A systematic study of

# THE DYNAMICS OF HUMAN COMMUNICATION

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to systems emergent
from the Action Frame
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by

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A C K N O W L E D G E M E N T S

I would like to express my sincere thanks to my mother and late father for making it possible for me to write this thesis, to Professor James Irving for the inspiration and supervision he has given, to Mrs. Sandra Movsowitz for her patience and willingness in typing the manuscript and to all those who provided encouragement and stimulated ideas through discussion.

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NOTES TO THE TEXT

(1) On final reading it was observed that repeated use was made of first person plural, instead of first person singular. This was unintentional, the thesis being the original work of the author.

(2) Where quotations and material are taken from the works of other authors, this is indicated by inverted commas, indented paragraphs or numbered notes appearing, usually, at the end of paragraphs.

# CHAPTER I

## I n t r o d u c t i o n.

### I DELIMITATION OF THE FIELD

"Communication" has been described as one of the busiest crossroads in the study of human behaviour.[1] Workers in many disciplines have stressed the importance of knowledge about communication to their own work as well as contributing to the general pool of literature on the various aspects of the subject.

The following is a list of disciplines which either are concerned directly with problems of human communication or which bear in an important way on an understanding of the processes and conditions involved.

> PSYCHOLOGY, SOCIOLOGY, ANTHROPOLOGY, POLITICAL SCIENCE, ECONOMICS, MATHEMATICS, HISTORY, LINGUISTICS[2], ELECTRICAL ENGINEERING, CYBERNETICS, TELECOMMMUNICATION ENGINEERING, INFORMATION THEORY[3], NEUROLOGY, BIOLOGY, BIOCHEMISTRY, PHYSICS, AESTHETICS.

The above list is not exhaustive but represents some of the major areas of importance to the study of human communication.

It would be possible to subdivide the subjects listed to show the varying importance of aspects of these subjects to the study of human communication. Thus, for example, semantics is a branch of linguistics[4]; so are phonetics, phonemics, morphemics[5]. Both acoustics and optics are branches of physics.

The list represents only a static view of a field which is growing and changing. Information theory, for example, is a relatively recent addition to the body of knowledge bearing on human communication. Its founders, generally held to be Claude E. Shannon and Warren Weaver published their classical work on the subject, <u>The Mathematical Theory of Communication</u>, as recently as 1949.

Kenneth Boulding, writing in 1956, proposes, partly in jest, that a new science, to be called "eiconics" be founded to study the concept of the image[6]: eiconics, it would appear, would bring light to an important problem in the study of human communication.

As a result of the relatively short period which has elapsed since workers in the subjects listed began to pay more than lip service to the processes involved in human communication, and as a result of rapid and important advances in specialized, but not general, aspects of its study, communication has not generally been accorded the status of a discipline in its own right.

A check on the principle universities of Australia, Canada, South Africa, Great Britain and the U.S.A. shows that there are relatively few chairs in human communication in those countries[7]: more usually, it would appear, the study of communication is limited to courses included under well established disciplines in the humanities and the social sciences.

On account of the state of the field no substantive body of general theory has yet emerged which unifies the work done in the various disciplines concerned with human communication. No framework exists which might act as a common denominator for specialized areas in terms of which seeming incompatibilities might be removed. Colin Cherry stresses that "the various aspects of communication, as they are studied under the different disciplines, by no means form a unified study; there is a certain common ground which shows promise of fertility, nothing more."[8]

The need for a common general theory is great for, while the various disciplines approach communication with specialized interests, there are nevertheless certain major problems, a large proportion of which are common to more than one discipline. Thus, <u>the problem of meaning</u>, the reason for the existence of semantics, is important to other branches of linguistics as well and is central to large areas of modern philosophy. It raises questions which are crucial to sociology, psychology, social psychology and to anthropology.

While information theorists have not concerned themselves with semantics, information theory would seem to touch directly on this problem.

Another problem, which only logical semantics seems to have escaped[9] is that which concerns the process of communication. There is a need in the field for a common understanding of what logical and empirical steps are required for communication to take place among humans.

Questions of measurement are another point of divergence for specialized disciplines. Thus Osgood provides a means for measuring "semantic space" as a psychological entity[10] which is not related to the mathematical measurement of the information content of messages provided by information theory.

There are thus specific needs for each of the special sciences as well as the need for an overall theory unifying the logical and empirical results of each.

## 2 APPROACH TOWARDS SOME TOPICS

The sketch drawn above defines approximately the range of interest of the present work. The boundaries of the thesis might be brought into sharper light by the following brief account.

### a) SOCIAL FACTORS

One of the main concerns of the thesis is with communication within a social system from the point of view of the logical and theoretical considerations involved. Empirical perspectives will be admitted in so far as they contribute to an understanding of the theory to be developed.

Historical perspectives are not deemed to be relevant in the pages that follow. While a treatment of the tremendous increase and elaboration of networks of communication which have taken place historically through technological advances in transport, printing and telecommunication, and through the concommitant social changes such as the growth of literacy[11] might help in understanding existant communication systems in the world today, it will not be undertaken here. Rather the theoretical model to be developed might serve as a means for interpreting these changes and as one possible basis for viewing the complex networks of communication in the world.

In the chapters that follow a primary object will be to explain micro rather than macro processes. It can be pointed out, however, that in so far as macro-systems may be viewed as constituting a multitude of interlocking micro systems the utility of an understanding of micro-systems to macro-theorists is obvious.

## (b) PROPAGANDA AND THE CONTROL OF MEANING

While, in the pages that follow we shall not pursue topics of this nature the theory set forth in chapters 3 and 4 might be thought to offer a framework for a study of propaganda and the control of meaning in so far as it does deal, in a general manner, with power in a social system and normative control over interchanges within it.

