INFORMATION AS A CONSTRUCT IN HUMAN COMMUNICATION SYSTEMS

Thesis for the Degree of Ph. D.
MICHIGAN STATE UNIVERSITY
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1968





This is to certify that the

thesis entitled
Information as a Construct in
Human Communication Systems

presented by

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has been accepted towards fulfillment of the requirements for

Ph.D. degree in Communication

Major professor

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ABSTRACT

INFORMATION AS A CONSTRUCT IN HUMAN COMMUNICATION SYSTEMS

by Clyde D. J. Morris

In the past two decades, a new discipline has appeared that is devoted to the scientific study of human communication. As with any science, one of the discipline's main goals is theory construction.

And one of the first tasks of theory construction is construct explication. One construct frequently used in communication research is "information." This paper describes ways the construct has been explicated during the last 20 years and suggests some areas for further explication of the construct.

Explication of a construct, for purposes of this paper, is taken to be establishing two linkages: a linkage to physical events (operational definition) and a linkage to other terms (constitutive definition).

These linkages are examined in various areas of communication research such as applications of information theory, dissonance theory, mass communication and diffusion of innovations.

After analyzing how the term has been used in communication research, a matrix of usages for the term "information" is presented that shows the locus of the usage, the function, the relationship to uncertainty and the advantages and disadvantages to the researcher of the particular usage. Usage number four is related to states of the communication system and is part of an approach to the study of human communication based on General Systems Theory.

Accepted by the faculty of the Department of Communication, College of Communication Arts, Michigan State University, in partial fulfillment of the requirements for the Doctor of Philosophy degree.

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INFORMATION AS A CONSTRUCT IN HUMAN COMMUNICATION SYSTEMS

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Clyde D. J. Morris

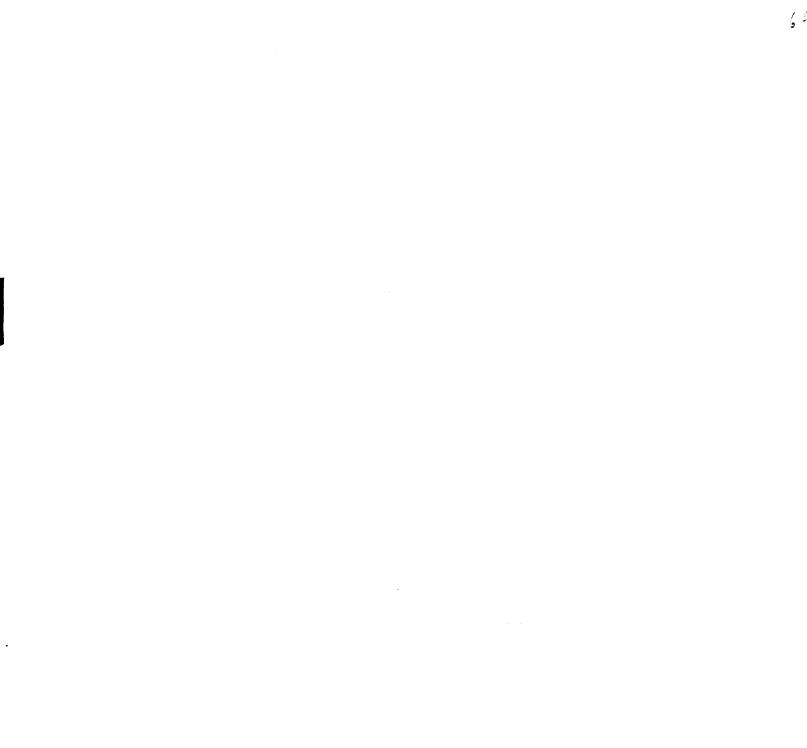
A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Communication

1968



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ACKNOWLEDGMENTS

My warmest thanks go to Dr. Randall P. Harrison, my thesis advisor; and to Dr. Hideya Kumata, Dr. R. Vincent Farace, and Dr. John Vinsonhaler, the members of my guidance committee. My thanks also to two men whom I greatly admire: Dr. Miles Martin and Dr. Everett Rogers.

A special kind of thanks to Dr. David K. Berlo - a man who understands how to create an intellectual climate in which researchers and scholars feel free to work on problems they're interested in with people that they like to work with.

So many colleagues have influenced my thinking that they can not be listed. But Jeffrey Katzer, David Beatty and Linda Davis have been particularly helpful to me in the formulation of this thesis.

And thanks to Gail Morris. Graduate programs are much harder on wives of graduate students than they are on graduate students.

Gail was patient and understanding when she should have been and not patient and understanding when she should not have been.

Two men who have greatly influenced my thinking should be thanked here: Mr. J. L. Thomas and Dr. John Paul.

My sincerest thanks to Mrs. Shirley Sherman, Mrs. Joyce Fles and Mrs. Donna Kokx for their help in preparing the several drafts of this thesis.

And a long overdue thanks to John Morris and Agnes Morris. I can think of several highly articulate and eloquently written books that have said things that my parents told me, in simpler language, when I was a boy.

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CHAPTER I

INTRODUCTION: THE PROBLEM

In the past two decades, a new discipline has appeared that is devoted to the scientific study of human communication. As with any science, one of the discipline's main goals is theory construction.

And one of the first tasks of theory construction is construct explication.

Berlo notes that "the creation, care and feeding of constructs is a fundamental task, and one which must precede most other scientific work."

(Berlo, p. 2).

One construct frequently used in communication research is "information." This paper will describe ways the construct "information" has been explicated during the last 20 years and will suggest some areas for further explication of the construct.

The Problem of Construct Explication

For purposes of this paper, construct is used in Conant's sense of the word - a concept that has been created or appropriated for scientific purposes. (Conant, p. 31). A construct is a word (a symbol) that the scientist can manipulate and for which he can provide meaning. To be useful to the scientist, the construct must be reliable; that is, when it is applied it must consistently include the same phenomena and exclude other phenomena. This suggests two things:

- 1. Tightness or rigor at a logical, formal level.
- 2. Tightness in operationalization or measurement.

In Berlo's terms, there are two linkages for the construct; the linkage of the term to physical events (operational definition) and the linkage of the term to other terms (the constitutive definition). (Berlo, p. 2).

These problems of definition are of practical importance when we deal with the construct information because the term is used by both the scientist and the layman. To the layman, "fish" is practically anything that swims, including whales, eels, etc. But to an icthyologist, it has a rigorous, specific meaning. And to the layman, "electricity" is a useful construct to describe whatever it is that makes the lights go on but the electrical engineer needs a good deal more precision. To him, electricity is almost a meaningless construct unless it is specified in terms of volts, amps, resistance, etc. in the circuit. These few sentences are, of course, only a clarification of what is involved in construct explication for purposes of this paper. Rudner deals at some length with the problem of construct explication in the social sciences (Rudner, p. 19).

