THE CONVERGENCE THEORY OF COMMUNICATION AND CULTURAL CHANGE

D. Lawrence Kincaid

Introduction

There is a tendency in American communication theory to limit the range of discourse to the situation in which a source transmits a message to a receiver(s) with some intended effect. This tendency is undoubtedly due to the predominance of certain disciplines which have contributed the most to the field: psychology, social psychology, sociology, and telecommunications. The result has been a bias toward models which posit communication as a one-way, linear act of message transmission in which the effects are primarily measured at the level of the individual. This bias in American communication theory is criticized in some detail by Rogers and Kincaid (1981, pp. 32-43), with a call for the development of models of communication which focus on the relatioships/differences among members of communication networks or intact social systems.

One of the consequences of the preoccupation with linear transmission models is the difficulty it has created for moving to a higher level of analysis and for making meaningful statements about the relationship between communication and culture, except as culture is manifested in the individual. The diffusion model (Rogers and Shoemaker, 1962, 1971) could be used for this purpose, but it also limits itself arbitrarily to the linear transmission of innovations to individual receivers/members of social systems.

The obvious alternative is to think about communication and culture on a larger scale with the group or collectivity as the unit of analysis. Because the unit of data collection is so often the individual, researchers have taken it for granted that the unit of analysis and the development of theory must also be at the individual level. This is not a necessary requirement. We can think of communication as a cultural process involving very large numbers of individuals organized into collectivities which share common cultures and which consist of numerous subcultures with varying degrees of difference and similarity to the culture as a whole. The ideal communication theory would be able to address problems at the level of intact cultures, but still be meaningful and even logically derivable from the micro-level of individual members.

The purpose of this paper is to develop a theory of communication which can account for large-scale processes of cultural convergence and divergence by drawing upon some of the concepts and methods of statistical thermodynamics. From the principles of thermodynamics we will derive the most fundamental principle of human communication, and then show how the same principle can be derived from an analysis of the cybernetic process of interaction between individuals. The relationship between energy and communication will make it clear that over the

long run cultures would be expected to oscillate in terms of complementary processes of convergence and divergence. Such an undertaking is no small task; it will require several years of collaborative effort.

The Influence of Mathematical Information Theory

In 1949 the academic field of communication "took off" with the publication of Shannon and Weaver's (1949) The Mathematical Theory of Communication. It brought scholars together from several scientific disciplines to the scientific study of communication.[1] The excitement and the promise were great, but "the effect which is stimulated to create a unified model of human communication failed because the theory did not consider the semantic or pragmatic levels of communication" (Rogers and Kincaid, 1981, p. 33). Two of the principle figures who introduced information theory to new scholars in the field-Schramm and Cherry-warned of its inherent limitations.

Schramm (1955), who introduced the theory to the field of mass communication, helped stimulate much of the initial excitement, but by the 1970's he had to acknowledge that "it soon became clear that direct application of the mathematical treatment was limited because the universe of human information is less simple and less finite than the mathematical and electrical universe for which the formulas had been created..." (1973, p. 39). In 1957, Cherry warned his readers that the mathematical theory of communication has a direct application only to the information capacity of telecommunication systems-technical equipment such as microphones, telephone lines, the printed tape, and so forth. "This is not to say that the mathematical concepts or technique are completely forbidden elsewhere but, if so used, this must not be regarded as a simple application of existing 'theory of (tele) communication' by extrapolation from its legitimate domain of applicability" (Cherry, 1978. p. 41).

As an example he mentioned that Bar-Hillel and Carnap's (1953) attempt to extend the theory to semantics "...makes no reference to communication between persons per se, or to natural historical languages" (Cherry, 1978, p. 244). For emphasis he quoted Bar-Hillel's own warnings and reservations: "Unfortunately, however, it often turned out that impatient scientists in various fields applied the terminology and the theorems of the statistical (communication) theory to fields in which the term information was used, pre-systematically, in a semantic sense ... or even in a pragmatic sense" (Cherry, 1978, p. 221). Cherry summed up the general consensus that has persisted until this day, that Shannon's measure of selective information only "concerns the statistical rarity of signals. What these signals 'signify' or 'mean' or what their value or truth is, simply cannot be discussed in the language of this statistical communication theory" (Cherry, 1978, p. 221).

These warnings are well taken, even today, but they have had the unintended consequence of discouraging further work on some of the important principles upon which mathematical information theory is based. The most important principle is that of entropy

or disorder. The relationship between entropy and information was made explicit by Shannon himself in 1949 and almost everyone else who has written about information theory (Wiener, 1948; Brillouin, 1956).