## (c) QUANTITY AND QUALITY

It is sometimes argued that there is no necessary connection between the quantity of communication and its quality. The argument goes that "high culture" is generally restricted to small elites of educated men, whereas culture produced for the mass is generally shallower and less meaningfully significant.[2]

In the chapters that follow, this type of discussion will be abandoned in favour of a more technical treatment of "quantity and quality". It is suggested that in any given communication system there is a direct and positive correlation between quality and quantity of INFORMATION. We shall attempt to adhere to the meaning given to the word INFORMATION in Information Theory. In Chapter IV INFORMATION will be defined and the means of measuring it set forth.

## (d) ANIMAL COMMUNICATION[13]

It is held here that comparisons of human and animal communication are appropriate in studies of physiological or cultural evolution, in attempts to answer questions such as "Do animals think?" or "What is Culture?" and in investigations into the interrelationships between humans and animals.

In the context to follow, however, concern will be with the development of a general theoretical framework for the study of human communication and will take for granted the existence of highly developed codes such as spoken and written language and "mature" socialized adult humans who use these codes. It is recognized that in communicating, humans are probably dependant on lower order processes such as those which occur in animal communication as well, but it is felt that this theme can be legitimately extended to the exclusion of a treatment of animal communication. Similarly it is suggested that the theoretical treatment to follow may, in part, be fruitfully carried over into the study of animal communication although no such attempt will be made here.

## (e) LANGUAGE

A fairly limited view of language will be taken here. Concern will be primarily with two aspects : on the one hand, the structure of the communication system must be specified in so far as this structure provides the physical means and sets the physical limits to the production and transmission of signals. On the other hand a discussion will be opened on the ways in which these signals might be ordered.

Thus, on the one hand, an account will be given of the mechanics of speech and hearing (involving physiology and neurology) and the nature of the channels which intervene between the two. On the other hand the minimal linguistic units with their syntactic and mathematical relationships will be discussed.

(f) VISUAL COMMUNICATION

The eye and its relationship to the external world of the human organism on the one hand and the brain on the other is regarded here as being important. Interest in the visual subsystem of a communication system will be centered primarily around the manner in which data from the organism's environment is received by the eye and encoded for transmission to the brain. The problem of how the human brain organizes information from the eye will also be considered.

In the proposed treatment of visual communication, studies in neurology and the general principles of feedback mechanisms will be referred to.

It is suggested that an understanding of how visual communication fits into a larger dynamic communication system would gain from a recognition of the ways in which the "information giving" environment itself is structured.

(g) WRITTEN LANGUAGE

As with spoken language, written language will be treated from two sides. Firstly, the structure of the communication system in which is occurs will be drawn and secondly the syntactic and mathematical ordering of written linguistic signals will be investigated.

(h) INFORMATION STORAGE

The storage of information (using the word in its ordinary sense) is seen to be of great importance in a communication system. In this thesis the general problems of the storage and retrieval of information will be investigated and an attempt will be made to integrate, in a dynamic scheme, the function of storage within a communication system.

Different types of storage are likely to fall into two main categories : storage within the central nervous system of human organisms (memory); storage accessible to humans but in their environment, such as libraries, films, tape-recordings etc. Running across these categories might be imposed other categories such as that of long-term - short-term. An extreme, although, possibly, admissable view would be that of seeing the environment itself or at least the constant parts of it as exhibiting the properties of stored information for the system.

(i) LONG-DISTANCE COMMUNICATION

It is hoped that the model to be presented will be flexible enough to explain both short and long-distance communication in that the same general terms might apply to both.

(j) TEACHING AND LEARNING

It is recognised that teaching and learning have prime empirical importance in regard to the content of communication in actual situations and the way it is structured. In sociological terms the socialization of children is seen to be of great importance to their later role performance.

This thesis assumes the existence of fully socialized humans who still have the capacity for learning (in its widest sense) and responding (correctly) to new information. This point will be developed in the terms of the model to be given but will proceed from the assumption just made.

Beyond the scope of this work are topics such as "teaching methods", "the spread of education", "teaching machines" although, in the case of the last mentioned the important inference may be drawn that culture may be transmitted to and act as a control upon people from a non-human source.

While the range of subjects discussed above is by no means exhaustive with regard to human communication it is hoped that we have indicated our rationale for inclusion - exclusion.

We might say that concern is restricted to component parts and processes in micro-communication systems. In this regard we assume the existence of socialized adult humans who interact with one another in social systems, have access to stores of information and have the capabilities of utilizing codes and channels of different types. In this regard we shall be interested in the transmission and control of information and its measurement. Our primary concern is the development of a theoretical model; nevertheless inferences shall be made from empirical and quasi-empirical material with the purpose of substantiating the theory.

## 3 SOME SPECIFIC PROBLEMS

### (a) INTEGRATION

A primary problem here is to find a means of merging into one common framework a number of diverse studies which illuminate different aspects of the process of human communication and which are concerned with different parts of the structure of human communication systems. While signs of cross-discipline linkage are already apparent, convergence is not highly developed.

### (b) SYSTEM[4]

The elements of human communication are seen here as constituting a system in the sense of a dynamic whole whose parts are related to each other in specified ways and effect one another with certain degrees of probability. The framework envisaged for achieving an integration of the different areas of human communication as studied in separate fields has the properties of a system. Thus, for example, the framework must provide a basis for showing how the transmission of signals through neural nets is logically linked to, say, spoken language. Accordingly it is necessary to find common ground for the study of neurology and the study of linguistics.