Information - Boundaries and Measures

As has been noted, to the layman "information" means a variety of vague things. For example, he could mean information about new cars, or the information explosion, or the service the phone company provides. Sometimes the communication researcher uses it like the layman, sometimes he uses it more precisely. When using the word information, this paper suggests that the researcher could be using the word even more precisely. As it has been used in research, the word seems to shift focus and change the boundaries of what is in and what is out. Sometime the boundary is drawn so that the "information" is in the external world (that is, in

the stimuli). Sometimes the boundary is drawn so the information is in the person's head (what is informative is what will change what is already "known.") This problem of changing focus and boundary will be dealt with as a problem of locus.

On the measurement dimension, the operationalization of information differs. It is often at the nominal level of measurement (that is information and this isn't); sometimes it is at the ordinal level of measurement (200 words is defined to be more information than 100 words but not twice as much). Sometimes it is difficult to measure information at all (the amount and kind of responses we get when we present a question to an information retrieval system). In this last case, the question of what is a relevant answer and what is not relevant becomes important, as does the problem of how much of the relevant information has been retrieved and how much has not been retrieved.

A Matrix for Examining the Multiple Usages of Information

Section V of this paper presents a table that illustrates four uses for the word "information," the locus of the usage, the function of the usage, how the usage relates to uncertainty, and some advantages and disadvantages of the particular usage of the construct when studying the process of human communication. The four usages are labeled I_1 , I_2 , I_3 , and I_{μ} .

I₁ is statistical information. The word is used here in Shannon's sense (Shannon, p. 32). I₂ may be looked at as "pieces" of information. ("Pieces" is used to avoid confusion with Shannon's "bits"). The pieces are known collectively as the world's knowledge. Another way of conceptualizing this usage is to borrow Teilhard de Chardin's word noosphere -

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a word he used to describe the "thinking layer" or the total sphere of intellectual activity which he predicted would eventually cover the earth, much as the atmosphere does. (Teilhard, p. 180). Still another way of conceptualizing I2 is in Brillouin's term "absolute information" as opposed to "distributed information," (Brillouin, 1950, p. 595). Absolute information exists as soon as at least one person has it. There is more absolute information as a result of a new scientific discovery, a musician composing a symphony, an author writing a book - anything creative or imaginative which adds to the noosphere. When the absolute information spreads to more than one person, we have distributed information which is labeled I3. This usage is close to the more normal dictionary sense of the word. This usage is an informing or being informed, a telling or being told of something, news, acquisition of facts, an answer to a question, etc. The fourth usage, I_{μ} , is proposed as concerning the state of the communication system. Much of I_{μ} at the interpersonal level is received via nonverbal channels (smile, frown, gestures, etc.) which makes it difficult to articulate its meaning. Its functions are largely to: 1) define the relationship of the living systems to one another, 2) define the communication system's relationship to the environment, and 3) define the relationship of the actions of the system to the goals of the system.

The next four sections of this paper will deal with the four usages of information. Section V presents some conclusions and implications for further research.

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CHAPTER II

SHANNON'S USE OF INFORMATION (I_1)

Shannon's concern is with the transmission of symbols within a specified system. As the symbols are sent from a source to a receiver, a certain amount of uncertainty of the receiver is reduced as the symbols are received. Shannon was looking for a measure of how much information is produced as the receiver receives the symbols. His measure is a measure of the freedom of choice in selection, which is related to how much uncertainty there is to begin with as the message is received. The measure he derived is:

$$H = - K_{\Sigma}^{n} p_{i} \log p_{i}$$

which states that the freedom of choice or uncertainty is a function of the number of alternatives and the probability of occurrence of these alternatives (Shannon, p. 50). Shannon was not concerned with meaning in the sense of what human value might be attached to the symbols being received. The symbols are not necessarily letters, as the next few examples attempt to illustrate.

Information as a Choice between "on" and "off."

A stimulus from the environment can be a source of information if we have a priori knowledge that the stimulus can either be on or off.

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If we have a doorbell, it can be in either of two states (ringing or not ringing). The meaning of the ring is arbitrary - something which we assign ourselves. In Shannon's sense of information, there are two symbols in the repertoire that we as receivers have a priori knowledge of: ringing and no ringing. In general, we assign the meaning "someone is at the door" to the state of ringing and the meaning "no one is at the door" to the state of not ringing.

It could easily be arranged the other way. The bell could ring continuously when no one was there and, when someone pushed the button, the bell would stop ringing which would tell us that someone was there. The latter case is the way we rig electronic eyes. The continuous beam tells us no one has crossed it. The cessation of the beam tells us someone is there. In each of the instances described, we have signs which are capable of being in more than one state (on or off).

Suppose that we get tired of answering the doorbell ourselves and we hire a butler. We'll call him Harry. If someone knocks (another on - off system) on the door or rings the bell, he responds by answering the door. But on Harry's day off his brother stands in for him. Alfred won't open the door until the caller rings the bell and knocks on the door. Our friends will ask us "What's with those two?" We'll reply with a shrug and say "I don't know, they're just different." By different, what we're saying is Harry and Alfred seem to process stimuli from the environment differently. All "objective" observers perceive two stimuli - a knock on the door and a ring of the bell. Most observers agree that the expected response for either stimuli is an opening of the door. Yet, Alfred doesn't open the door until he hears

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both. Or maybe he doesn't "hear" both. Maybe his hearing response curve drops sharply at the frequency range of the ring of the bell. Or, maybe he requires a ring and a knock as conditions for opening the door.

This discussion underscores that we know what we know by what we perceive through our senses. But we may not all have the same meaning for what we perceive. And even if we perceive the same stimuli as someone else, maybe we process incoming stimuli differently and respond to them differently. A stimulus isn't a stimulus unless there is more than one alternative on the incoming channel. It must be bell-no bell, or hi bell-low bell, light-no light or green light-red light, touch-no touch or hot touch-cold touch, smell of roses or smell of beer. If our receptors (our senses) perceive some change in the environment and we take these changes into account, then these changes become information to us.

Information as Freedom of Choice (Degrees of Freedom)

Information in this sense is a measure of the freedom of choice (in the statistical sense) when selecting a "message" from an available set. Many more symbols to which more meanings could be assigned could be packed into our doorbell code. A bachelor with five girl friends could agree in advance with each one on a unique ring. Mary has one, Betty has two, etc. Now when the bell rings, he knows which of the "on" states he hears which tells him: 1. someone is there, and 2. who the someone is. The patterned input has a referent; the pattern now signals a unique young lady.

