an activator. The *sensor* provides *feedback* to the *comparator*, which determines whether the machine is deviating from its established norm. The comparator then provides guidance to the *activator*, which produces an output that affects the environment in some way. This fundamental process of output-feedback-adjustment is the basis of cybernetics.

Feedback mechanisms vary in complexity, as Figure 3.3 illustrates.[28] The most basic distinction is between active and passive behavior. *Active behavior* comes from the system itself, whereas *passive behavior* results strictly from outside stimulation. Scratching an itch is passive behavior, but waving to a friend is active. Active behavior can be further divided into purposeless, or random, and purposeful behavior. *Purposeful behavior* is

27 Rollo Handy and Paul Kurtz, "A Current Appraisal of the Behavioral Sciences: Communication Theory," *American Behavioral Scientist* 7 (6, 1964): 99–104. Supplementary information is found in Gordon Pask, *An Approach to Cybernetics* (New York: Harper & Row, 1961); G. T. Guilbaud, *What Is Cybernetics?* (New York: Grove, 1959). For a historical review, see Norbert Wiener, *Cybernetics or Control and Communication in the Animal and the Machine* (Cambridge, MA: MIT Press, 1961), pp. 1–29. See also Rogers, *A History*, pp. 386–410. For a cybernetic approach to communication, see D. J. Crowley, *Understanding Communication: The Signifying Web* (New York: Gordon and Breach, 1982), especially chap. 1.

28 Arturo Rosenblueth, Norbert Wiener, and Julian Bigelow, "Behavior, Purpose, and Teleology," *Philosophy of Science* 10 (1943): 18–24 [reprinted in *Modern Systems Research for the Behavioral Scientist*, ed. W. Buckley (Chicago: Aldine, 1968), pp. 221–225].

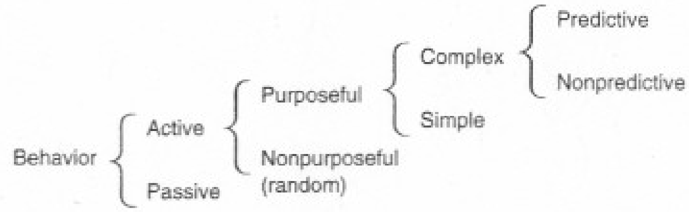

FIGURE 3.3

Model of Cybernetic Complexity

From *Philosophy of Science*, "Behavior, Purpose, and Teleology," by Arturo Rosenblueth, Norbert Weiner, and Julian Bigelow. Copyright © 1943 by the Williams & Wilkins Co. Reprinted by permission of the publisher.

directed toward an objective or aim, whereas *random behavior* is not. Rubbing one's face or moving a hand may be just a random action, but when done to express an idea or emphasize a point, the action is clearly purposeful.

All purposeful behavior requires feedback, which varies in complexity, as indicated in the model, and purposeful behavior may be further subdivided into complex and simple types.[29] In *simple systems* the organism responds to feedback only by turning on or off. A thermostat is a perfect example of a simple feedback mechanism. *Complex systems,* however, use positive and negative feedback to adjust and adapt during the action itself. Complex systems may be predictive or nonpredictive. *Predictive behavior* is based on anticipated position or response rather than actual position or response. A good quarterback passes the football to the spot where the receiver will be, not to where the receiver is at the moment. Often, the quarterback even releases the ball before the receiver turns to look for it.

A simple feedback model is represented in Figure 3.4. In the figure, B is an energy source directing outputs to C. A is the control mechanism responding to feedback from C. Depending on the complexity of the system and the nature of the output, the control mechanism itself is restricted in the kind of control it can exert. Figure 3.5 illustrates some possible situations.[30]

The first model in Figure 3.5 demonstrates a situation where the signal itself is modified, in this case amplified, by A. A high-pitched squeal from a loudspeaker is an example. The next model illustrates a simple switch such as a thermostat or circuit breaker. The third model illustrates selection control in which A chooses a channel or position on the basis of criteria. In a guided missile, for example, the guidance system may specify turning in one direction or another, based on feedback from the target.

A regulated system must possess certain control guidelines. The control center must "know" what environmental conditions to respond to and how. It must possess a sensitivity to aspects of the environment that are critical to its goal seeking.[31]

Feedback can be classified as positive or negative, depending on the way the system responds to it. *Negative feedback* is an error message indicating deviation, and the system adjusts by reducing or counteracting the deviation. The most important type of feedback in homeostasis is negative feedback because it maintains a steady state.

29 I have changed the original nomenclature here to avoid confusion and inconsistency with previous usage in this chapter. The authors' intent is unchanged.

30 Adapted from Guilbaud, *Cybernetics.*

31 Walter Buckley, *Sociology and Modern Systems Theory* (Englewood Cliffs, NJ: Prentice-Hall, 1967), pp. 52–53.

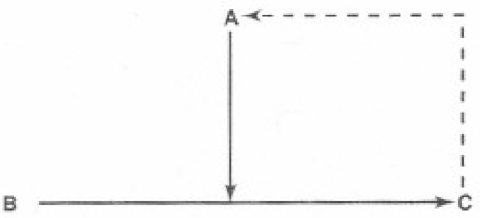

FIGURE 3.4

A Simple Feedback Model

A system can also respond by amplifying or maintaining deviation, in which case the feedback is *positive*. This kind of interaction is important in morphogenesis, or system growth such as learning. The inflationary cycle in economics is an example of positive feedback effects. Whether in mechanical or human systems, the response to negative feedback is "cut back, slow down, discontinue." Response to positive feedback is "increase, maintain, keep going."