The Action Frame of Reference, especially as expounded by Talcott Parsons, will be shown to provide an adequate framework for our purposes in that it provides a minimal set of categories around which it is possible to organize a host of seemingly unrelated material on human communication.

The reasons for choosing the action frame of reference as a framework will become apparent in the next chapter, in which is discussed the general problem of communication as treated or avoided by a number of important sociologists. The work of Talcott Parsons will be discussed in some detail and it will be shown why his conception of the action frame of reference adequate.

The Parsonian exposition of the action frame of reference will not be accepted IN TOTO. Rather, it will be modified for adaptation to the central problems of this thesis. The rationale for alterations to the Parsonian treatment will also be offered in chapter 2.

(c) HYPOTHESIS

Even within the limitations imposed by viewing a communication system in terms of the categories of the action frame of reference, the number of ways of integrating the different specialized areas in the field of human communication must be very large indeed and the number of conceivable relationships among the pertinent variables must be astronomical. Thus it is not sufficient to attempt to integrate the field. It is also necessary to organize this integration around one set or, at most, a few sets of variables.

The sets of variables on which the model (constructed in chapter 3 and formalized in chapter 4) is built are related in terms of the hypothesis that :

> IN A COMMUNICATION SYSTEM COMPRISING A CULTURAL SYSTEM, A SOCIAL SYSTEM, ORGANISMS, AND AN OBJECT WORLD, SEMANTIC CONDITIONS FOR PERFECT COMMUNICATION ARE SATISFIED WHEN, IN THE ORGANISMS, EXPECTATIONS INVOLVING SIGNALS FROM THE CULTURAL SYSTEM MATCH PERFECTLY EXPECTATIONS INVOLVING SIGNALS FROM THE OBJECT WORLD.

Elaborate discussion of this hypothesis would be premature at this point. It is worth noting however, that it involves the field of semantics - data from the object world (reality, things, designata etc.) must match, or correspond with data from the cultural system (code, language, referential system etc); it involves the field of information theory in so far as the quantity of information in the two sets of data has a bearing on their correspondence; and involves the field of sociology, for subsystems of the communication system derive from the action frame of reference. Inclusion of a cultural system means that we must pay attention to the field of linguistics;inclusion of a social system means that we must pay attention to certain special aspects of sociological theory as well as to the empirical work which has been conducted with reference to small groups; and inclusion of an organism means that we must pay attention to physiology. Furthermore in so far as we shall be concerned with the internal links in the communication system we must turn to cybernetics which is concerned with feedback and control in self-adaptive systems and to parts of physics which can throw light on the nature of the channels linking the subsystems.

It is hoped that the hypothesis will serve as a minimal set of interrelated variables which can integrate concepts from these fields with reference to a central problem - that of semantics.

## 4 SOME PREDOMINANT THEMES

### (a) THE SEMANTIC PROBLEM

The hypothesis was formulated largely as a result of trying to clarify the essential semantic problem - that dealing with the relationships between words and objects (or between symbols and referents; signals and designata etc.)

An attempt to answer the questions posed by the semantic problem in a pragmatic fashion takes one beyond the fields of linguistics and logic in which it originated. In fact it seems a fairly pervasive problem in that it has reference to practically any part of a communication system which receives or transmits signals as well as to the various types of signals themselves.

"Semantics" means different things in different disciplines. Thus, for example, to Osgood semantics involves the study of the psychological meanings of words.[15] To philosophers such as Carnap and Wittgenstein it poses problems of ontological and epistemological magnitude.[16,17] D.M. MacKay, Professor of Communication, University College of North Staffordshire, suggests that "semantic questions find their natural place in information theory when (but only when) we ... take account of goal-directed self-adaptive systems."[18] Noam Chomsky, a linguist, in dealing with components of grammar writes that "the semantic component assigns a semantic interpretation to an abstract structure generated by the syntactic component".[19]

The treatment of semantics in the text to follow is likely to be different yet from the viewpoints just mentioned - to a large degree in some instances. The intention is, however, to provide a view of semantics which is at once sufficiently general to serve as a common denominator for other views and sufficiently concrete to conform to a description of the processes in a communication system. It is hoped that the nature of the departure may be described as heuristic rather than eclectic.

## (b) THE APPLICATION OF INFORMATION THEORY

Loosely, and, incorrectly, speaking, information is the stuff that passes through, is acted upon and controlled by a communication system. A phrase such as "the transmission of information" seems to conjure up a picture of a dynamic, working communication system. Since we are concerned with the dynamics of communication, it appears natural and obvious to turn to the field of information theory in quest of answers to all questions on dynamic relationships.

It appears from a study of information theory, however, that signals (of different types, and reducible to units of different sizes) constitute the stuff which passes through communication systems and not "information". Signals have information and the amount of information which any one signal has (measurable in terms of "bits") depends on its power of selection from a message source.

With regard to the application of information theory in fields other than that of its founders(the statistical study of language and telecommunication engineering) we are told on the one hand of its great utility in solving certain problems existing in a wide range of knowledge, and, on the other hand, warned to proceed with caution.

According to Shannon the " ..... fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have MEANING: that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem."[20]

Warren Weaver, the co-author with Shannon of The Mathematical Theory of Communication clarifies the issue :

> The word "information", in this theory, is used in a special sense that must not be confused with its ordinary usage. In particular, "information" must not be confused with meaning.
>
> In fact, two messages, one of which is heavily loaded with meaning and the other of which is pure nonsense, can be exactly equivalent, from the present viewpoint, as regards information. It is this, undoubtedly, that Shannon means when he says that "the semantic aspects of communication are irrelevant to the engineering aspects". But this does not mean that the engineering aspects are necessarily irrelevant to the semantics aspects.[21]

Weaver distinguishes three levels of communications problems :

<u>LEVEL A</u>. How accurately can the symbols of communication be transmitted? (The technical problem).