But a problem arises. Any stranger is likely to use one or two or so rings. And our friend may wish to know whether a friend or a stranger

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is at the door. So he puts in a conveniently located but secret second bell which has a different sound from the first. Now when he hears a bell he knows: 1. someone is there, 2. friend or stranger, and 3. which of the five girls it is.

If our friend has a desire for even more certainty as to the "meaning" of the bell when he heard it, he could assign every friend a unique ring. He may even want to discriminate between close friends and acquaintances. He could use more bells and more codes. But then he may find himself in the position, if he is a popular young man with many friends, of waiting for several minutes as his friends ring out their assigned code. He could reduce his waiting time by putting in more bells with fewer codes per bell, but bell installation can become costly. He may ask himself if it wouldn't be cheaper and faster to install a closed circuit TV system. He has figured intuitively that he can get more information per unit of time per unit of money on a TV channel than on many spearate wire channels.

This comparison of the relative information carrying capacity

(number of alternatives) of different channels of information transmission

is the one faced for many years by engineers at Bell Telephone Laboratories.

The man who devised a statistic to compare different channels was Claude

Shannon. He didn't care what the "meaning" of the information being

transmitted was. That would be left to the discretion of the person

using the channel.

Shannon's Mathematical Theory of Communication (Information Theory)

Shannon, in his classic paper, points out that information, as he uses the term, is significant in that the actual message is one

selected from a set of possible messages. His problem, as a communication engineer, is to design a system to operate for each possible selection, not just for the one which will actually be chosen since this is unknown at the time of designing the system.

Information theory is not a theory as much as it is a measurement.

It is a useful statistical technique for quantifying amount of information.

Information in Shannon's sense as we have noted is a function of

- 1. the number of alternatives.
- 2. the probability of occurrence of these alternatives.

To clarify this point, let us consider an example. Imagine a dime on one square of a checkerboard. A checkerboard has 64 squares counting red and black squares. Pretend you have your back to the board and a friend is standing there who will answer yes or no to any question you ask about the location of the dime. With one question, you could know for certain which half (left or right) of the board the dime is on. If you say "Is it on the left half," and it is on the left half, he will answer "yes." If it is not on the left half, he will answer "no." In either case, you know which half for sure with just one question.

With another question, you could find out whether it is in the top or the bottom of the half. If you try this yourself with a dime and a board, you will see that with six questions, you can locate the dime precisely. In other words, each yes or no answer reduces your uncertainty (remember you are the receiver) by one half. You start with 64 possibilities and, with one appropriately asked question, reduce

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these alternatives to 32. The next question reduces the alternatives to 16 and so on down to the last question which reduces the alternatives to one - the one with the dime. This example is intended to illustrate information as a function of the number of alternatives; the more alternatives to begin with, the more information, i.e., the bigger the statistics. Now to the probabilities.

Imagine a school with 500 boys and 500 girls. You are to guess whether or not the first person you see coming through the door is a boy or a girl. You have a 50-50 chance or a probability of 0.5. Now, imagine a school with 999 boys and one girl. There are still two alternatives (boy or girl) but the probability of seeing a boy is 0.999 and the probability of seeing a girl is 0.001. While the number of alternatives remains the same (boy or girl), the appearance of a boy in the first case is more "informative" than a boy in the second case since it is less probable (.50 vs. .999).

In general then, the more alternatives we have and the more equally probable these alternatives are, the more "information." Each binary decision (yes or no) reduces the receiver's uncertainty by one half, given equal probabilities. It is the different probability of the alternatives that makes the game 20 Questions possible. Each question has a binary (yes or no) response. The total information available is 2²⁰ alternatives or 1,048,576 if we express it in the decimal system. If we restricted the game to just people, this means that we can eliminate as possible answers just a little over a million people with 20 questions. But there are over 3 billion people on earth at present and more than that if we count those who have lived and those

who will live. The only reason we can, with 20 guesses, reduce the choices to Liz Taylor or Julius Caesar is because they are more probable selections than the third name from the top on page 33 of the New York telephone directory or the centurion who was in charge of the palace guard on the night Caesar was killed. Shannon's theory then gives us a measurement for "information" specifically based on the number of alternatives and probabilities for the alternatives.

Information and Uncertainty - Some Distinctions

This paper attempts to illustrate different kinds of information.

These different kinds of information each reduce some uncertainty. But,

just as there seems to be different kinds of information, there seems

to be different kinds of uncertainty, which might be useful to distinguish.

For some kinds of uncertainty, there are methods for having a priori knowledge of the range of uncertainty. If we roll a die, for example, we have some knowledge that the outcome will be one of six possibilities. In reading a message written in English, we have a priori knowledge of the letters that will be used and the words that will be used. But we have no way of calculating the probability that the nth person reading this paper will drink a glass of orange juice while he or she reads it. There appears to be some limits for the different kinds of uncertainty.

Brillouin (1962a) presents a discussion of uncertainty in terms of scientific experiments which illustrates some of the different kinds of uncertainty. If we plot two variables against one another, for example x and y, and let a be the full range for x and b be the full

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range for y, then after a few measurements we conclude that x and y always fall within a certain shaded stripe (See Figure 1). This accounts for a certain empirical law and certain limits of error. P_0 = ab the full range of variation of x and y while P_1 is the area of the shaded region. Range of error is e_1 to e_2 .

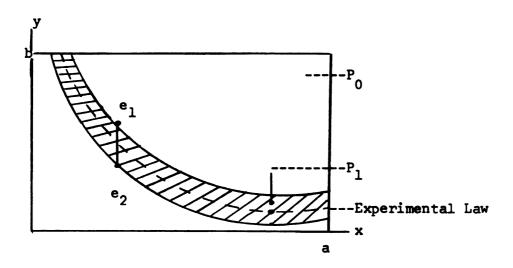


Figure 1. Kinds of Information and Uncertainty

He notes that a scientific law:

- 1. has a limited field of application
- 2. is correct "within possible errors"

Without specifying both 1 and 2 the statement of the law is incomplete and valueless.

In summary, then, there are several levels of uncertainty. There is the uncertainty of measurement error but this falls within a range that we can specify. There is the uncertainty of where the relationship

will lie when measured but, before measuring, we can predict that it will fall in the range ab. Finally, there is the uncertainty of all other variables not covered by the area ab. If the system we are examining is a complex one, we may not know if ab is orthogonal or what the relationship of a and b are to the rest of the variables we could use if we considered them separately.