Figure 3.6 illustrates three system states. The first is a steady state, the second a growth state, and the third a change state. A *steady state* involves the use of negative feedback to keep the system on track. Negative feedback signals deviate from the standard, and the system adjusts in order to return to the line. Notice that the system is always moving; it is constantly changing, but it never gets too far from the desired state because of negative feedback. For example, a manager may want to maintain a supportive relationship with all her subordinates. She continually tries to be supportive, and when employees are feeling unsupported, she detects the dissatisfaction and tries harder to make them feel included. This manager may waver from time to time but, because of negative feedback, maintains support most of the time.

The second state is *growth*. Here as the system deviates, positive feedback maintains the deviation, and the result is farther and farther movement from the original state. The system accelerates some behavior, and if this continues indefinitely, the system will disintegrate.

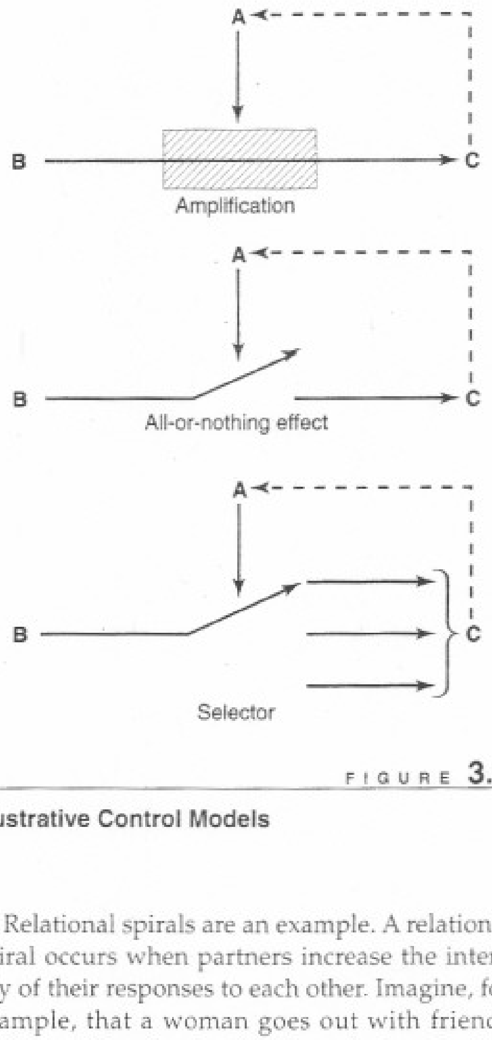

FIGURE 3.5

Illustrative Control Models

Relational spirals are an example. A relational spiral occurs when partners increase the intensity of their responses to each other. Imagine, for example, that a woman goes out with friends without telling her boyfriend, and when he discovers this, he gets irritated. She thinks that his irritation is unjustified and decides to go out with her friends again. Now he gets even more upset, and she goes out again just to make the point that she has the right to do so. In time, she is going out very frequently with her friends, and he is exploding in anger and jealousy. Here, each partner's actions are taken as positive feedback, creating even more deviation from the original state. If the spiral does not stop, the relationship will not survive. Notice that "positive" feedback does not mean "good" feedback; indeed, it may be very bad. And negative feedback

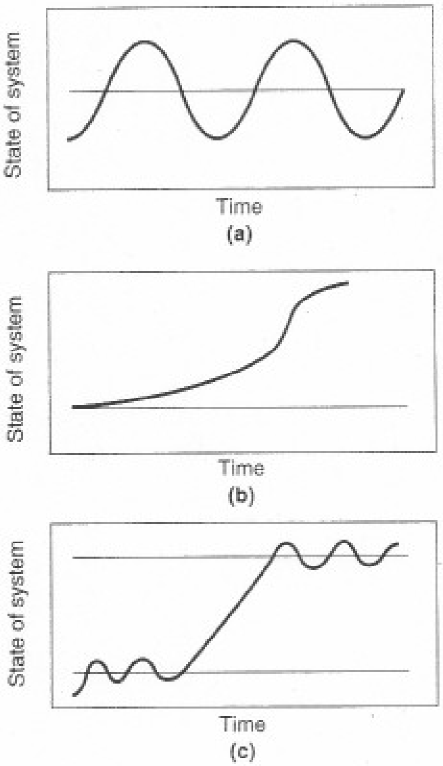

FIGURE **3.6**

Three Feedback States: (a) Steady State, (b) Growth State, and (c) Change State

is not necessarily bad, because it is needed by the system to maintain balance.

The third state is *change*. Here, the system moves from one state to another state. It requires both negative and positive feedback. Positive feedback gets the system moving in a new direction, but negative feedback comes into play at some level to return the system to balance. The ability of systems to maintain balance and yet continue to adapt and renew themselves is a remarkable feature of both natural and human systems.[32]

Let's return to our example of the supportive manager. As sometimes happens, too much support causes the suppression of productive conflict and the stifling of needed change. Assume that our manager begins to get feedback saying that her department is not productive enough. She responds by criticizing her employees' work habits and in the process becomes less supportive. At some point the workers' productivity increases, and she reduces her criticism. At this point the system has moved to a new state of somewhat less supportiveness and a bit more scrutiny.