In spite of his own constructive discussion of the entropy concept, Cherry is even more emphatic in his rejection of the applicability of entropy to human communication than he was for information theory. Of the two ways that the mathematical equivalence between information and entropy could be exploited-either precisely and mathematically or vaguely and descriptively-he was overly preoccupied with the latter, noting how many "method-starved studies" in language, sociology, and economics had applied it as a "sweeping generality which people will clutch like a straw" (Cherry, 1978, p. 216). The vague and descriptive misuse of the entropy concept coupled with Cherry's own definitive position on the subject have, in this author's opinion, discouraged further work on the concept by communication scholars, even work of a more precise and mathematical nature.

In fact, there is evidence that Cherry even discouraged himself from further pursuing the direct application of mathematical entropy to human communication. Later in the same book he described what may be a "true communication problem" to him, the situation in which a person converses with a friend about some topic: "Physical sounds of signs pass to and from in a closed cyclic manner; the signs of one stimulate response signs in the other. Conversation we have described as a convergent or 'goal-seeking' activitiy" (Cherry, 1978, p. 249).

Before the cycles of information flow begin, a certain state of mind exist for each party, consisting of certain sets of beliefs. The evidence derived from the information process coverts the prior state of belief of each party to a posterior state of belief. If positive, the "range of beliefs is sharpened by the reciept of signs; if your range of hypotheses is reduced, your beliefs become more restricted, your uncertainty made less" (Cherry, 1978, p. 250).

At this crucial point in his work, he tentatively states that "Such a change we may perhaps interpret as a kind of pragmatic-information content of the signs- <u>though with no pretense of setting up any true theory</u>-the change from a prior to a posterior state of belief" (Cherry, 1978, p. 250, emphasis added). Had he been less cautious and less concerned about the effects of communication processes on single individuals, he might have considered the direct application of the entropy measure (whose principle he uses anyway) to the distribution of belief structures of large ensembles of human populations. With the publication of the third edition of his book, this caution has persisted from 1957 to 1978.

There are, of course, other important reasons why entropy and statistical thermodynamics in general have not been pursued more thoroughly by communication scholars despite their relevance to communication. The overriding reason is the communication field's overwhelming preoccupation with the "individual receiver of messages." Shannon and Weaver's mathematical information theory was perceived as especially relevant to human

communication theory when it was introduced because it seemed to deal with the transmission of messages from a source to areciever, in which the surprise value of one message out of a sequence of messages could have effect on the "psychological uncertainty" of a receiver. The traditional bias of communication scholars towards effects on individual receivers automatically made the concept of order/disorder in large ensembles irrelevant to their needs.

The second most important reason is the traditional separation and antagonism between the natural scienes where the concept of entropy originated and the human sciences/humanities. But this opposition has always been ambivalent and inconsistent. On the one hand, there is a general acknowledgement of the success of the application of mathematical techniques from natural sciences to the social sciences for the prediction of macroscopic, average quantities and rates such as birth rates, death rates, accident rates, and so forth. On the other hand, the whole approach is rejected because the same methods cannot give the life history of any one individual (Cherry, 1978, pp. 24-26). Social scientists are also extremely sensitive about the misuse of physical analogies which liken human beings to atoms, molecules to groups, and that speak of social forces, energy, momentum, and swings of the pendulum. At the same time, however, these very analogies continue to be useful for social commentators, political analysts, and policy makers who run our government and corporations.

Additional opposition comes from those who think that the use of the scientific method will ultimately negate the concept of "free will," even though it is acknowledged that the behavior of individuals in human societies is considerable constrained by those societies as a positive alternative to chaos and social anarchy. And finally, there is the notion that social and biological processes are irreversible, in contradiction to the reversibility inherent in the differential equations of Newtonian mechanics, and that social systems "rarely reach a true equilibrium" like physical systems which can be studies in a closed state of stationary equilibrium (Cherry, 1978, p. 25). The latter of course, is contradicted by the whole field of non-equilibrium thermodynamics and the study of dynamic processes in general.

Thus, for a variety of reasons some of the most important implications of information theory and its relationship to thermodynamic entropy have not been developed by communication scientists as thoroughly as they could have been. The mathematical analogy between entropy and information is evidence that a similar structure exists in two different classes of events (e.e., the distribution of gas molecules and the distribution of a sequence of signals). It is the structure of distribution of various aspects of culture that deserves further attention. A conceptual obstacle to the use of the entropy may have been artificially created by Shannon's 1949 treatment. He defined entropy with a sign just the opposite of the standard thermodynamical definition. "Hence what Shannon calls entropy of information actually represents negentropy" (Brillouin, 1956, p.

161). Shannon (1949, p. 27 and p. 61) even gives examples which show that some irreversible processes decrease his entropy of information measure. "To obtain agreement with our conventions, reverse the sign and read negentropy" (Brillouin, 1956, p. 161). In thermodynamics negentropy (low entropy) refers to a state of greater order, predictability, and certainty, and for these reasons a lower potential for an observer to reduce his uncertainty (gain information). The high entropy condition, because so many states are possible, has a high potential for information gain by the observer. This unfortunate problem might have been avoided had Shannon equated the high entropy condition with a high potential for information rather than simply high information.