Information as Uncertainty Reduction

We may now examine the point of view in the previous examples. It is the receiver's uncertainty which is being reduced, and the uncertainty is within specified bounds. The sender encodes a message using a set of symbols which is agreed upon as a code by the sender and the receiver. The receiver must have prior knowledge of the code in order to decode the symbols. The meaning of the symbols is arbitrary. Even in the game, 20 Questions, the sender already knows the answer. It is the receiver who is reducing the uncertainty that he, the receiver, has.

A Note on Shannon and Weaver

As this chapter progresses, the examples shift from what has been labeled I₁ to what we have labeled I₃. This is, in part, due to a shift in emphasis from the writing of Shannon to the writing of Weaver. Shannon deals primarily with what has been labeled I₁. Weaver deals with information, but suggests an extension of the work into the semantic level and the behavioral level. These levels treat meaning - something Shannon does not do in his paper. Weaver is careful to make the distinction in his paper but, in the application of Shannon's work by other researchers,

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information (in Shannon's sense) and meaning are sometimes confused.

This confusion will be discussed later in this section.

Uses of "Information" Similar to Shannon's

MacKay distinguishes two kinds of psychological information the logon and the metron. He defines logon as "a priori information"
due to the logical structure of a set of alternatives or of an experiment; this is closely related to the concept of degrees of freedom.
He describes metron as information which is obtained from measurements
we take. It is related to the concept of precision in the statistical
sense of the word.

Garner uses MacKay's notions in an example of reaction time as a function of the modality of the stimulus. Let's say we have three stimuli: visual, auditory and tactual. This limits the amount of information we can obtain. Three stimuli have more potential information to a receiver than one stimulus. This aspect of the problem provides logon content. We then measure reaction time for each of these stimuli. This measurement also provides information, but its amount is limited by the precision of the measurement; and we ordinarily determine several such reaction times in order to obtain some estimate of the precision of the measurement. This aspect of the problem provides metron content (Garner, p. 10).

MacKay's distinction between logon and metron is important to

Psychology because humans apparently make use of both kinds of information.

Sometimes one or the other is more important for human processing of information.

Broadbent (p. 113) has said:

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- 1. SR psychology uses occurrence of stimuli past or present.
- Gestaltists consider patterns of stimuli present at any one time.

Neither talks about effect at any moment of the stimuli which might have occurred but did not. Broadbent considers what might have happened to be important in psychology. An example in human communication illustrates this. A person may do a good job and turn to the person he has done the job for expecting to hear a well deserved "thanks."

If the "thanks" is not said, the person who has done the good job may feel bad. What has not occurred, in this case, becomes important in the communication system involving two people.

Garner in his Uncertainty and Structure as Psychological Concepts says he uses "uncertainty" rather than "information" to avoid confusion with Shannon's work. His "uncertainty" is reduced by "information" gained during a communicative act.

Some of the more important assumptions he makes are:

- Uncertainty is a prerequisite to structure. Structure is related uncertainty, not the lack of it, and to have structure is to have uncertainty. Figure 1 illustrates this point.
- 2. The search for structure is inherent in human behavior.
 People in any situation will search for meaningful relations between the variables existing in the situation.
 Psychologists who run experiments where minimal or ambiguous cue differences exist find that subjects will find any cue at all to relate their responses to even if the cue is irrelevant to the task.

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- 3. Structure can exist meaningfully only within specified systems. The subject who sees a single stimulus as structure does so only because he generates an implied set of stimuli against which the particular stimulus can be contrasted or within which the particular stimulus can be subsumed.
- 4. Structure as such is a property of systems. Structure is an entire set of relations between variables and its amount and form can be specified without statement of the particular significations which operate because of the structure. The structure can be perceived even without the ability to verbalize the significations.

One application of Garner's notions of information measurement in a human communication situation is when we build displays such as a radar display for an aircraft controller. We can ask the question - if we use any perceptual or sensory continuum as a method of coding and displaying any information continuum, is it better to use a small number of discrete steps on the continuum, a large number of small steps or even to use the complete continuum with its infinity of steps?

For example, how could we show the altitude of an aircraft by the size of the symbol used to represent the aircraft? Assuming the higher the aircraft, the larger it appears on the radar screen, should we use 2, 3, 5, 10, 20, or 40 steps? A simple "errors made" experiment shows that performance deteriorates with an increase in the number of steps beyond some minimum value. But, we may want to trade off increased discrimination to offset the number of errors. Five categories may

give us no errors and ten categories may give us just one error. We get twice as many steps at a modest increase in the number of errors.

In summary, with writers like MacKay, Broadbent and Garner, we find "information" measures being applied to problems of psychological uncertainty.

Information and Meaning -- A Controversy

A controversy in the literature concerns Shannon's use of information and the use of information by others to mean "meaning."

Bar-Hillel for example, says there's no connection between the amount of semantic information conveyed by a statement and the measure of rarity of kinds of symbol sequences. He says "Apples are red" carries semantic information regardless of how frequently the statement is transmitted.

Weaver's discussion of three levels of communication problems helps reduce some of the confusion (Shannon and Weaver, p. 4). He refers to the following levels:

Level A. How accurately can the symbols of communication be transmitted? (The technical problem).

Level B. How precisely can the transmitted symbols convey the desired meaning? (The semantic problem).

Level C. How effectively does the received meaning affect Conduct in the desired way? (The effectiveness problem).

Information and Behavior

While Weaver's distinction of levels helps reduce the confusion, it also illustrates some of the confusion. His levels B and C imply that

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meanings can somehow be transmitted if the sender is only skillful enough in his selection of symbols. It may be more useful if we view meaning as an attribute of the person and not of the message. The incoming stimuli can elicit certain meanings in the person receiving them. This places the focus of communication research on the linkage system between two persons or, as will be suggested later, between any two living systems. Some questions we may wish to determine are:

- 1. What signals from the environment are detected by the organism we are studying? (What information is produced?),
 - 2. How subtle are the discriminations of these signals?
- 3. How are these incoming signals used by the organism to adapt to its environment?

For example, we use the word "blind" to describe those organisms which are incapable of sensing visual stimuli. And George Miller (1956) describes experiments which suggest that even those who see normally can discriminate a limited number of changes on a given channel.

By this we mean that given a range of light intensities, for example, with each intensity being given a label, above seven or eight different intensities most people make errors in responding with the correct label when presented with a given intensity. Finally, stimuli from the environment take on "meanings" for a particular organism. Rats being conditioned, for example, will associate the ringing of a bell with obtaining food and respond to a bell in a manner greatly similar to the manner in which they originally responded to food.