Complex Networks

Our discussion of feedback thus far has given the impression that a system responds as a unit to feedback from the outside. This impression is realistic only for the simplest systems such as a heater and thermostat. As a series of hierarchically ordered subsystems, advanced systems are more complex. A subsystem at any moment may be part of the larger system or part of the environment.[33] Further, we know that subsystems respond to one another. As a result we must expand the concept of feedback in complex systems. In a complex system, a series of feedback loops exist within and among subsystems, forming *networks*. At some points the feedback loops are positive, at other points negative. But always, consistent with the basic feedback principle, system output returns as feedback input. No matter how complicated the network, one always comes back to the beginning.

A simple illustration of a system network is the example of urbanization in Figure 3.7.[34] In this figure the pluses (+) represent positive relationships and the minuses (–) negative ones. In a positive relationship, variables increase or decrease together. In a negative relationship, as one increases, the other decreases. For example, as the number of people in the city (P) increases, modernization also increases. With increased

32 For an excellent discussion of the paradox of stability and change in systems, see Margaret Wheatley, "Change, Stability, and Renewal: The Paradoxes of Self-Organizing Systems," in *Leadership and the New Science: Learning About Organization from an Orderly Universe* (San Francisco: Berrett-Kochler, 1992), pp. 75–99.

33 Magoroh Maruyama, "The Second Cybernetics: Deviation-Amplifying Mutual Causal Processes," *American Scientist* 51 (1963): 164–179. See also, Caley and Sawada, *Mindscapes*, pp. 99–109.

34 Maruyama, "The Second Cybernetics," p. 311.

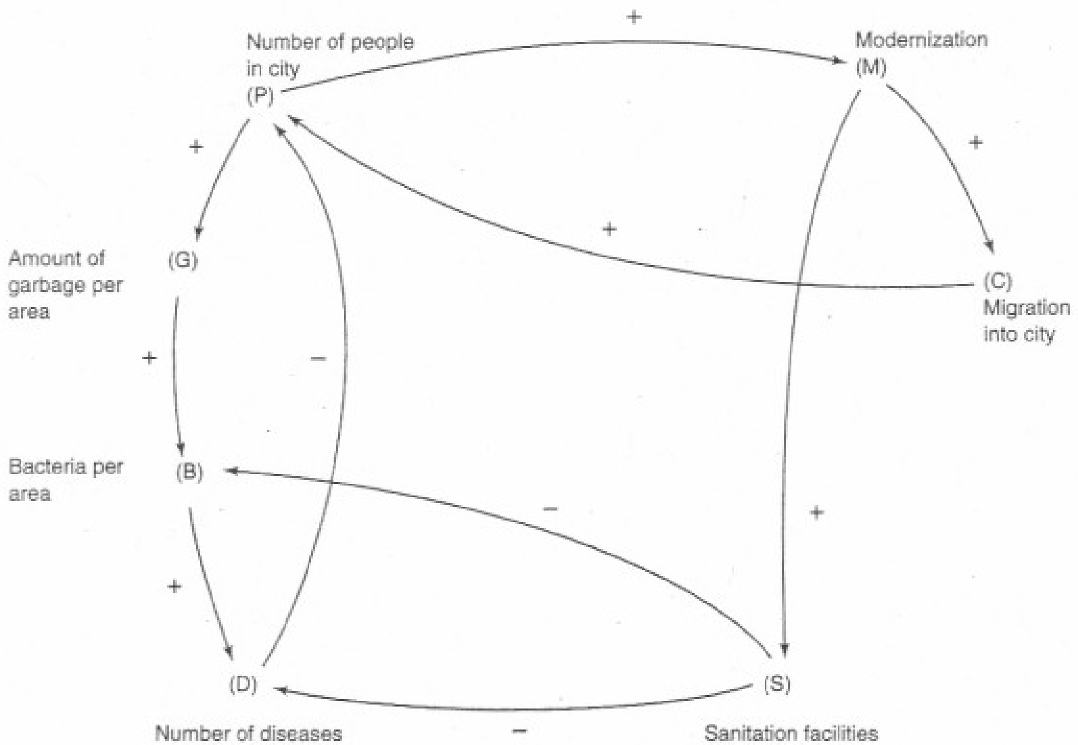

FIGURE 3.7

A Simplified Feedback Network

From *American Scientist*, "The Second Cybernetics," by Magoroh Maruyama. Copyright © 1963. Reprinted by permission of the publisher.

modernization comes increased migration, which in turn further increases the population. This relationship is an example of a positive feedback loop. A negative relationship is illustrated by the effect of the number of diseases (D) on population (P).

As our discussion to this point implies, cybernetics is a central process in systems, for it explains such qualities as wholeness (a portion of a system cannot be understood apart from its loops among subsystems), interdependence (subsystems are constrained by mutual feedback), self-regulation (a system maintains balance and changes by responding appropriately to positive and negative feedback), and interchange with the environment (inputs and outputs create feedback loops).

Although these cybernetic concepts originated in the fields of physiology, engineering, and mathematics, they have tremendous implications in the behavioral and social sciences.[35] As Norbert Wiener, the founder of cybernetics, states, "This principle in control applies not merely to the Panama locks, but to states, armies, and individual human beings. . . . This matter of social feedback is of very great sociological and anthropological interest."[36]

Indeed, cybernetics is a way of thinking. Emphasizing circular reasoning, cybernetics chal-

35 See Karl Deutsch, "Toward a Cybernetic Model of Man and Society," in *Modern Systems Research for the Behavioral Scientist*, ed. W. Buckley (Chicago: Aldine, 1968), pp. 387–400.