<u>LEVEL B.</u> How precisely do the transmitted symbols convey the desired meaning? (The semantic problem).

<u>LEVEL C.</u> How effectively does the received meaning effect conduct in the desired way? (The effectiveness problem).[22]

The view taken in this thesis is that these distinctions are spurious with reference to the transmission of signals in a fully specified human communication system : the satisfaction of semantic conditions depends directly on the accurate transmission of the correct "symbols". If "conduct"in Level C is communication then the accurate transmission of the correct symbols will have the desired effect. Weaver concludes his contribution, in fact, by showing the distinctions among the three levels of communication to be spurious.[23]

This point will be further developed in chapter 3. In the meantime, if we assume that the distinctions drawn by Weaver are spurious, it means that information theory, which has applicability to Level A, also has applicability to Levels B and C.

Since, in the following chapters, particularly Chapter 4, information theory will be incorporated quite extensively it is worth reviewing the opinions of a few writers on the application of information theory.

Colin Cherry writes that it is in TELECOMMUNICATION that a really hard core of mathematical theory has developed. He warns that while the mathematical concepts or techniques should not be forbidden elsewhere, they should not be applied simply by extrapolation from their legitimate domain of applicability.[24]

Cherry's warning is heeded. In this thesis communication theory will be applied, not indiscriminately, but with due regard to the nature of a human communication system as conceived from alternative sources. It is necessary to admit, however, that its application will be of a speculative nature. Nevertheless it is hoped that this speculation is sufficiently tempered by canons of logical and methodological consistency.

J.R. Pierce[25] stresses the abstractness and generality of communication theory. It provides in the "bit", a universal measure of amount of information in terms of choice or uncertainty and tells us how many bits of information can be sent per second over perfect and imperfect communication channels in terms of rather abstract descriptions of the properties of these channels. It tells us, writes Pierce, how to measure the rate at which a message source, such as a speaker or a writer, generates information.

Pierce points out that because communication theory has such an abstract and general mathematical form, it has a very broad field of application. It is useful in connection with written and spoken language, the electrical and mechanical transmission of messages, the behaviour of machines, and, perhaps the behaviour of people.

Pierce, like Cherry, warns against the indiscriminate use of communication theory. Nevertheless, dabbling in what he calls "scientifically informed ignorance " he points to many interesting ways of applying it in various fields such as language, psychology and art.

Professor MacKay shows some impatience with regard to the application of information theory to semantics. "Otherwise excellent leading textbooks unashamedly proclaim a divorce between what they call 'information theory' and semantics, which topic is discussed, if at all, in the woolliest terms, and generally relegated to the philosopher."[26]

Wilbur Schramm[17] takes a fairly extreme position is applying the concepts of information theory to human communication. The points he makes which have relevance to the model to be developed here are :

1) While most human communication chains contain a large number of coupled systems, they contain one kind of system which Shannon has not primarily dealt with : the FUNCTIONAL as opposed to the STRUCTURAL system. A functional system is one that learns; its states depend in part on its own past operations.

   Schramm writes that this is one of the pitfalls in the way of applying information theory mathematics to human communication. These are probability formulas, and if the probabilities are altered - i.e. if any learning takes place the events can no longer be regarded as a stochastic process and the formula will not apply. It is therefore necessary to control the learning factor.

2) He shows in what way the concept "ENTROPY" - initially used in thermodynamics, it refers to the "mixed-upness" of a system - can be applied. Thus be writes that it is evident that the maximum entropy of a newspaper or a broadcasting station is immensely greater than that of a calling card or a personal letter. It is also evident that no medium uses as much of the available freedom as it could. Complete freedom would mean random content.

3) The idea of NOISE is another information theory concept which intuitively makes sense in the study of (human) communication. Noise ...... is anything in the channel other than what the communicator puts there. Noise may be competing stimuli from inside - AC hum in the radio, print visible through a thin page in a magazine, day-dreaming during a class lecture - or from the outside - competing headline cues on a newspaper page, reading a book while listening to a newscast, the buzz of conversation in the library.

4) CHANNEL CAPACITY is another important concept which is common to both information theory and to human communication. All channels, human, electronic or mechanical, have an upper limit to their ability to assume different states or carry different events. We can estimate, for example, the amount of information the eye is capable of transmitting to the optic nerve, and it is less than the information available to the eye, although apparently more than the semantic system can handle.

Schramm admits the difficulty of bridging the gap between the (entropy) formula's concept of information (which is concerned with the number of binary choices necessary to specify an event in a system) and the concept of information in human communication (which is concerned with the relation of a fact to outside events - e.g. how "informative" is it?) He writes:

> This is not to say that the transfer cannot be made. Certainly I have no intention of saying that the theory has only analogic value, and that the contribution of its mathematical tools is necessarily small. These tools seem to me to be extremely promising in the study of language, channel capacity, couplings, and network groups, if nowhere else.[27]

In Chapter 4 we shall, among other things, attempt to bridge the gap of which Schramm speaks.

Alfred Kuhn[28] writes that without information theory the growth of the study of electronic data processing machines would have been handicapped. Similarly certain ways of thinking about biology, especially with regard to the brain and the central nervous system would be restricted. He points to its extended use in the field of social organization and uses it as part of his "Unitary Nomological" set of interlocking and mutually consistent concepts for dealing with the subject matters of economics, sociology and political science in a unified view of society.