This confusion should not be allowed to obscure the most important principle underlying both thermodynamics and information theory: the principle of structure and order as measured interms of the probability distribution of a state of occurrence. To extend this basic idea to human communcation we will do what was not done earlier: ignore for the moment the problem of an individual receiver's uncertainty regarding a sequence of physical signs. Instead, we will concentrate on the distribution structure of the mental states of a large collectivity of individuals referred to as a culture. The main principle to be elaborated is that the communication process results in a change in the statistical distribution of the beliefs and values of the members of a culture, and that for important theoretical reasons this distribution change should be measured by use of the mathematical formula for thermodynamic entropy.

Toward a Statistical Thermodynamics of Cultural Change

Classical thermodynamics dealt with conclusions that can be reached from experimental laws about the relationship between marco-level variables such as volume, temperature, pressure, heat capacity, and entropy. As a purely experimental science, it made no hypothesis about the nature of matter. Science went beyond these limits only by making certain assumptions (verified only later) about the nature of matter, specifically, that matter is not continuous in structure but is composed of extremely large numbers of particles called molecules. The kinetic theory of gases applied the laws of classical mechanics (motion, mass, and force), to the individual molecules of a gas (in imagination only) and derived mathematical expressions for pressure, its internal energy, and heat capacity.

Statistical mechanics, on the other hand, ignored the details of individual molecules and applied the principles of probability theory to the very large numbers of molecules that make up matter (Sears, 1950). Individual details had to be ignored because of the extremely large number of particles that exists at the atomic level, on the order of 10^{24} (Sachs, 1973). How could one possibly determine the position and momentum coordinates at some initial point in time and then solve the 10^{24} coupled equations to predict their future motions? Boltzmann (1844-1906) solved

this dilemma by finding the average values for the properties of a gas in terms of a distribution function. In this manner he discovered that "the temperature of a gas is nothing more than an expression of the average kinetic energy of its constituent atoms" (Sachs, 1973, p. 13). Different temperatures of a given volume of gas correspond to different average velocities of its constituent molecules. A gas in a non-equilibrium state "corresponds to the assertion that the distribution of the constituent atoms ...with respect to their speeds and positions, at any time, must correspondingly approach a most probable distribution" (Sachs, 1973, p. 14).

In other words, if all the particles of a gas at constant volume were squeezed into one corner of their container, or if a proportion of them were moving at a faster velocity, then over time the particles would redistribute themselves evenly throughout the container, and would tend towards the most probable distribution around the mean velocity. This most probable distribution corresponds to the minimum amount of order in the system, or maximum entropy.

The mathematical formula for the statistical probability distribution of entropy, S, is:

$$S = - \sum_i P_i \log_n P_i \qquad (1)$$

where, P_i is the probability of a system being in cell i of its phase space (the universal gas constant per particle, Boltzmann's k, is omitted since it merely amounts to the choice of a unit of measure).

The statistical measure of entropy indicates how closely one can pinpoint the state of a system. A high degree of predictability implies a low level of entropy, and vice versa. Thus, S is not a mechanical quantity, but an informational one, corresponding to how much uncertainty there is in the situation (Andrews, 1975). When entropy is interpreted in terms of disorder, as described above, an increase in entropy, S, means the sytem has departed further from a defined state of order. "However, the whole general idea is perhaps most accurately expressed in terms of the notion of 'spread,' entropy increase is due to a 'spreading' of the system over a larger number of available microstates" (Denbigh, 1975, p. 70). In the same sense, the statistical measure for the variance around a mean of a distribution is also a measure of spread, and its inverse may be used to represent the amount of information (Fisher, 1937).

The statement that an isolated system left to itself will tend toward the most probable state corresponds to the most fundamental law of nature, the Second Law of Themodynamics, which is relevant to all sciences, including communication. "Isolated systems evolve until they reach equilibrium" (Andrews, 1975, p. 168). A more useful expression for our purpose is that "the spontaneous tendency of a system to go toward thermodynamic equilibrium cannot be reversed without at the same time changing some organized energy, work, nto disorganized energy, heat" (Morse, 1969, p. 43). This form of the principle implies that

the natural entropy increasing process can be reversed (in local regions) by drawing upon the matter-energy resources of the surround to perform work to increase the order and structure within the localized system. The Second Law remains intact, however, because the entropy of the localized system plus the environment that it draws upon does increase. Thus, all of the entropy reversing processes which we observe in nature-flowers in bloom, babies born, cars rolling off the assembly line, and so forth-are examples of a temporary increase in localized order/structure, but always as the expense of increased disorder of the local system plus surround, earth plus the sun.