36 Norbert Wiener, *The Human Use of Human Beings: Cybernetics in Society* (Boston: Houghton Mifflin, 1954), pp. 49–50.

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lenges the very idea that one thing causes another in a linear fashion. It calls our attention to the ways in which things impact one another in a circular way.[37] What goes around comes around. In its more recent forms, cybernetics claims that observers can never see how a system works by standing outside the system itself because the observer is always on some level engaged cybernetically with the system being observed. Let's see how this is so.

Second-Order Cybernetics

Whenever you observe a system, you affect and are affected by the system.[38] The term *second-order cybernetics* was coined by Heinz von Foerster to capture this idea. Second-order cybernetics is sometimes called the "cybernetics of the observing system," because it shows how observation itself is a cybernetic mechanism with feedback loops between the observer and observed.

It is also called the "cybernetics of knowing" because it shows that knowledge is a product of feedback loops between the knower and the known.[39] What we observe in a system is determined in part by the categories and methods of observation, which in turn are affected by what is seen. This circle is a cybernetic system, and observers cannot escape it.

The ideas of second-order cybernetics have been developed by a closely knit group of thinkers, including von Foerster himself, Gregory Bateson, Humberto Maturana, and Francisco Varela.[40]

Second-order cybernetics is revolutionary in system theory because it says that objective observation and knowledge are not possible. Traditional system theory and cybernetics treat systems as objectively observable, but in second-order cybernetics, the observed system both affects and is affected by the observer. This idea has powerful implications not only for system theory but for the philosophy of knowing as well (see Chapter 2). Von Foerster puts the matter in these terms:

> One may see this fundamental epistemological change if one considers oneself first to be an independent observer who watches the world go by; or if one considers oneself to be a participant actor in the drama of mutual interaction, of the give and take in the circularity of human relations.[41]

This theory seems strange at first because we human beings feel separate from what we observe. This impression is a result of *autopoiesis*, or the tendency of a living system to distinguish itself from other systems and to act in ways that maintain a sense of autonomy or separateness.[42] Yet the structural relationships within a system limit the distinctions that the system can make. In other words, what we see in another system is very much determined by our own makeup and history, including past interactions with other people.

At the same time, when we observe another system, we are affected by the structure and history of that system. In second-order cybernetics, this is called *structural coupling*. Here two systems can have mutual effects. They coordinate their actions, and they can evolve together. This is true in the natural world as well as in human relations.

The cybernetics of observation becomes quite interesting when the observed system is the observer's own environment. People make this kind of observation all the time. For example, if

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37 See, for example, Klaus Krippendorff, "Cybernetics," in *International Encyclopedia of Communications*, eds. Erik Barnouw et al. (New York: Oxford University Press, 1989), vol. 1, pp. 443–446; Søren Brier, "Forward," *Cybernetics and Human Knowing: A Journal of Second Order Cybernetics and Cyber-Semantics* 1 (1992). (http://www.db.dk/dbaa/sbr/vol1/v1-1for.htm).

38 Heinz von Foerster, *Observing Systems: Selected Papers of Heinz von Foerster* (Seaside, CA: Intersystems Publications, 1981). For information about von Foerster, his ideas, and his life, see Francisco Varela, "Heinz von Foerster, the Scientist, the Man: Prologue to the Interview," *SEHR* 4(2). (http://shr.stanford.edu/shreview/4-2/text/varela.html); Stefano Franchi, Güven Güzeldere, and Eric Minch, "Interview: Heinz von Foerster," *SEHR* 4(2). (http://shr.stanford.edu/shreview/4-2/text/interviewconf.html).

39 Rodney E. Donaldson, "Cybernetics and Human Knowing: One Possible Prolegomenon," *Cybernetics and Human Knowing* 1 (1992): 1–4; Brier, "Forward."

40 Chief among their works are Gregory Bateson, *Steps to an Ecology of Mind* (New York: Ballantine, 1972); Humberto Maturana and Francisco Varela, *The Tree of Knowledge: The Biological Roots of Human Understanding* (Boston: Shambhala, 1992).

41 Heinz von Foerster, "Ethics and Second-Order Cybernetics," *SEHR* 4(2): 4. (http://shr.stanford.edu/shreview/4-2/text/foerster.html).

42 Randall Whitaker, "Overview of Autopoietic Theory." (http://www.acm.org/signois/auto/ATReview.html#Background).

you try to explain how brains work, you must account for how your own brain is working right now as you explain how brains work. Your observation of the system must include an observation of the observation itself! Another example is observing a group of which you are a member. You cannot do this completely if you do not take into account your own behavior (including your observing) as a member of the group.

Family system therapy has made good use of second-order cybernetics and illustrates how it works.[43] Old-style system theorists would say that the therapist can work as an outsider by observing, diagnosing, and prescribing, but second-order cybernetics denies this. When the therapist meets a family, the therapist (herself a system) observes and interacts with the family (another system). The therapist and the family constitute a cybernetic system of feedback loops, in which each affects the other in a new system.

Therefore, the therapist must realize that the therapeutic relationship itself is a system, and the therapist should look at this bigger system too. In other words, the therapist is part of the system being observed. Therapy is a series of *interactions* and is viewed in this tradition as an organic, step-by-step process that can shift from one direction to another. Although the therapist and family hope that the result will be healthier, happier relationships, the precise outcome cannot be predicted or prescribed in advance. The idea is to affect the patterns of interaction in the system in such a way that the family itself comes to discover new ways of changing its system in a positive way.