One thing we might consider when talking of the behavioral aspects of communication (Weaver's Level C) is whose point of view are we taking?

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Ackoff's model of communication illustrates this point. Ackoff has a particular use for information. First, he assumes a person is in a purposive state. By this is meant the individual has a decision to make and he has at least two alternative methods of achieving a goal. His decision consists of selecting an alternative to achieve his goal. If we modify the person's value of the goal (in relation to the set of goals he might have) the message is one of "motivation." If we change his estimate of the relative efficiency of a given alternative such that it changes the probability of his selecting that alternative, the message is one of "instruction." If we provide him with an alternative which he was not aware of before he received our message, the message is "information."

Ackoff's labeling is from the point of view of someone in the environment watching the person who is making the decision. An experimenter has some knowledge of what messages he is sending to the subject from the experimenter's point of view but he has no certain knowledge of what the subject perceives and he has no knowledge of what past experience or present needs the subject is bringing to bear to operate on the stimuli from his environment.

Man As An Information Processor

James Miller, Norbert Wiener, Colin Cherry, Stafford Beer, and Others have suggested that we look at man as an information processor. Wiener has said the world may be viewed as a myriad of "To whom it may Concern" messages. Man gets data from his environment in the form of lights, colors, sounds, smells, symbols, pictures, touch, taste, etc. If we view man as an information processor, we might ask what kinds

of operations he can perform on raw sensory data coming in from the environment. Eventually we would like to be able to say under what circumstances a given person will perform a given operation. Some of the possible operations are:

- He has the ability to filter and smooth data, to reject extraneous detail and to fill in missing elements.
- 2. He has the ability to integrate, or combine, an array of coded data into a composite picture of a physical process or event.
- 3. He can store and relate large quantities of data far beyond the capacity of any known computing device.
- 4. He can extrapolate from diverse data to establish future trends and interpolate between available data to predict missing data or determine the need to seek out additional or new data.

The human also has remarkable adaptability at times. He will often respond to overload by reducing the number of input sources he attends to; or change the pattern of scan across the inputs. He will often reduce the number and kind of his outputs to adapt to emergency situation. An example here is the random crawl of a baby heading toward a swimming pool and the variation in sampling frequency the attending parent, who is also reading a book, will devote to watching the baby as a function of distance to the pool. In this instance, the data sought from the environment is based on observation of the environment plus extrapolation of the baby's speed and direction. If the baby approaches the point of no return (point at which present heading and speed will

carry him into the pool before the parent can overtake him) the parent behaves by dropping the book, jumping up and picking up the baby.

It would appear that the kinds of data the human seeks from the environment depends sometimes on what activities he is engaged in, what his goals are (e.g., save baby from falling in pool) and the kinds of decisions he must make.

This section has attempted to illustrate how changes in a given stimulus from the environment are perceived by man and how these changes take on meaning as a function of the man and the environment in which the stimulus appears.

Shannon's use of information is a measure of the freedom of choice one has when selecting a message from an available set. Information, in this sense, is related to the number of alternatives and the probability of occurrence distributed across these alternatives.

Researchers such as Garner, Berlyne, Attneave, Broadbent, and MacKay have adapted Shannon's notion and have looked at characteristics of the stimuli which can be varied in a manner that seems to affect human behavior.

Although Shannon's work has some use in the study of human communication, it deals with an optimal theory of coding of sets of arbitrary symbols. Since any stimulus in the environment can be considered as a set of symbols, the theory has provided some insights into the mechanical limitations of man's sensory system. The question of why man does as he does when he senses data from the environment is another matter.

CHAPTER III

INFORMATION2 AND INFORMATION3 (ABSOLUTE AND DISTRIBUTED)

It may be useful to begin this section by considering Brillouin's notions of absolute and distributed information. He suggests that active, creative thinking requires invention, methodological imagination, unexpected comparisons; and it results in a new idea, representing a completely new type of absolute information. He says that there is more absolute information when we have a scientific discovery, a new scientific law, an author writing a book, a musician composing a symphony, an artist painting a canvas, and other examples of creative work. Brillouin (1962a) defines absolute information and distributed information as:

- absolute information, exists as soon as one person has it, and should be counted as the same given amount of information, whether it is known to one man or to millions.
- 2. distributed information, defined as the product of the amount of absolute information and the number of people who share that information. In the process of broadcasting the information, from the point where it originates to all the persons who finally receive it, a certain amount of information may get lost and the total amount of distributed information will be reduced by a certain percentage.

These two types of information suggest different types of research. The area of creativity research seems to be devoted to finding out how some people devise new answers to questions; to how they devise new questions to ask; and to how they devise new ways of looking at some phenomena. A creative researcher is a man who can ask the significant question.

Distributed information, on the other hand, suggests a focus on the linkage system between persons. This linkage system is found in teaching, in therapy, in mass communication, in diffusion of innovations in any area of communication research involving transformation of I_2 to I_3 . The next few pages attempt to present some boundaries of what is and what is not information in the I_2 and I_3 usage of the word.

Past Operationalizations of Information₃

Information₃ has been the focus of many areas of communication research. It is often operationalized as a measure of some kind of information gain or recall. It is sometimes operationalized as time spent attending to a communication. Dervin (p. 5) notes that information gain, information level, learning, memory, retention and recall are used interchangeably. Some of the definitions used are:

1. <u>Information level or support</u>: the knowledge an individual possesses which is relevant to his attitude, the amount of information an individual is capable of bringing to bear in appraising the topic of an attitude. (Smith, Bruner and White)

- Recognition: information level measured with true/false or multiple choice items which require a discrimination of what one has learned in the past. (Mednick)
- 3. Recall: free response by the individual of information learned in the past, a method of measuring information gain and retention in which individuals must freely verbalize and produce responses without structured guidelines. (Mednick)

Examples of information operationalized according to one of the definitions above are abundant in the communication literature.

Recognition is used by mass communication researchers in studying the spread of a news story (Tannenbaum and Greenberg), recognition or recall is used in the study of the diffusion of innovations (Rogers), recognition is used in the study of rumor (Shibutani), recall and "time spent listening to a communication" are used in dissonance research (Brehm and Cohen). In a sense, much communication research concentrates on information; if we consider some message being presented to some group of persons. It may be more useful to consider messages as raw data in the environment and that information; depends on the message, the person and the context for more explicit specification.