A change in entropy from state A to state B may be represented by the following equation:

$$S_B - S_A = \log_n (P_B/P_A) \qquad (2)$$

As entropy increases, an increased number of microstates becomes available and there is an increased degree of uncertainty about the actual microstate that is occupied at any instant. If there are P_A possible microstates available to an isolated system the probability is $1/P_A$ that any one of them is occupied, and if P_A increases to P_B the probability diminishes to 1/P (Denbigh, 1975, p. 69). Thus, the Second Law of Thermodynamics can be formulated as:

$$S_B \geq S_A$$

$$S_B - S_A \geq 0 \qquad (3)$$

and there exists a function, S, which increases monotonically until it reaches its maximum at the state of thermodynamic equilibrium:

$$dS/dt \geq 0 \qquad (4)$$

Equation (4) states that the change of entropy, or order of a system, is equal to 0, or else is positive (increases with time). This equation (4) represents an irreversible process of a closed system, one which spontaneously increases with time to a maximum, but can never reverse or become more ordered without at the same time producing changes in its environment.

The situation described in equation (4) may be extended to open systems that do exchange energy, matter, and information with their environment, simply by distinguishing between the transfer of entropy across the boundaries of the system, d_eS, from entropy produced inside the system, d_iS. Again, the second law assumes that entropy production inside the system is positive or 0 at equilibrium. By assuming that entropy production depends on the same variables away from equilibrium as it does at equilibrium-the assumption of "local equilibrium"-then themrodynamics can be extended to non-equilibrium processes (Prigogine, 1978). The basic formula for entropy production, P, for the macrospcopic therodynamics of irreversible processes is:

$$P = d_iS/dt = \sum_p J_p X_p \geq 0 \qquad (5)$$

Where the J_p are the rates of the various irreversible processes, p, involved (heat flow, diffusion, chemical reactions) and the X_p are the corresponding generalized forces (gradients of temperature, chemical potential, affinities). At equilibrium, the rates, J_p and the forces, X_p, would go to 0, and entropy production, P, would cease. The greater the forces and rates, the faster the rate of entropy production, P. A system of this nature is called a dissipative structure, and it is central to the study of self-organization in non-equilibrium systems (Prigogine, 1978; Nicolis and Prigogine, 1977).

In these dissapative states the system no longer moves spontaneously to a state of maximum entropy where it remains, but rather "...the system is moving towards a stationary stable state where it remains as long as its interaction with the envirnonment continues to take place" (Priogogine and Stengers, 1977, p. 327). Prigogine refers to this as the "theorem of minimum entropy production," which in essence states that due to the interaction with the environment, the Second Law requires the system to produce the minimum quantity of entropy consistent with the interaction. Prigogine and his colleagues see the contribution of the new non-equilibrium thermodynamics to biological and social systems as well as physical ones because of its relevance to the processes of self-organization.

One of the key elements that has been lacking in order to apply the statistical thermodynamic model to human communication is an appropriate measurement model. The method of direct magnitude, ratio estimations (Stevens, 1975; Lodge, 1981) of the differences between the concepts that a population has for a given domain of meaning, in combination with the metric multidimensional scaling technique (Galileo$_{TM}$) developed by Woelfel and his colleagues (1980a; 1980b), places no arbitrary restrictions on the number of possible states that can be observed. Therefore, it is ideal for the application of statistical thermodynamics to the study of communication and cultural processes. Using the method of paired comparisons, the members of a population of interest estimate the separation or difference between the pairs of work/concepts used to define a topic. The meaning of this set of concepts is represented by an N x N symmetric dissimilarity (distance) matrix. The psychological configuration of a group of subculture is then represented by the average matrix, **A**, where any entry, a_{ij}, is the arithmetic mean conception of the dissimilarity between concepts i and j as judged by members of the group. Each vector of the matrix, indicating a concept's distance relationship to all other concepts, represents the concept's definition for that group.

The processual nature of a culture may be represented by a series of matrices ($\mathbf{A}(t_0)$, $\mathbf{A}(t_1)$, $\mathbf{A}(t_2)$,...,$\mathbf{A}(t_n)$, whose elements represent the average distances among the concepts at each point in time (t_i). The spread of the distribution around the mean for

each pair of concepts can be measured by the variance statistic or the measure of statistical entropy describe above (equation 1). This spread and the entropy measure may be considered as the degree of conceptual convergence of a culture around the collective mean at each point in time.

All of these methods share the basic advantage of statistical thermodynamics, that the predictability of individuals at the micro-level of analysis is not required, and in fact can contain a considerable degree of randomness without jeopardizing the predictability of the culture as a whole at the macro-level of analysis. Measurement reliability and stability over time at the individual level is not as important as long as the average values demonstrate predictable functional relationships with time and other macro-level measures, such as the structure of the communication networks of the same culture.