Human beings always have choices in how they act within a larger cybernetic system. As a part of many systems that have interacted with many other systems, people have a tremendous repertoire of ways to respond to feedback. A fundamental principle of autopoiesis is that the system can act in many ways to maintain its identity as a system.

This means that when you observe another system, you can frame your observations in a variety of ways, and when you respond to what you see, you can act in a variety of creative ways. As an observer, then, you can assume some personal responsibility for how the framework with which you observe may affect the system, how your responses may change the system, and how your observations of the system may change you.

Ecologists use this kind of reasoning. They understand that a redwood forest, say, can be understood in a variety of ways and that how we understand the forest will affect how we act toward it, which in turn will change us and the natural and social environments in which we live.

Because observers never work in isolation and are part of many systems, the second-order cybernetic process can be quite complex. How we observe a given system, what we see when we observe, and the ways in which we engage a system are produced by a history of interaction with many groups of people over a lifetime. Observation and engagement of any system then is a *social* process. Second-order cybernetics, therefore, is related to theories of *social constructionism* (Chapter 9), with both placing interaction and communication at the center of knowing.[44]

Dynamic Social Impact Theory: A System Theory of Communication

System theory has had a major influence on the study of human communication. Although it would be impossible to mention all the lines of work that reflect system influences, several of these appear in the following chapters. In this section, we will look at a very general theory that illustrates clearly how system theory can be applied to communication.

43 For a good discussion of applications of system theory in family therapy, see Janet Yerby, "Family Systems Theory Reconsidered: Integrating Social Construction Theory and Dialectical Process," *Communication Theory* 5 (1995): 339–365.

44 Yerby, "Family System Theory."

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Dynamic social impact theory (DSIT) has been developed by Bibb Latané and his colleagues.[45] The theory imagines society as a giant communication system consisting of numerous cultural subsystems, which include individuals interacting with one another. Because the most basic elements of the system are individuals, let's begin there.

DSIT adopts the widely held axiom that individuals are different in many ways. They have different ideas, beliefs, attitudes, and behaviors. But individuals also share many characteristics with others, and they tend to group together into clusters of like-minded people. Indeed, cultures are large groupings of individuals who share common ideologies and practices. DSIT attempts to explain, in system terms, how these commonalities develop and how cultures form.

Individuals are not isolated. They interact with one another in social spaces. *Social spaces* are the "areas" in which people meet, communicate, and influence one another. Latané has found that social space is largely a physical space, constrained by actual physical distance among individuals. Other things being equal, on average you will be more influenced by people close to you than by individuals far away. Physical distance, however, is not the only aspect of social space. For many reasons, we do not interact equally with everyone in proximity. Various social arrangements, such as race and class, keep people from interacting even though they may live and work quite close to one another.

Another factor influencing social space are various media of communication that enable people to communicate at a distance, including telephone, e-mail, and mass media. Imagine all of the people you are most likely to communicate with. Most of them live and work close to you, but some may be at a distance. You all occupy a common social space and are likely to influence one another in various ways.

To help understand how dynamic social impact works, imagine your university as a social world. Let's say you are a graduate student in the communication department. With whom are you most likely to communicate? Probably with other members of the communication department and especially those with whom you have regular contact. You are less likely to communicate with medical students or staff members in the grounds maintenance department. You could therefore predict that you will share more attributes with other members of the communication department than with people from other, more distant groups.

In time, as you interact more and more with communication department members, you will begin to influence one another and think alike in certain ways. You will share knowledge, and attitudes will begin to converge. After a while, you might even begin to identify a communication department culture, a way of thinking and doing things common to the department. Even within the department, there will be certain subgroups. For example, a small group of graduate students may get together socially, maybe even going out for drinks every Friday afternoon.

This group clustering phenomenon is caused by mutual influence among individuals who share a common social space. The shared characteristics of a group change dynamically with new contacts and interactions.

Clearly, this grouping phenomenon is not random. Influence among individuals varies along three dimensions. The first is the *strength* of influence of various individuals in the social space. The second is *immediacy,* or closeness between people, or openness of channels between persons. The third is the *number* of people in the social space. If you have many people, a large number of whom are influential, drawn together to communicate, the grouping tendency will be very high. If there are fewer people, few influential people, and little opportunity to talk, grouping will be less likely.

One thing is clear: Individuals in contact with one another will not remain random,

45 Bibb Latané, "Dynamic Social Impact: Robust Predictions from Simple Theory," in *Modelling and Simulation in the Social Sciences from the Philosophy of Science Point of View,* eds. R. Hegselmann, U. Mueller, and K. G. Troitzsch (Dordrecht, Netherlands: Kluwer Theory and Decision Library, 1996), pp. 287–310; see the symposium on DSIT, Edward L. Fink, "Dynamic Social Impact Theory and the Study of Human Communication," *Journal of Communication* 46 (1996): 4–77.

unconnected nodes but will organize themselves cybernetically into a dynamic structure of groups with common characteristics. You can see how the organization of the system perpetuates itself: Groups form by proximity in the social space, but those groups in turn give additional structure to the social space, which in a circular way affects the possible patterns of influence within the space itself.

This self-organizing tendency explains the formation of minority groups. Over time the influence of the majority is considerable because of sheer numbers, leading to a preponderance of beliefs being shared by most of the people within the social space. Yet, ironically, continued communication within a minority group bolsters its shared beliefs and practices, shielding it from the majority view. This is a cybernetic mechanism that ensures diversity within the larger system.