## C) SPECIFICATION OF SYSTEM PARTS

The third predominant theme in this thesis concerns the analysis of a communication system into parts or sub-systems and establishing what pertinent relationships hold among these parts. The primary problems here are to do with linkage, boundaries and cross-boundary inputs and outputs.

The principles of cybernetics are of great value to such an analysis in particular those dealing with feedback and control. The concept of network will be applied at a number of different levels. In general concern will be with the specification of the types of channels, the nature of energy sources and information sources and the types of unit applicable. The three most important types of unit will be found to be the physical, the biological and the socio-linguistic.

In general this thesis assumes a physical, material basis for all system parts and interchanges between them although, for purposes of presentation and economy, functional, oversimplified descriptions will be given. Accordingly block and flow diagrams will be used. This is in accord with perspectives offered by cybernetics and network theory.

A full specification of system parts is given in Chapters 3 and 4. The specification is made in accordance with the problem of semantics and the theorems of information theory.

## 5) SUMMARY AND CONCLUSION

i) While the study of human communication has not generally been accorded the status of a discipline in its own right, it is seen to be central to a large number of disciplines.

ii) It is further apparent that no substantive body of general theory has yet emerged which unifies the work done in the various disciplines.

iii) As a result it is proposed to attempt unification of the field with regard to the problem of meaning, viewed here primarily as a semantic issue.

iv) It is further proposed that unification might be achieved by means of a framework derived from the action frame of reference.

v) It is suggested that in terms of this framework a description of "the process of communication" can be couched in terms which will have meaning in a wide range of disciplines.

vi) It is further suggested that the proposed framework can provide a basis for demonstrating in what manner certain basic units, separate to some of the various disciplines, are co-ordinate, thus also resolving some of the divergences with regard to the question of measurement.

vii) Concern will be primarily with the development of a "special" theory which will purport to satisfy the hypothesis stated above. Empirical perspectives will be admitted, however, in so far as they contribute to an understanding of the theory. Historical perspectives are not deemed to be relevant.

viii) Interest will be restricted to the micro rather than the macro view of things.

ix) We shall assume the existence of socialized adult humans who interact with one another in social systems and have the capabilities of utilizing codes and channels of different types.

x) We shall be concerned with the physiological and neurological aspects of the human sensory and motor nervous system with particular regard to the mechanics of speech, hearing, writing, vision, learning and memory.

xi) A corresponding interest involves the structure of seuqences of signals of different types with special reference to syntactic and mathematical relationships.

xii) It is proposed to view human communication in terms of a goal-directed, self-adaptive system which functions in terms of cybernetic feedback and control mechanisms.

xiii) This system will be seen to comprise a number of subsystems. An attempt shall be made to utilize information theory for measuring input-output exchanges among these subsystems. In this regard the entropy formula will be seen to provide a convenient way of measuring channel capacity and noise.

xiv) In terms of the theory to be developed it shall be attempted to demonstrate in what manner the entropy formula is directly applicable to the semantic problem. It will also be found essential in describing the requirements for "the satisfaction of semantic conditions for perfect communication" as stated in the hypothesis.

It might appear that certain of the terms we have used such as "information" and"entropy" require elucidation. The reader is requested to bear with them until chapters 3 and 4 in which they will be discussed in some detail.

CHAPTER 2

# The Place of the Problem of Communication In Sociology.

While communication occurs within the human organism and as such poses a problem for neurology, physiology, biochemistry, psychology and cognate fields, it also takes place between organisms. The occurrence of communication between organisms poses problems for sociology, social psychology and cultural anthropology.

## 1 THE INDIVIDUAL AND THE GROUP

Fundamentally the problem of communication among organisms raises the question "Which is 'real' - the individual or the group?"

It might be suggested that individuals alone are real and alone constitute empirical systems. In this view all input-output exchanges among organisms are explained with reference to the different empirical systems they comprise and there is no need to posit a higher order system such as that of "group", "society", "collectivity" or "social system."

Once it is admitted, however, that there is normative control (or any other type of control) over the nature and content of the interchanges among organisms, it would seem to be necessary to posit a higher order system in the sense that the control must come from some source other than the individual organism. It might be objected that the normative control over the content of interchanges derives from cultural factors internal to the individuals as concrete empirical systems and so there is still no place for a social system as a higher order system. In fact culture may be seen, quite simply, to be acquired by one individual from another individual.

There is a major reason, however, for discarding the notion that the individual organism is the sole empirical system. The reason is that input-output exchanges do not usually occur among individuals on a random basis but are structured : with varying degrees of probability they can be predicted.[1] It might then be argued that the structure of inter-individual exchanges arises from the characteristics of the individual organisms. However the differences in the make-up of individuals are insufficient to account for the great variety in types of exchange especially because these persist in some cases for longer periods than the life-time of individuals who may participate in them.

Alvin Gouldner puts it this way : "At one extreme, each element may be involved in a mutual interchange with all others; at the opposite extreme, each element may be involved in mutual interchanges with only one other. The former may be regarded as defining maximal interdependence or 'systemness', the latter as defining minimal interdependence or systemness."[2] The significant point, of course, is that when the behaviour of one individual can be shown to influence, control or change the behaviour of another individual in such a way that the change would not have arisen without it, the two individuals, for at least analytical purposes, may be said to constitute a system; in our context, a social system.

Charles K. Warrimer[3] writes that contemporary writings on the small group exhibit four main orientations to the group and to the question of its reality.

NOMINALISM, the oldest and most extreme position holds that the group is not a real entity, but is merely a term used to refer to "an assemblage of individuals."