Communication, of course, consists of much more than the flow of matter and energy; it also consists of the flow of information, differences in matter-energy which affect uncertainty in a situation where a choice exists among a set of alternatives (Rogers and Kincaid, 1981). If molecules were capable of making choices based on information regarding their speed, then the situation described by Maxwell's demon (Brillouin, 1956; Morowitz, 1970) would be true and the Second Law contradicted. Maxwell imagined a situation involving two adjoining chambers isolated from their environment which contain gas molecules at two substantially different temperatures and hence different average absolute velocities. The wall separating side A with the higher temperature from side B with the lower temperature contains a trap door which can be opened and shut at the necessary speed by a small demon. When the faster molecules on the cooler side, B, happen to approach, the demon opens the trap door let them pass into the hotter side, A; when the molecules on the slower end of the velocity distribution in the hotter side, A, approach the trap door, the demon opens it up to let them pass into the cooler side, B. In this manner, the overall difference in the temperature and average velocities of the two sides of the chamber would increase, producing an overall decrease in the entropy of the system as a whole and an overall icrease in the order of the molecules. The Second Law would no longer prevail.[2]

The demon was eventually exorcised by Szilard (1929) when he was the first to point out that "the demon is acting on information about the detailed motion of the gas, and is actually changing information into negentropy" (Brillouin, 1956, p. 163). In other words, the act of "seeing" the individual molecules, if that were actually possible, and then making a decision and actinig on the trap door (all three forms of work) would require the expenditure of energy, and would produce some amount of disorganized energy, heat. Szliard was able to demonstrate that the entropy increase added by the demon's activity would always exceed by some amount the apparent decrease in entropy created by the sorting of the molecules. The import of this thought experiment for human communication should be clear. All of the action of the demon required to reverse the entropy process are

subprocesses of communication: perception, pattern recognition, understanding, and action (Kincaid, 1979; Rogers and Kincaid, 1981), and all of these subprocesses involve decision and choice and an intervention in the on-going, natural process.

The fundamental behavior of ideal gas particles (no vibration or electical information processing similar to that of Maxwell's demon, but with two very forces) is that of collision. The fundamental behavior of human beings is important difference. First, human information processing has error built into it, and therefore takes the form of a cybernetic decision-making process of approximation and convergence. Second, much human information processing occurs between two or more individuals in the form of communication as we know it.

Communication Networks and Cultural Convergence

The link created by sharing of information with another person simultaneously creates and maintains a portion of a communication network in which both participants become embedded. A communication network consists of a set of interconnected individuals who are linked by patterned flows of information (Rogers and Kincaid, 1981). To determine the structure of a communication network relational data about these information flows are analyzed using some type of interpersonal relationship as the unit of analysis. Since it is theoretically possible that everyone in the world is ultimately linked into one global communication network one of the main tasks of network analysis is to identify relatively bounded, sub-networks (cliques) in which a greater number of communication linkages occur inside among its members than outside with non-members.

Within this research paradigm communication is treated as a process that unfolds over time and which focues on the mutual relationships between participants rather than on what one individual does to another individual or mass audience. The new orientation envisions a flow of information through networks of communication which is shared by those who participate in the process, and in which the effects that occur take place between members of such communication networks. The outcome or results are indicated by the changes in the relative position between two or more participants over time and in the structure of the networks which they comprise. The researcher looks for multiple points or nodes in networks of communication in which there are regions of greater density characterized by less variance or difference within their boundaries than between such local regions.

From this perspective communication is defined as a process of convergence in which two or more participants share information in order to reach a better mutual understanding of each other and the world in which they live. Information is defined as a difference in matter-energy which affects uncertainty in a situation where a choice exists among a set of alternatives. Mutual understanding can only be approximated by the sharing of additional information, or what is commonly known as feedback. When a feedback process is successful the results are described

by "a series of diminishing mistakes--a dwindling series of under-and-over corrections converging on a goal (Deutsch, 1968, p. 390). Usually several cycles of such information exchange are required to correct for initial divergences or differences of understanding. In the convergence model of communication (Kincaid, 1987; Rogers and Kincaid, 1981; Kincaid, 1979) mutual understanding-reduced within-group variance-becomes the primary function of the communication process, and a prerequisite for collective action and the achievement of other social goals.

In theoretical terms, individuals within the same subregion of a communication network who meet or by some other means share the same information with one another about a given topic will, over time, develop a more similar conceptualization of this topic. Although considerable divergence may at times exist within a group or local network, the group as a whole will tend over time to defiine and to conceptualize matters more similarly than those who have not shared in the exchange of the same information.