Imagine that upon entering the graduate program, you find that the students and faculty differ in their attitudes toward qualitative and quantitative research methods. At first there is no real grouping of individuals into two camps, but over time groups begin to develop. Because of the strong influence of certain members of the department and relatively close relations among some, a majority view favoring quantitative research develops. More and more students come to affiliate with the quantitative group. At the same time, however, a minority qualitative group emerges and reinforces its own view by continual communication among themselves.

An interesting thing happens when groupings like this occur. Once a group is formed, its interaction brings about additional influence and even more convergence on issues that are not logically related to the topics that brought the group together in the first place. For example, suppose that certain members of the quantitative group smoke, and because of their frequent interaction with one another, others start to smoke too. Perhaps the unique interaction patterns in the qualitative group do not lead to this outcome. You would observe, then, that the quantitative group tend to be smokers, whereas the qualitative group are not. Quantitative methods and smoking become correlated, even though there is no logical connection between these, and such correlations give further structure to the system.

If the individuals within a social space had equal contact with one another, you would expect that divergent views would slowly converge to the center, making everyone in the social space the same and not extreme in any way. Eventually, you might predict, everyone in the department would come to favor quantitative methods. We know, of course, that this is rarely the case, for the system tends to maintain diversity. This is because interaction is never entirely random, and influence is never entirely linear. Nonlinearity in the system is therefore very important for maintaining system change and diversity. Let's see how.

Especially on important issues, people do not just keep changing incrementally over time. They cling to their ideas and practices for quite a while until a "tipping point" is reached and a shift occurs—the straw that broke the camel's back. Once the pressure to change outweighs the pressure to stay the same, a major shift may occur.

The more important the issue and the more involved the individual is with the issue, the less linear change seems to be. In fact, in the face of increasing social pressure, you can actually become more extreme in the views you hold. From our example above, the quantitative and qualitative groups may become quite polarized, creating even more diversity than before.

You can see positive and negative feedback loops at work here. Negative feedback loops tend to cancel out diversity and lead to convergence, whereas positive feedback loops tend to create diversity and lead to divergence. Imagine society as a huge system of interacting individuals in which many such loops continually bring about both social order and diversity.

Commentary and Critique

System theory has been a popular and influential tradition in communication. Because it is a complex set of variables that relate to one another, communication seems to be a natural topic for the application of system principles. System theory can be useful for understanding communication in general as well as instances of communication occurring in everyday life.

System theory also shows us concretely how functionalism works (Chapter 1). Functional approaches to theory examine the links, influences, and associations among the parts of a system, and many of the ideas presented in this chapter demonstrate how this is done.

In the abstract, fundamental system principles may seem esoteric, but when you see them in actual operation, they make sense. The most important system principle is wholeness and interdependence. What really makes a system work is the interaction among its parts. Even system qualities such as self-regulation and interchange with the environment are basically extensions of the interdependence principle.

Interdependence is a cybernetic process, because system parts influence and control one another. Although the simple feedback loop is basic to cybernetics, most complex systems—certainly all human systems—make use of entire networks of influence.

System ideas have been criticized on several fronts, although their supporters remain undaunted.[46] Six major issues have emerged:

1. Does the generality of system theory provide the advantage of integration or the disadvantage of ambiguity?
2. Does the theory's openness provide flexibility in application or confusing equivocality?
3. Is system theory merely a philosophical perspective, or does it provide useful explanations?
4. Has system theory generated useful research?
5. Is the system paradigm an arbitrary convention, or does it reflect reality in nature?
6. Does system theory help to simplify, or does it make things more complicated than they really are?

The first issue clearly relates to theoretical scope. From the beginning, supporters have claimed that system theory provides a common vocabulary to integrate the sciences and that it establishes useful logics that can be fruitfully applied to a broad range of topics. Others, however, claim that system theory merely confuses. If it is everything, it is really nothing. If all phenomena follow the same system principles, we have no basis for understanding how one thing is different from anything else.

Along the same line, some critics point out that system theory cannot have its cake and eat it too. Either it must remain a general framework without explaining real-world events, or it must abandon general integration in favor of making substantive claims. Jesse Delia expresses this concern:

> General System Theory manifests a fundamental ambiguity in that at points it seems to present a substantive perspective making specific theoretical claims and at other points to present a general abstract language devoid of specific theoretical substance for the unification of alternative theoretical views.[47]

The second issue is this: Does the theory's openness provide flexibility of thought or confusing equivocality? Detractors claim that the theory embodies what Delia calls "a fancy form of the fallacy of equivocation." In other words, by permitting a variety of applications in different domains, it cannot prevent inconsistencies among these applications. Two theories using system principles may even contradict each other. Where, then, Delia asks, is the supposed unity brought about by system theory? This problem is exacerbated by the fact that system theories can employ various logics, which are not necessarily consistent with one another.[48]

Chang-Gen Bahg points out that "system theory" as a label is confusing.[49] There are actu-

46 For arguments supporting system theory, see especially Ludwig von Bertalanffy, "General Systems Theory: A Critical Review," *General Systems* 7 (1962): 1–20; Buckley, *Sociology*; Peter Monge, "The Systems Perspective as a Theoretical Basis for the Study of Human Communication," *Communication Quarterly* 25 (1977): 19–29; B. Aubrey Fisher, *Perspectives on Human Communication* (New York: Macmillan, 1978).