INTERACTIONISM has tended to replace pure nominalism. It rejects the group-individual dichotomy and stresses the indivisibility of the two. Neither the group nor the individual is real except in terms of the other.

NEO-NOMINALISM accepts the proposition that the term "group" refers to an objective reality, but claims that the group is less real than persons for it is, after all, made up of persons and of processes which have their locus and immediate origin in the person.

MODERN REALISM holds that (1) the group is just as real as the person, but that (2) both are abstract analytical units, not concrete entities, and that (3) the group is understandable and explicable solely in terms of distinctly social processes and not by reference to individual psychology.

Warrimer writes that there are four basic propositions in the thoughtways of contemporary social science that serve as the basis for arguments against the realist position. They are :

1. We can see persons, but we cannot see groups except by observing persons.

2. Groups are composed of persons.

3. Social phenomena have their reality only in persons; this is the only possible location of such phenomena.

4. The purpose for studying groups is to facilitate explanations and predictions of individual behaviour.

It is Warrimer's thesis that these propositions are fallacious : The first because reality is not restricted to that observable through the senses; the second because it ignores the fact of interaction; the third because internalization of social facts in the person is not a prerequisite for the existence of social facts; the fourth because it is a value issue.

Warrimer notes that argument against the critics of a position does not prove that position. He suggests, however, that A PRIORI rejection of realism is founded upon fallacy and misconception.

The view taken in this thesis is that groups and persons are both concrete but that abstract analytical units can be used to study CERTAIN aspects of, or to see the operation of, CERTAIN variables in the concrete entities (from which an astronomical number might conceivably be elicited). For the purposes to follow, the analytical concept of network will be an important abstraction from the concrete reality, group, in that it can be shown that individuals are related to one another in networks having ecological, stratificatory and organizational dimensions. A network, in our view, is greater than the sum of its parts. Individuals serve merely as points of reference in a larger relational system, and in some cases are substitutable within the larger system.

2. The purposes of the above discussion was to introduce an examination of the emergence of the problem of communication in sociology. It is evident that in the mainstream of sociological thought conceptions of the individual and the group are fundamental to the treatment of this problem.

(a) COMTE

Yielding to the temptation of attributing to a past writer meaning which he might not have intended it is possible to see in Comte's hierarchy of sciences the germinal idea of a normative, cultural order imposed on a biological system. Comte put sociology at the top of the hierarchy, physiology and chemistry taking successively lower order positions.

In the present context Comte's chief merit is in indicating the importance of an understanding of the individual to the study of social phenomena[4,5,6] and in stressing the interconnectedness and specialized division of functions in social systems.[7] As will appear later his insistence on the study of the central nervous system in relation to social phenomena was, from our point of view, well-founded.

Comte's conception of a society as an organism (particularly as developed in Volume II of The Positive Philosophy) is, by contemporary standards, naive and his account of the interconnections between the individual organism and the social organism and within the social organism is largely undeveloped.

The study of human communication requires a full specification of the points of articulation between the individual and other individuals within a larger system. It is pertinent, therefore, that the problem of communication does not emerge explicitly in Comte's work.

(b) SPENCER

Spencer did make explicit reference to the problem of communication : "and along with the development of the social organism, there always goes development of directive centres, general and local, with established arrangements for inter-changing information and instigation serving to adjust the rates and kinds of activities going on in different parts."[8] Nevertheless, communication never emerges as a problem in its own right in Spencer's work. It is likely that Spencer's strong evolutionary interests led to an emphasis on the change and growth of the parts of the social system rather than a study of the dynamic interrelationships among these parts in terms of abstract, general categories.

Despite Spencer's reliance on the methodologically suspect device of analogy - in this case the organic analogy - he is aware of important differences between society and the individual organism: "Whereas in the individual organism the component parts form a concrete whole and the living units are bound together in close contact, in the social organism the component parts form a discrete whole and the living units are free and more or less dispersed. Again, and even more fundamental, whereas in the individual organism there is such a differentiation of functions that some parts become the seat of feeling and thought and others are practically insensitive, in the social organism no such differentiation exists; there is no social mind or sensorium apart from the individuals that make up society."[9] In our opinion this view is correct - there is no need to posit a group or social mind to account for the reality of social phenomena.

(c) DURKHEIM

It is evident that communication, as a problem, is inherent in Durkheim's conceptions of the group and the individual. He emphasizes the externality of the group and culture to the individual and at the same time stresses the constraints they impose on him.[10,11] Had he asked the question "what mechanisms are responsible for implementing constraint?" or "what processes underly the constraint of the individual by society?", he would have been closer to formulating the problem.

Nevertheless, Durkheim's treatment of the concept of "dynamic density" can be seen as a contribution to the study of the (numerical) ordering of parts in a communication system.[12] Durkheim writes :

> The principal task of the sociologist ought to be ..... to discover the different aspects of (the human) milieu which exert some influence on the course of social phenomena. Until the present, we have found two series of facts which have eminently fulfilled this condition; these are : (1) the number of social units or, as we have also called it, the "size of a society"; and (2) the degree of concentration of the group, or what we have termed the "dynamic density."
>
> Social life can be affected only by the number of those people who participate effectively in it. That is why the dynamic density of a people is best expressed by the degree of fusion of the social segments .......[13]
>
> As for physical density - if it is understood thereby not only the number of inhabitants per unit area but the development of lines of communication and transmission - it progresses, ORDINARILY, at the same rate as the dynamic density and IN GENERAL, can serve

to measure it ........[13]

(d) COOLEY[14]

Cooley sees mind as an organic whole made up of co-operating individualities. The unity of the social mind is, to Cooley, not in agreement, but in organization, in the fact of reciprocal influence or causation among its parts. Cooley means by "social organization" the differentiated unity of mutual or social life, present in the simplest intercourse but capable of infinite growth and adaption.