Although he did not recognize the cybernetic mechanism responsible for the process, Barth (1969) did identify the fundamental convergence principle in his study of ethnic boundaries: "...where persons of different cultures interact one would expect [their] differences to be reduced, since interaction both requires and generates a congruence of codes and values-in other words, a similarity or community of culture" (Barth, 1969, pp. 16-17). For inter-ethnic relations to be stable, boundaries or a set of prescriptions must be established to control communication between groups to prevent information from being shared in certain areas, and thus insulatiing parts of the respective cultures from confrontation, modification, and eventual convergence.

Logically, the outcome of the communication process could only be expectedto have five possible outcomes:

(1)	Convergence	(less difference, greater order)
(2)	Divergence	(more difference, greater disorder)
(3)	No change	(perfectly stable equilibrium)
(4)	Random change	(either more or less difference by chance)
(5)	Unknown	(beyond our current knowledge capacities)

As mentioned above, Cherry (1978) described the outcome of communication as a convergence of mental states, but by making "no pretense to setting up any true theory" he in effect opted for the fifth logical outcome: beyond our current knowledge capacities. The fourth option, randomness, is tantamount to accepting communication as an unsystematic, fundamentally unpredictable and chaotic process. This, of course, goes against everyone's normal experience with communication, and if it were true would lead to perfect uncertainty, mental breakdown, and, very quickly, the cessation of communication itself. More importantly for our purposes, the acceptance of the positions stated in both (4) and (5) above would completely undermine the theory building process by denying its possibility.

The third option, no change, is purely a matter of the precision of measurement available to determine the outcome. Crude measures would be unable to detect any change, but increased precision would always detect some change even if only that of oscillation around some point of equilibrium. The change that would be detected would then fall into one of the two remaining outcomes, convergence or divergence.

The first option, convergence, is the only rational position upon which to base a theory of human communication. Differences of opinion can occur without the need for communication, either by chance circumstances or simply by the experiences of living in different envirnoments. One who desires to be different from someone else normally stops communicating with that person. Furthermore, one cannot purposely attempt to misunderstand someone else; the mind will not function that way. The mind first attempts a "correct" perception and interpretation, not a false one. Purposeful misunderstanding is not the same as making a mistake or error, which can be corrected if communication is allowed to continue. Even to deceive another into thinking that one has misunderstood first requires one to make some authentic assessment of the other's actual position (a better understanding) so that it can then be misstated. But even this phonomenon is rare, for it could only lead to a disruption of social harmony and/or invite accusations of incompetence.

In most situations, communication is used for the purpose of reaching a better understanding of others, and for others to reach a better understanding of oneself. This mutual understanding is the primary function of the communication process. Mutual understanding can reveal a certain level of mutual disagreement, but it is expected that given enough time and continued interaction (with no outside interference), greater levels of mutual agreement would also eventually result. Experience shows us that people behave as if they expect greater convergence to result from communication, and when progress is too slow or fails, communication ceases. Statistically speaking, on the average the result of the communication process will always be towards greater agreement than disagreement, if only because disagreeing parties tend to cease communication.

The Principle of Communication and Cultural Convergence

We are now in a position to derive the important principles from statistical thermodynamics and cybernetics which apply to the macro-level phenomena of communication and cultural convergence. In a culture as a whole, we would expect the cybernetic process of communication to reverse the natural tendency of a culture to move toward a greater state of entropy and disorder characterized by a greater number of possible states and greater differences among members of the population. The reversal produced by communication would correspond to a state of greater negentropy and order characterized by a smaller number of states and less difference among members of the population in terms of their beliefs, values, and overt behavior. The entropy measure can be used to quantify both discrete and continuous

measures of belief, values, and behavior, and the conventional measure of variance around a mean can also be used for continuous measures. The entropy measure, however, will not be applied to one individual, but rather to the distribution of belief, value, and behavior in a culture or population as a whole, or from a sample estimate.

In order to make the basic theorem as clear as possible, it will be stated in two converse forms for an idealized system closed to information from the external environment. Another reason to state is two ways is because communication, as emphasized in the discussion above, can be turned off voluntarily be the members of a population, or in some cases restricted legally or by force, with obvious consequences for the process of convergence.

Theorem 1(a): In a closed social system with no communication among its members, the system as a whole will tend to diverge over time toward a collective pattern of thought of greater entropy.

In this situation, the number of microstates in which individual members can be found would increase, and the proportion of members in each available state would decrease, producing a system state of greater disorder and entropy. The most obvious example of this situation is the growing number of subcultures in the world as a whole that proliferated over thousands of years as long as each one could be isolated from the others by natural boundaries which served to restrict communication among them. A similar example today would be the behavior of a religious cult that moves physically to isolate itself from nonmembers and then restricts its contact with the outside world. These tactics serve to protect initial differences, and over time the loss of contact would be expected to foster even greater differences. Within such isolated communities, however, the opposite cultural process would unfold.