Information 3 viewed as an Interaction Process

Let us consider, for a moment, the number "80" as a potential element of information₃. If the question is posed by a stockbroker "What is General Motors selling at today?" the answer "80" becomes information₃ to him. But if a physician asks his nurse "What is that patient's temperature?" The answer "80" is not within the range of

acceptable answers. The physician's experience with body temperature of live patients causes him to "believe" temperatures from perhaps 95 to 105 degrees. The number "80" is a data point in the environment. In other words, as raw data from the environment becomes transformed into a cognition, the data become information₃ to the person. The information₃ can be correct or incorrect depending on some belief system. In this view, then, information₃ can be taken as an interaction between the person and the environment or, more generally, an interaction between a living system and its environment.

In this view, there appear to be a number of elements:

- 1. Some kind of energy pulse which is: a) above sensory thresholds and b) similar to some energy pulse which has had sign or symbolic relevance for the organism previously. (That is, it's recognized as "80" not as the nurse clearning her throat it is seen as a signal rather than noise).
- 2. Some aspect of the environment for which the energy pulse acts as a symbol (that is, 80 refers to temperature, not weight, or dollar value, or number of patients).
- 3. A "program" inside the receiver which tells him how to handle incoming inputs. ("I ask the temperature because it is related to x,y, and z; if it is above point t, I take steps a, b, and c; if it is below point t, I take actions d,e, and f; if it is outside the range 95 to 105, I recheck...)

More generally, information (in any of the usages) is a meaningless construct unless it is specified in terms of its constituents some set of symbols interacting with some receiver with information being produced as a result. For example, let us consider I_1 , again. Weaver (p. 33) notes that information may be a function of time f(t) as in radio or telephony, or it may be more complex. Black and white TV, for example, may be thought of as a function of two space coordinates and time; the light intensity at point (x,y) at time t on a pickup tube plate.

A color TV provides more information and is even more complex. It is several functions of several variables f(x,y,t), g(x,y,t), and h(x,y,t). For us to specify the message of a combined color reception and associated sound at any time t, requires the specification of the several functions noted for color TV plus the specification of the associated sound message f(t).

Weaver's comments have their locus in the channel and the code. But information in the I_3 sense becomes information in an analogous manner. The distributed information is a function of some living system in some context at some point in time. (For example, the stock-broker in the context of his office receiving the answer "80" to his question.)

In a similar manner, the next section examines I_{ij} (information about the state of the communication system). In the case of the physician, he had a "theory" of what the answer should have been when he asked his nurse for the patient's temperature. An answer that fell outside the range of answers predicted by his theories was not accepted or believed. The information in this instance was erroneous in the context of his question but it may have caused the physician to think about the state of the communication system between him and his nurse (for example, she didn't understand my question, she's incompetent,

she must be kidding me, I didn't hear her correctly). The "80" becomes information, - information about the state of the communication system.

We can use an example given earlier in this paper to illustrate I_{4} . In an earlier section of this paper, the game 20 Questions is used to illustrate the gradual reduction of uncertainty by receiving "yes" or "no" answers to questions. This example can be used in another sense to illustrate I_{4} - information about the state of the system. If a person were playing the game 20 Questions and were told that "yes" and "no" represented the complete repertoire of symbols, how would he react if he got the response "maybe," to a question he posed? If he were a simple receiver (as a radio or TV is), the "maybe" would be perceived as noise. But the human receiver (for example, the physician) is more complex than that. An answer like "maybe" would be a cue that the rules of the game were being changed. It would be perceived as a communication about the game because it is not one of the symbols permitted within the game.

Information, in any of the usages, seems to be a process of becoming aware of, or of ordering, or comprehending, or accepting raw d ata from the environment. It may be convenient to view information as a process - an interaction between a person (or any living system) and data in the environment.

CHAPTER IV

INFORMATION - GENERAL SYSTEMS THEORY APPROACH TO COMMUNICATION

Since the early 1950s, there has been increasing interest in General Systems Theory and its application to the study of various areas such as management (Beer), formal organizations (Katz and Kahn), economics (Boulding), living systems (Miller) and other areas of scientific inquiry (See General Systems Yearbooks beginning in 1956). There has been some attempt to apply this approach to the study of human communication (Watzlawick, Beavin and Jackson). This section explores some of the implications of the General Systems approach with regard to the discussion of information. To begin, we might consider another approach that has been used as a model for communication - the S-R model from psychology.

The S-R psychologist, as we know, goes to great lengths to control as many variables as possible; he then manipulates one variable and measures some response variable. This Stimulus-Response model has had great success in psychology and, through it, some important theories in psychology have been constructed.

It is tempting to think of messages and humans in terms of the S-R model. A message is presented to a person and he reacts in some manner which is predictable and measurable. And, in the case of learning machines, the S-R model may be quite useful. The learner is

put into a controlled environment in which competing stimuli are eliminated; then, the learner is presented with a stimulus or aseries of stimuli. His "correct" responses are rewarded in a manner that shapes his behavior. The end result is that his response to a given set of stimuli is changed and the change is relatively enduring - in a word, he has "learned."

But in many communication situations, the S-R model doesn't seem to help theorists construct a theory of communication. In the everyday world, many stimuli (cues, messages) compete for the attention of the individual. Furthermore, a communication system involves more than one person. A patient talks to a therapist, a student talks with a teacher, a husband talks to his wife or, on a higher systems level, one company deals with another or one nation conducts diplomatic relations with another. These communication systems are more complex than the S-R situation in that the stimuli available for selection are more numerous and the responses to the stimulus are also more numerous.

There is, of course, a theoretic issue involved here. Many S-R theorists argue that there is nothing intrinsically limiting about the S-R approach. They would say that complex S-R models - taking into account hierarchies, etc. - will eventually handle these problems that have been raised. They would say that the criticism offered is just a criticism of research to date, not a criticism of the heart of the S-R approach. Others would argue that S-R is intrinsically limited and could never get to these problems. This paper views the General Systems approach as appearing to be more fruitful for examining complex communication systems.

As an example of a system, let us consider a boat that is rowed by eight men with a ninth man guiding the boat by use of a steering oar. The boat plus the nine men may be considered a system, with each man being considered a subsystem. The kinds of statements we might wish to make about the system (boat plus men) would refer to speed and direction. Each man who is rowing is participating in the overall goal of the system - getting from point a to point b. If one of the eight men stops rowing, the velocity is affected somewhat but the direction is not affected as much. But if the man at the helm stops steering, the heading is affected more than the velocity.

It becomes easy to see the effect of varying the number of subsystems. If the boat were a large one - rowed by 32 men (sixteen on each side), then the effect of one oarsman (whether he rows or does not row) becomes less important to the outcome of the overall system (boat plus men). In this case, it is doubtful if the single oarsman could change the heading or velocity no matter how hard or fast he rowed. On the other hand, if there are only two oarsmen, the effect of one oarsman is great on the heading and velocity of the overall system (men plus boat).