47 Jesse Delia, "Alternative Perspectives for the Study of Human Communication: Critique and Response," *Communication Quarterly* 25 (1977): 51. See also Edgan Taschjan, "The Entropy of Complex Dynamic Systems," *Behavioral Science* 19 (1975): 3.

48 Delia, "Alternative Perspectives," pp. 51–52.

49 Bahg, "Major Systems Theories."

ally a variety of system theories with different names. Bahg discusses twenty-one different system theory traditions. To make matters worse, different system theories sometimes use the same name. "System theory" means different things in different parts of the world.

Particularly confusing among system theories are their different epistemologies, or ways of understanding events. Some are very mechanical and imply a world that works like a machine. Others, like second-order cybernetics, see systems as socially constructed (see Chapter 9).[50]

Supporters answer that openness is one of the main advantages of system theory. It provides not a single tool but a variety of related tools to use in many useful ways. That a set of common ideas such as wholeness and interdependence has been used in so many different ways shows the rich potential of the system enterprise.[51]

Apropos of the third issue, some critics question whether the system approach is a theory at all, claiming that it has no explanatory power. Although it gives us a perspective or way of conceptualizing, it provides little basis for understanding why things occur as they do. B. Aubrey Fisher agrees:

> These principles are quite abstract (that is to say, general). Consequently, they can be applied in numerous ways by differing theorists with equally different results. In fact, system "theory" is probably a misnomer. . . . In short, system theory is a loosely organized and highly abstract set of principles, which serve to direct our thinking but which are subject to numerous interpretations.[52]

System advocates would agree with this assessment of general system theory but point out that any given system theory of communication could itself be highly explanatory. Even if system principles are useful, however, their application to real problems may distract observers from significant problems ignored by system principles. Family system therapy is such a case, according to H. Russell Searight and William Merkel, who write: "By focusing almost solely upon interpersonal interactions as sources of clinical problems, family therapy has neglected intrapersonal factors such as central nervous system dysfunction. This neglect has created unnecessary barriers to treating problems such as attention deficit disorder, learning disabilities, and panic disorder."[53]

Searight and Merkel extend this point further by suggesting that family system theory is culturally inappropriate in the United States. This country is typically an individualistic culture, and problems are understood largely in individualistic terms. There seems to be a split, then, between family system therapy and the culture at large. Searight and Merkel do not reject system therapy, but they judge it as overly closed to other important approaches and hope that future refinements will take into account insights from different theories.

The fourth critical issue questions system theory's heuristic value or its ability to generate research. According to Donald Cushman, "Systems is a perspective which has produced more staunch advocates than theoretical empirical research."[54] Again, critics return to the extreme generality of the approach as the basis of their criticism. They claim that the theory simply does not suggest substantive questions for investigation.

In contrast, advocates claim that the fresh perspective provided by system theory suggests new ways of looking at old problems and thus is highly heuristic. Wayne Beach points out, for example, that a great deal of fruitful research followed Aubrey Fisher and Leonard Hawes's 1971 article on small-group systems.[55] Today a system approach is often assumed in communication theory. It is taken for granted in much of the work of the field without being labeled as such.

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50 Yerby, "Family System Theory."

51 See, for example, Bahg, "Major Systems Theories."

52 Fisher, *Perspectives*, p. 196. See also von Bertalanffy, "Critical Review."

53 H. Russell Searight and William T. Merkel, "Systems Theory and Its Discontents: Clinical and Ethical Issues," *The American Journal of Family Therapy* 19 (1991): 19–31.

54 Donald Cushman, "The Rules Perspective as a Theoretical Basis for the Study of Human Communication," *Communication Quarterly* 25 (1977): 30–45.

55 B. Aubrey Fisher and Leonard C. Hawes, "An Interact System Model: Generating a Grounded Theory of Small Groups," *Quarterly Journal of Speech* 57 (1971): 444–453. See also Wayne Beach, "Stocktaking Open-Systems Research and Theory: A Critique and Proposals for Action" (paper presented at the annual conference of the Western Speech Communication Association, Phoenix, November 1977).

The fifth issue relates to the validity of system theory. Critics question whether system theory was developed to reflect what really happens in nature or to represent a useful convention for conceptualizing complex processes. In fact, system advocates themselves take different positions on this issue. Critics place system theory in a dilemma. If the theory attempts to describe phenomena as they really are, it is invalid. It posits similarities among events that are not really there. If, on the other hand, the theory provides merely a useful vocabulary, attributed similarities among events are only semantic and essentially useless for understanding those events. As Delia points out: "[Events] have different referents; they require different explanations; calling them the same thing . . . does not make them the same."[56] Bertalanffy calls this objection the "So what?" argument.[57]

The final issue of system theory is parsimony. Adherents claim the world is so complex that a sensible framework such as system theory is necessary to sort out the elements of world processes. Critics generally doubt that events are that complex. They claim that system theory overcomplicates events that are essentially simple. Charles Berger states the case against overcomplication:

> In the behavioral sciences . . . we may be the victims of what I call irrelevant variety. Irrelevant variety is generated by the presence of attributes in a situation which have little to do with the phenomenon we are studying but which give the impression that what we are studying is very complex. . . . Merely because persons differ along a larger number of physical, psychological, and social dimensions, does not mean that all of these differences will make a difference in terms of the phenomena we are studying. . . . It is probably the case that relatively few variables ultimately can account for most of the action.[58]

And yet, system theory *can* be a parsimonious approach, as dynamic social impact theory so well illustrates.