Theorem 1(b): In a closed social system in which communication is unrestricted among its members, the system as a whole will tend to converge over time toward a collective pattern of thought of greater negentropy (or lower entropy).

Compared to the year 1000 A.D., this could describe the situation in the world in 1982 A.D. In practice, however, the entropy change for world culture as a whole would be very hard to estimate because of the effect of two factors known to increase thermodynamic entropy: adding particles and increasing the volume of the container. For the global social system, we would have to take into account the effect of the tremendous increase in the world population (and hence, possible subcultures), and

this population's increased expansion geographically into the far corners of the globe since 1000 A.D. Furthermore, it would be a mistake to conclude prematurely that no one is exempt from the current process of global communication and apparent convergence, because local pockets or niches exist and are being created which can reverse this trend locally by restricting the flow of information with their external environment. Hence, the theorem cannot be applied without careful consideration of the nature of the communication networks and the content of the information that is allowed to flow within such communication networks.

Both forms of the theorem are stated for systems closed to external sources of information. There is no intent to restrict the exchange of matter and energy with the external environment as well; in fact, this would be required for the Second Law to prevail. The work that is done in the internal processes of communication require the expenditure of energy which (as described above) would produce an overall (system plus environment) increase in thermodynamic entropy, S. The increased negentropy and order within the social system is "paid for" in accordance with the principles of natural science. Thus, we should emphasize that we are not drawing an analogy between natural systems and social systems: the convergence produced by the processes of human communication is not separate, but rather a part of nature and therefore functions according to the known principles of the natural sciences.

Considering the process in an idealized closed social system simplifies the situation so that the basic principles can be understood. In practice, however, it is very rare to find social systems closed to all external information, for very long periods at least. For short periods such closed systems are very common: the school classroom during the hour that it is in session, the business meeting, the professional convention, the courtship process and family groups during intermittent periods, and so forth. When information is exchanged with the external environment, this information becomes a new source of diversity and entropy, but only if that information differs from the information already flowing within the system.

In general, there are two main sources of entropy for social systems: new information from external sources and new information created by internal sources and allowed to be shared. The latter corresponds to creativity and innovation, the former to the diffusion of innovations from the environment. Hence, three of the sources of modernization identified by Lerner (1964) --literacy, mass media exposure, and travel to outside communities-are all encompassed by the fundamental theorem as means of reducing the restrictions on information exchange with the environment and increasing the potential number of microstates. If carried to extremes, the system in question would eventually lose its integrity as a separate social system and become part of a larger one. For a social system to endure as a localized, integrated entity requires that a greater density of information flow be maintained within its local communication network than outside.

In the natural social systems in which we live it is impossible at our current state of knowledge to state with any confidence whether or not the general tendency overall is one of convergence or divergence. To do so would first require us to enumerate and then to measure the relevant beliefs, values, and behavior of all the content areas that pertain. Such a task is beyond our current means and capacity. If we could, however, we would find that some content areas are undergoing a process of convergence, others diverging. At a later point in time, the situation could easily be reversed for these same content areas. Why? Each content areas must in a sense "compete" for access to the existing communication network and for the energy resources required for the process. This situation is obvious for the interpersonal system. A pair of individuals cannot carry on a dialogue of all topics at all times; each content area must be considered in some order and under the constraints of the number of hours available during the day and the limited energy of the participants to do the work. The need to prioritize and select one topic area at a time means that some will receive more attention than others. During some periods, certain topics might be ignored altogether.

In society as a whole this same process of selection and concentration takes place with a net result of convergence in some content areas and divergence in others. As the divergence becomes intollerable for a given content area its priority would be expected to increase, and the renewed attention that it would receive would reverse its direction from divergence to convergence. The general picture for a culture as a whole would be a simultaneous convergence and divergence across content areas, and for a particular content area over a long period of time, oscillation, first a reduction then an increase in the degree of negentropy.

Research according to this paradigm has to be conducted in specific content areas. Some initial progress has been made along these lines. Kincaid and others (1983), for example, successfully applied the mathematical model for damped harmonic oscillation to the difference between the value configuration of the host society and groups of Korean immigrants who had arrived in Hawaii over a fifteen year period. Rogers and Kincaid (1981) discovered a greater degree of knowledge, attitude, and behavioral convergence in twenty-four Korean villages for those whose family planning communication networks were more highly interconnected (more dense). Work is not underway on methods of content analysis that will allow us to measure the process of convergence in a culture from the words that it selects for exchange in addition to the beliefs, values, and other behaviors that result. The work is just beginning. The promise for the future is a science of human communication whose fundamental principles and methods are no longer estranged from the other sciences.

NOTES

1. Engineers attribute the information formula to Hartly (1928), but it was introduced by Boltzmann (1896-98) in the last century. Szilard (1929 first pointed out that a decrease in physical entropy implies the obtaining of information by an observer, and Watanabe (1939, 1972) initiated the independence of information theory from thermodynamics.