In this example, it is also possible to illustrate levels, differentiation of function of subsystems, and relative power over system goals. (That is, the oarsmen can be taken as one subsystem - with each man a component in this subsystem - while the helmsman comprises another subsystem. The first is a power subsystem while the second is a guidance subsystem).

In summary, the subsystems (men in the boat) cooperate in sharing a common goal or value. Each of them contributes his share to the goal of the overall system - getting from point a to point b. In order for the overall system to achieve the goal, the subsystems must each contribute their share. If the overall system is large (many subsystems), the effect of one particular subsystem may be small. If the overall system is small (two subsystems), the effect of one of the subsystems on the goal is likely to be quite large. And each subsystem is affected by the others.

So far, it has been suggested that a communication system, in many cases, may be more complex than suggested by an S-R learning model; that a communication system must consider the total number of living systems within it and that the minimum number seems to be two; and that these systems plus the environment should be examined. The manner in which information (in all its usages) is processed by the living systems may be a useful focus for the study of communication.

If we view communication as a process involving systems, we can look to General Systems Theory for guidance in an analysis of a communication system. One writer in General Systems Theory, Kenneth Boulding, notes:

Almost every discipline studies the interaction of some kind of "individual" with its environment. The individual may be an electron, atom, molecule, crystal, virus, cell, plant, animal, man, tribe, state, church, firm, corporation, university, and so on. Each of these individuals exhibits "behavior" action or change and this behavior is considered to be related in some way to the environment of the individual - that is, with other individuals with which it comes into contact or into some relationship. (Boulding, p. 199)

at least two living systems. In order to study communication, it is suggested, the system must be specified, and the environment in which the system exists must be specified. The information (all usages) produced is a function of the living system in the context of some environment. Going back to the example of the number "80", the living system, in one case, was a stockbroker and the environment is his office. In that context, the reply "80" becomes information, to him.

Boulding posits nine levels of systems - each of which may have some use in the study of communication systems. Each level incorporates the characteristics of previous levels but has added characteristics of its own. The sixth, seventh and eighth levels may be of particular use in studying communication systems. The sixth is the animal level in which we have the development of specialized sense receptors (eyes, ears, etc.) and an enormous increase in the intake of information. This information is channeled through a nervous system and is apparently organized by the brain into what Boulding calls a knowledge structure or "image." "Once the image structure is well established," says Boulding, "most information received produces very little change in the image."

At the seventh or human level, the system possesses self consciousness. By this Boulding means that not only does man know but he knows that he knows. At the eighth level - the level of social organizations - the person in the organization is more of a "role" than a person. Boulding would view any social system as a set of roles tied together with channels of communication. At this level, he would

concern himself with content and meaning of messages, nature and dimensions of value systems, etc.

Boulding suggests that living systems have agreed upon rules for deciding what information to process and how to process this information. Constructs such as "role" and "value" suggest preferred states of the system and of systems within the system. Boulding says behavior is described in terms of restoration of these preferred states when they are disturbed by changes in the environment. These preferred states of the system may be considered $Information_{\mu}$. Several writers have suggested that we look at the relationship aspect of communication as well as the content aspect. I_{μ} is information about states of the system or the relationship aspect of communication.

Thayer suggests that information from the environment permits the living system to adapt to the environment. The living system's ability to take into account features and events of the environment serves the purpose of establishing, maintaining, exploiting, or altering some relationship between the living system and the environment. (Thayer, p. 33). Another living system is part of the environment to any given living system. When one living system behaves (uses languages, gestures, etc.), the originator's product is nothing but sense data to the other living system. The functional message the second living system gets is an internal, subjective creation of the second system.

Thayer suggests the only reality upon which an individual can base his behavior is his own reality - his conceptual structuring of the world, his model or image of it, his expectations about the future.

The world we see and hear and comprehend depends on how we are individually organized to convert raw event-data into information (all usages), and the sort of conceptual systems we individually have to make messages out of that information.

Thayer notes every individual must develop his own model of the world either:

- 1. In and through his own individual sensory experiences of it, or
- 2. In and through his accumulation of standardized interpretations of it - via education, socialization, observation, and imitation, etc. The price of membership in a culture or a subculture is the abdication of certain degrees of freedom by the individual (wittingly or not). (Thayer, p. 48).

Other writers have suggested looking at man as a creature who views the world in terms of theories he might have about the way things are. Kelly's notion is that a person's processes are psychologically channelized by the way in which he anticipates events. Miller, Gallanter and Pribram title their book Plans and the Structure of Behavior to suggest that man has expectations before he acts, then he acts, then he checks to see if events conform to his plans.

A recent book echoes these thoughts even though the terminology used is slightly different. Watzlawick, Beavin and Jackson see a content and a relationship aspect for any inter-communication between individuals. Psychiatric symptoms are viewed as behavior appropriate to an ongoing interaction. Such symptoms grow out of an interaction with others rather than being caused by one's "insanity." In a similar

manner, a "leader" would also be a relationship growing out of a particular communication situation.

Content refers to the information I_1 and I_3 derived from a message. Relationship refers to the kind of message it is in terms of relationship (I_{ij}) between communicants. Watzlawick et al., say communication is virtually interchangeable with behavior. All behavior in an interactional situation has message value. It is impossible to not communicate. An attempt to not communicate communicate just that: "I do not wish to communicate." "Cause" and "effect" begin to become meaningless in an interaction situation. It is meaningless to describe any given behavior as the "cause."

An interactional system is one involving two or more communicants seeking to define their relationship with each other. This includes notions such as rejection ("I'm busy, leave me alone") acceptance ("I'd love to go with you" or "that idea of yours is a good one") disqualification ("close one's eyes and hope that he goes away", evade the issue, etc.).

In terms of uncertainty reduction, I_{4} reduces the uncertainty that the living system might have concerning his relationship with other living systems in the communication system. The "meaning" of I_{4} is difficult to articulate and, hence, difficult for the researcher to work with. For example, North Americans are often exasperated with persons from other cultures when doing business with them. The persons from South American countries, for example, do not "get to the point" when conducting a business transaction. But, may

we not view this as a cultural difference in the relative emphasis on the content and relationship aspects of communication? Perhaps the main goal of the conversation in a South American country is to "define the relationship." What a North American would call "getting to the point" would be bad manners and cause social disapproval. This social disapproval is an example of I_{μ} which would be perceived by both persons in the conversation as a defining of the relationship.