Cooley does not question that the individual is a differentiated centre of psychical life, having a world of his own. But he holds that this uniqueness is no more apparent and verifiable than the fact that he is in the fullest sense member of a whole.

He distinguishes at least three aspects of consciousness : (1) Self-conciousness, or "what I think of myself", (2) social-consciousness (in its individual aspect) or "what I think of other people"; and public consciousness, or a collective view of the foregoing as organized in a communicating group. All three are phases of a single whole.

In accordance with his views Cooley sees public opinion as an organization, a co-operative product of communication and reciprocal influence. He states that a group "makes up its mind" in very much the same manner that the individual makes up his.

Cooley's style, while lively, is, however, loose and prevents the emergence of a rigorous set of categories in terms of which a full specification of interrelationships among the variables might be offered.

Further, his conception of mind appears at times to be non-material. For our purposes, as will appear later, the term "culture" is preferable and a materialist view of culture will be insisted upon.

(e) W.I. THOMAS

W.I. Thomas is concerned with solving the problem of the dependence of the individual upon social organization and the dependence of social organiation upon the individual.[5] The resolution of this problem can be found in Thomas' concept of "situation".

The situation for Thomas is the set of values and atti-tudes with which the individual or the group has to deal in a process of activity and with regard to which this activity is planned and its results appreciated.

The situation involves three kinds of data : (1) the objective conditions under which the individual or society has to act, that is, the totality of values which at the given moment affect directly or indirectly the conscious status of the individual or the group; (2) The pre-existing attitudes of the individual or the group which at the given moment have an actual influence on behaviour. (3) The definition of the situation, that is, the more or less clear conception of the conditions and consciousness of the attitudes.

By a social value Thomas means any datum having empirical content accessible to the members of some social group and a meaning with regard to which it is or may be an object of activity. The meaning of these values becomes explicit when we take them in connection with human actions.

By attitude Thomas means a process of individual consciousness which determines real or possible activity of the individual in the social world.

The attitude is the individual counterpart of the social value; activity is the bond between them.

According to Thomas' concept of "becoming", the cause of a value or of an attitude is never an attitude or a value alone, but always a combination of an attitude and a value.

Clearly Thomas had advanced in the development of a few pivotal variables which can dynamically organize the subject matter of social psychology. Further, he states, implicitly, a fundamental aspect of the problem of communication in that he posits values as objects accessible to members of a group which have meaning and attitudes as values internalized by the individual. The problem of communication arises as soon as it is asked "what are the mechanisms whereby a combination of an attitude and a value causes a new value or a new attitude?" or "By what means, in a situation, do values affect the conscious state of the individual or the group?"

## (f) GEORGE MEAD

George H. Mead considerably advanced the understanding of the individual-group problem and hence, also threw light on study of human communication.

Mead writes

> The ideal of human society is one which does bring people so closely together in their interrelationships, so fully develops the necessary system of communication, that the individuals who exercise their own peculiar functions can take the attitude of those whom they affect. The development of communication is not simply a matter of abstract ideas, but is a process of putting one's self in the place of the other person's attitude, communicating through significant symbols ...... What is essential to a significant symbol is that the gesture which affects others should affect the individual in the same way. It is only when the stimulus which one gives another arouses in himself the same or like response that the symbol is a significant symbol.[16]

> Human communication takes place through such significant symbols, and the problem is one of organizing a community which makes this possible. If that system of communication could be made theoretically perfect, the individual would affect himself as he affects others in every way. That would be the ideal, an ideal attained in logical discourse wherever it is understood. The meaning of that which is said is here the same to one as it is to everybody else. Universal discourse is then the formal ideal of communication.[16]

It is apparent that Mead has here touched on two fundamental problems - that of semantics in which concern is with congruity of meaning and that of feedback which, as will be shown, must be present if an individual is to call out in himself the same response as he calls out in the other.

To Mead the central nervous system is not simply a set of automatisms, that is certain inevitable reactions to certain specific stimuli. The nervous system provides not only the mechanism for that sort of conduct, but also for recognizing an object to which it is going to respond; and that recognition can be stated in terms of a response that may answer to any one of a certain group of stimuli. He notes that mere complication does not present serious difficulty because the central nervous system has almost infinite numbers of elements and possible combinations, but he asks "can one find a structure there in the central nervous system that would answer to a certain type of response which represents for us the character of the object we recognize, as distinct from the mere sensations?"

Mead shows that the central nervous system is capable of representing both spatial and temporal dimensions. He thus sees no reason why one should not find, in the organization of the attitude as presented in the central nervous system, what it is we refer to as the meaning of the object, that which is universal.

Mead stresses the point that the process of communication is nothing but an elaboration of the peculiar intelligence with which the vertebrate form is endowed. The mechanism which can analyze responses, take them to pieces, and reconstruct them, is made possible by the brain as such, and the process of communication is the means by which this is brought under the control of the individual himself. He can take his response to pieces and present it to himself as a set of different things he can do under conditions more or less controllable. The process of communication simply puts the intelligence of the individual at his own disposal. But the individual that has this ability is a social individual. He does not develop it by himself and then enter society on the basis of this capacity. He becomes such a social individual, and it is only in society that he can attain this sort of a self which will make it possible for him to turn back on himself and indicate to himself the different things he can do.