2. The Second Law in its statisical form does not rule out the possibility of a decrease in entropy by chance (spontaneously) if the trap door is simply left open without the help of a demon, but it has been estimated that the time required for this improbable outcome to occur by chance alone would easily exceed the entire age of the universe since its beginning.

REFERENCES

Andrews, F. C. Equilibrium Statistical Mechanics (2nd ed.). New York: Wiley-Interscience, 1975.

Barth, F. "Introduction," in F. Barth (ed.), Ethnic Groups and Boundaries: The Social Organization of Cultural Difference. Boston: Little Brown, 1969.

Boltzmann, L. Vorlesungen uber Gas Thorie. Leipzig, 1896-1898.

Brillouin, L. Science and Information Theory. New York: Academic Press, 1956.

Brown, A.F. Statistical Physics. Edinburgh: Edinburgh University, 1968.

Cherry, C. On Human Communication. Cambridge: M.I.T. Press, 1957, 1978 (3rd ed.)

Denbigh, K.G. An Inventive Universe. New York: George Braziller, 1975.

Deutsch, K.W. "Toward a Cybernetic Model of Man and Society," in W. Buckley (ed.), Modern Systems Research for the Behavioral Scientist. Chicago: Aldine, 1968.

Fisher, R.A. The Design of Experiments. Edinburgh, 1937.

Hartley, R.L.V. Bell System Technical Journal, 7, 1928, 535.

Kestin, J.& J.R. Dorfman. A Course in Statistical Thermodynamics. New York: Academic Press, 1971.

Kincaid, D.L. "The Convergence Theory of Communication, Self-Organization, and Cultural Evolution," in D.L. Kincaid (Ed.) Communication Theory from Eastern and Western Perspectives. New York: Academic Press, 1987.

Kincaid, D.L. J.O. Yum, J. Woelfel, & G.A. Barnett. "The Cultual Convergence of Korean Immigrants in Hawaii: An Empirical Test of a Mathematical Theory," Quality and Quantity, 18, 1983, 59-78.

Kincaid, D.L. "Communication Technology and Cultural Diversity," Informatologia Yugoslavica 15 (5-7), 1983.

Kincaid, D.L. "The Convergence Model of Communication," Honolulu: East-West Center Paper, No. 18, 1979.

Lerner, D. The Passing of Traditional Society. New York: The Free Press, 1964.
Lodge, M. Magnitude Scaling: Quantitative Measurement of Opinions. Beverly Hills: Sage, 1981.
Morowitz, H.J. Entropy for Biologists: An Introduction to Thermodynamics. New York: Academic Press, 1970.
Morse, P.M. Thermal Physics (2nd edition). Reading, MA: Benjamin/Cummings, 1969.
Nicolis, G. & I. Prigogine. Self-Organization in Non-Equilibrium Systems. New York: Wiley-Interscience, 1977.
Prigogine, I. "Time, Structure, and Fluctuations," Science, 201 (no. 4358), 1978, pp. 777-785.
Prigogine, I. & I. Stengers. "The New Alliance," Scientia, 112, 1977, 319-332.
Rogers, E.M. & D.L. Kincaid. Communication Networks: Toward a New Paradigm for Research. New York: Free Press, 1981.
Sachs, M. The Field Concept in Contemporary Science. Springfield, IL: Thomas, 1973.
Schramm, W. Men, Messages, and Media. New York: Harper and Row, 1973.
Schramm, W. "Information Theory and Mass Communication," Journalism Quarterly, 32, 1955, 131- 146.
Sears, F.W. An Introduction to Thermodynamics, the Kinetic Theory of Gases, and Statistical Mechanics. Cambridge, Mass. Addison-Wesley, 1950.
Shannon, C. & W. Weaver. The Mathematical Theory of Communication. Urbana, Illinois: University of Illinois, 1949.
Stevens, S.S. Psychophysics. New York: Wiley, 1975.
Szilard, L. In Zeitschrift fur Physik, 53, 1929, 840.
Watanabe, S., "Information," in Scientific Thought: Some Underlying Concepts, Methods, and Procedures. Paris: Mouton/Unesco, 1972, 129-144.
Watanabe, S., In Zeitschrift fur Physik, 113, 1939, 482.
Wiener, N., Cybernetics. New York: M.I.T. Press, 1948, 1961 (second edition).
Woelfel, J. & E.L. Fink. The Measurement of Communication Processes: Galileo Theory and Method. New York: Academic Press, 1980a.
Woelfel, J. & J. Danes. "Multidimensional Scaling Models for Communication Research," in P. Monge & J. Capella (eds.), Multivariate Techniques in Human Communication Research. New York: Academic Press, 1980b.