These six criticisms of general system theory are probably fair. However, actual system theories of communication must be evaluated on their own merit. The many theories of communication that make use of system principles are specific and help us understand concrete experiences, as we can see from the examples earlier in this chapter. You will also notice that these theories tend to be consistent and mutually supportive. Because of system influences, a common vocabulary makes these theories coherent and useful as a group.

The coherence among system theories of communication does not invalidate the criticism that general system theory can be applied in inconsistent ways, but at least in the study of communication, we find instances of consistent application in which system principles clarify rather than obscure. Further, although general system theory is not very explanatory, various applications of system theory can be quite explanatory, as DSIT well illustrates.

No survey of communication is complete without at least touching on information theory. Although this theory has been influential in a variety of ways, these days the concepts of information theory are often considered arcane in human communication studies. The subject is much more relevant to communication technology and engineering. If you are technically minded, enjoy mathematics, and tinker with electronics or broadcasting equipment, you will appreciate information theory and see its relevance. At the same time, however, if you like analogies and looking at human experience by applying physical concepts, you will see the relevance of information theory as a metaphor.

It is not surprising that most students of human communication today find information theory difficult to apply and less relevant than many of the other theories you will encounter in this book. The most directly applicable topic from information theory as presented in this chapter is Shannon and Weaver's model of transmission, which has been immensely popular,

56 Delia, "Alternative Perspectives," p. 51.
57 Von Bertalanffy, "Critical Review."
58 Charles Berger, "The Covering Law Perspective as a Theoretical Basis for the Study of Human Communication," *Communication Quarterly* 75 (1977): 7–18. See also Gerald R. Miller, "The Pervasiveness and Marvelous Complexity of Human Communication: A Note of Skepticism" (keynote address delivered at the Fourth Annual Conference in Communication, California State University, Fresno, May 1977). See also Beach, "Stocktaking."

although somewhat simplistic, in teaching the basic elements of communication for nearly a half century.

Although it is indispensable for developing advanced electronic communication devices, some of the original information theorists, system theorists, and other scholars looked to information theory for answers it could not provide. Shannon and Weaver hoped to use the theory as an overarching model for all human and machine communication. However, even Colin Cherry, whose famous 1957 treatise on communication was based largely on information theory, argued later that "the language of physical science is inadequate for discussion of what is essentially human about human communication."[59]

Most criticism of information theory relates to the standard of appropriateness.[60] The philosophical assumptions of the theory are not considered appropriate for understanding many aspects of human communication. Roger Conant captures the essence of the argument:

> When Shannon's theory first appeared it provoked a lot of optimism, not only in the telephone company for which it had clear technical applications, but also among biologists, psychologists, and the like who hoped it would illuminate the ways in which cells, animals, people, and perhaps even societies use information. Although the theory has been put to use in these ways, the results have not been spectacular at all. . . . Shannon's theory provides practically no help in understanding everyday communication.[61]

Many critics have centered on the ill-advised use of the term *information* as a symptom of this problem. Because the usage of the term is at such odds with popular meanings of *information*, much confusion has resulted. Ironically, information theory is not at all about information as we commonly understand it. One critic has suggested that the approach be retitled the "theory of signal transmission."[62] Because the term *information* as used by these theorists is so difficult to apply to human communication, other scholars have developed new definitions of the term that have caused even more befuddlement.[63] Of course, terminological confusion is only a symptom of the problems involved in stretching the concept to fit alien domains. Three such problems have been cited frequently in the literature.

The first is that information theory is designed as a measurement tool based on statistical procedures. Human messages in their full complexity are not easily broken down into observable, measurable signals. Although the phonetic structure of language is amenable to analysis, when you add vocal cues, not to mention body language, information measurement becomes virtually useless. Also, many of the codes used in human communication are continuous, not discrete; that is, they do not consist of off-on signals. Such codes are difficult to fit into the mathematical paradigm.

A second problem of applying information theory to human communication is that the theory downplays meaning. Even if we could predict the amount of information received by a listener, we would know nothing of the degree of shared understanding among the communicators or the impact of the message on them.

Finally, information theory does not deal with the contextual or personal factors affecting an individual's channel capacity. For example, learning, which improves one's ability to comprehend certain types of messages and ultimately one's capacity to receive signals, is left untouched in classical theory.

System theory, cybernetics, and information theory provide an excellent backdrop for many theories of communication. Let us turn our attention now to some of the specific topics of communication theory.

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59 Colin Cherry, *On Human Communication*, 3d ed. (Cambridge, MA: MIT Press, 1978), p. ix.

60 Criticism of information theory can be found in many sources, including the following, on which my summary relies: Anatol Rapoport, "The Promise and Pitfalls of Information Theory," *Behavioral Science* 1 (1956): 303–309 [reprinted in *Modern Systems Research for the Behavioral Scientist*, ed. W. Buckley (Chicago: Aldine, 1968), pp. 137–142]. See also Handy and Kurtz, "Current Appraisal"; Roger C. Conant, "A Vector Theory of Information," in *Communication Yearbook 3*, ed. D. Nimmo (New Brunswick, NJ: Transaction, 1979), pp. 177–196.

61 Conant, "Vector Theory," p. 178.

62 Yehoshua Bar-Hillel, "Concluding Review," in *Information Theory in Psychology*, ed. H. Quastler (Glencoe, IL: Free Press, 1955), p. 3.

63 See, for example, Krippendorff, "Information Theory."