Out of the Hovland research we find that "social approval" or "social disapproval" is a major factor in opinion change or attitude change. A person may conform (behave) in some manner because of the threat of detection and punishment. It might be useful to keep Hovland's "social approval" factor in mind and, viewing man as a living system, look at communication, in part, as an attempt at two or more living systems to define their relationship to one another. The "defining of the relationship" may be one of the most important goals of the attempt to communicate. Man may be viewed as a living system attempting to relate to other living systems.

An area of communication research that is not devoted to the study of language is currently labeled "nonverbal communication." It is probably through nonverbal cues (nods, smiles, frowns and other behavior) that we obtain most "social approval" or "social disapproval" messages. If "approval/disapproval" cues are important in defining the relationship and if "defining the relationship" is an important goal of communication, the study of nonverbal communication becomes as important as the study of language. Nonverbal communication may be considered as information, about the state of the system.

Information, and Learning

It may well be that I_{μ} will be most difficult to work with in communication research. Once a relationship has been established, it seems to be difficult to change. Bateson suggests that learning to define a new relationship may be the most difficult kind of learning. He posits four levels of learning (Bateson, p. 183):

- 1. Simple learning or what we have called the ability to take something into account.
- 2. When a person changes his ability to receive the yes or no answer to a question (e.g. when a dog learns that a buzzer means future meat powder).
- 3. Acquisition of "test wisdom or set learning". A person learns to look out for sequences of a certain sort in his universe, which includes external events and his own behaviors.
- 4. Problem of changes at the third level. To make changes at the third level is painful and difficult.

Bateson feels that fourth level learning (or changes at the third level) is a necessary part of human life. It obtains in courtship, in psychotherapy, in any reconstruction of relationship. He feels we don't know much about the phenomena.

To illustrate the problem, he tells of experiments by Alex Bavelas in which subjects are given a set of buttons to push and told that when they push them the correct way, a bell will ring. Actually, the bell rings after 50 pushes, then after 45 pushes, then after 40 pushes and so on until the number of pushes before the ring of the bell is 20.

Then, the subject is told that there is no relation between what he is doing and the ringing of the bell - that the bell is geared to a hypothetical learning curve. Subjects usually cannot be convinced of this but will reassert their theory of the relationship between the buttons and the ringing.

Several examples from other areas of communication research illustrate the usefulness of examining the relationship aspect of communication. Cross cultural researchers, such as Rogers, find that technical innovations are resisted in most cases until persons in the target population perceive that their referent group begins to adopt the new idea. As another example, we might consider T-Groups (training groups). One function of these groups is to get participants to reexamine their relationship with others (Bradford, Gibb and Benne, p. 1). The communication strategy involved is to change the environment - to unfreeze the perceptions. In this manner the same raw data from the environment can be reexamined for new interpretations. In Bateson's terms, the purpose is to make changes at level 3.; to develop new theories of viewing familiar phenomena. This area (I₄) deals with learning to define relationships and learning to redefine relationships. The relationships being defined may be viewed as:

- 1. Subsystems to one another
- 2. Communication system to the environment
- 3. Actions of the communication system to the goals of the system.

 The next section discusses some areas of possible research in defining these relationships.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS FOR RESEARCH

Table 1 shows the four usages of information that have been discussed in this paper. The matrix contains comments on each in terms of locus, uncertainty, function, advantages of using information in the particular sense and disadvantages of the particular usage. One immediate suggestion is the level of analysis suggested by I_{μ} - Information about the state of the system. This suggests that constructs such as attitude, opinion, belief and value be examined at a system level consisting of two or more living systems rather than using them as attributes of individuals.

Part of the difficulty with a discussion of this sort is the many labels we use for "ignorance." If two football teams are evenly matched on a number of criteria, considered to be predictors of winning teams, but one team defeats the other soundly and we don't know why, we say that one team was "motivated" more than the other. The word "motivated" is a convenient label we use for an intervening variable which we feel is there but which we don't know how to measure or demonstrate in any publicly observable manner. It seems this may be the case with constructs like "attitudes," "beliefs" and "values." These are often labels for intervening variables which we posit to explain why people behave as they do.

In contrast, the systems approach is more like the sportscaster watching the game. He watches the process - the two teams struggling to define their relationship to one another. Then, he attempts to identify the factors that contributed most to the outcome. This is not to say that posited constructs are not used. A system is presumed to have a goal (preferred state) such as the goal of getting from point a to point b by the men in the boat. But the posited construct will be in terms of the communication system rather than an attribute used to explain why an individual does as he does. Study of communication, in this sense, is a move away from the S-R model to the more complex systems model.

An example was used earlier of the North American wishing to "get to the point" whereas persons from other cultures may wish to spend more time defining the relationship. Communication systems may be viewed more conveniently if the relative amounts of I_3 and I_4 in them are specified. A communication system consisting of a patient and a therapist may be heavily oriented to I_4 , for example, whereas the communication system between a physics instructor and a lecture section of 500 students would be oriented to I_3 . It may be convenient to develop typologies of communication systems for purposes of analysis.

Specifying the goal of a system is of particular importance when building a system, which is the case when building information retrieval systems. It would seem that a distinction could be drawn

between libraries (devoted mainly to storing I_2) and information retrieval systems (perhaps more conveniently viewed as oriented to I_3). Rather than build an IR system by storing documents first, it may be more useful to identify a population of users, determine the kind and frequency of questions they ask, and build a system of answers to the questions. This means that questions of relevance of the answers, acceptability of the answers and other measures of system effectiveness might be worked out before the system is built.

In the classroom situation, we may wish to have teachers (persons) when the emphasis is on I_4 . Some content areas might be well enough specified so that we may consider them primarily I_3 and relegate them to more automated teaching techniques. This presupposes that those building the teacher-student communication system have some means of specifying beforehand the relative emphasis on I_3 and I_4 for different subjects. It also allows us, as Bruner suggests, to think about ways and means of developing in students the ability to create I_2 - in both the artistic and the scientific sense.

Table 1. Four Uses of "Information"

Locus	Uncertainty	Function	Advantages	Disadvantages
Channel, code	Function of alternatives and probability of the alternatives	Governs rules for coding symbols	Good for symbolic code analysis	Codes not available for many communi- cation situations
External to persons, "noosphere"	Not readily measurable	Man's attempt to explain his universe	Use as standard to measure I ₃	Difficult to operationalize
 Person (living system)	Content can be measured (cognitive type testing)	Helps person to adapt to his environment	Treats content portion of communication	No agreed upon measuring technique
System (two or more subsystems)	Relates to states of the system what is expected, pre- ferred state, etc.	Relationships being defined are: 1. Subsystems to one another 2. System to environment 3. Actions of systems to goals of system	Treats re- lationship portion of communi- cation	I is often ambiguous, thus, it is difficult to measure.

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