The merits of a social behaviourism which takes as its unit a biosocial individual will be seen later, especially when criticising the concept of a "personality system" as offered by Parsons. It is possible to see inputs and outputs being interchanged among organic individuals without positing a personality system. This is especially so when the complexity and nature of the central nervous system is understood and appreciated.

Nevertheless the extreme view of such a social behaviourism leads Mead to write that the institutions of society, such as libraries, systems of transportation, the complex interrelationship of individuals reached in political organizations, are nothing but ways of throwing on the social screen, so to speak, in enlarged fashion, the complexities existing inside of the central nervous system.

Such a view cannot be admitted for it can be shown that the institutions into which individuals are organized have properties independent of the individuals. In fact it can be shown that the ways in which individuals are organized in systems can be varied independently in which case individual adjustments can be seen to be the dependent variable.

## (g) TALCOTT PARSONS

As the title of this thesis suggests, the systems which are seen to be emergent from the Action Frame of Reference are to be taken as the sociological framework for the present investigation into human communication.

The Action Frame of Reference evolved historically through the writings of a number of prominent sociologists, psychologists, economists and philosophers and represents a minimal set of categories and units sufficiently generalized and abstract to serve as a common theoretical frame of reference for a large number of particular, specialized studies.

It is not our object here to trace the origins and growth of the Action Frame of Reference. Rather, we shall show its importance to the study of communication and accordingly we turn to the work of Talcott Parsons, its leading exponent and the man who has given it its most complete and adequate expression.

### (a) BASIC ORIENTATIONS

Professor Devereaux in The Social Theories of Talcott Parsons gives a summary of what are seen to be the basic orientations which Parsons carried forward from his critical review of earlier literature and which serve as guiding principles in his own efforts at theory construction.

(i) The objective is always to construct an adequate general theory : for Parsons this means a theory which is elegant, analytical, systematic and complete in the sense that some place is found in the theory for all types of factors concretely relevant to the operation of the empirical* system, including those which are treated as parameters or simply ignored in various types of special theories.

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* See overleaf.

The scheme to be developed in the following chapters might be seen as a special theory in that it highlights certain specific features of the general theory of action. Yet with regard to its own special area of abstraction it should also be capable of being analytical, systematic and complete. While in some instances it will be wider than the Parsonian scheme, in others it will be narrower. In general, however, after certain necessary modifications to the Parsonian scheme, it can be seen as consistent with it.

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* According to Gouldner in Symposium on Sociological Theory, Parsons uses "empirical system" in a peculiar way. There are two meanings which might be attributed to his usage :

1) Refering to a "natural" system which is somehow there "in itself" in a realistic sense, i.e. apart from any particular conceptualization. This is, however, at variance with Parsons' constructionist methodological position.

2) A more acceptable interpretation is, perversely enough, what philosophers of science call a "formal system" i.e. devoid of any kind of empirical content. The formal concept of an "empirical system" is largely unexplored by Parsons or taken simply as setting the terms within which the theoretical system must develop.

(ii) An adequate general sociological theory must be an action theory : for Parsons this means that the central mechanism must always be some notion of actors orienting themselves to situations, with reference to various sets of goals, values and normative standards.

We accept such a view of an action theory as a starting point for the study of communication. Fundamentally the problem of communication is to analyse the NATURE of the actor's ORIENTATION to objects and to show how this orientation is normatively structured. The problem of communication, especially when treated dynamically, demands that the concept of orientation be translated into physical terms including the notion of movement in space and time.

(iii) Any meaningful action theory must be based on a voluntaristic postulate: for Parsons this means simply that choice among alternative values and courses of action must remain at least partially free. By implication it seems to follow that human action systems can never become empirically closed.

We accept this as a correct empirical statement. Theoretically, however, it can be shown that two extreme cases can be presented: the case of no choice in which case goals and norms completely determine action and the case of complete choice in which case goals and norms are absent and action is random. In the application of information theory to communication systems it is seen that these two extremes are represented by the case of full redundancy (no choice) and the case of one hundred per cent entropy (complete, random choice).

Empirically most situations are likely to fall about midway along this continuum. Warren Weaver writes "It is interesting to note that the redundancy of English is just about 50%. In other words, about half of the letters or words we choose in writing or speaking are under our free choice, and about half are really controlled by the statistical structure of the language ....."[17]

(iv) In a voluntaristic theory of action, ideas, ideals, goals and normative standards must be treated as causally relevent variables and not as epiphenomena. These ideal elements are regarded as mutually interdependent empirically with the various non-ideal elements in the empirical world, but this interdependence never uses up all the degrees of freedom : the content of the ideal variables is never wholly determined by the pressures of non-ideal forces and constraints.

In the context of a study on communication, this can be seen as essentially a semantic issue. It will be argued that communication can only be semantically perfect in a strictly formal sense when the ideal and non-ideal elements are completely interdependent. This can only happen in the fully redundant case when there are no degrees of freedom for either ideal or non-ideal elements.

(v) Sociological theory must take into account the principle of emergence : for Parsons this means that at various levels of organizational complexity, systems which emerge have properties which cannot be inferred from or explained in terms of the operation of their component parts or elements, and that emergent properties must be treated as causally relevant variables in the theory. By implication, at each emergent level certain new degrees of freedom are created.

(vi) Systems and their emergent properties never become wholly detached from their own component parts; important areas of mutual interaction and empirical interdependency function to limit degrees of freedom on both sides. For Parsons, this clearly implies not only that emergent properties are limited though not determined, by the nature of the system from which they emerge, but also that the nature of the parts may themselves be significantly altered, though not without limit, by operation of the emergent variables.

In this thesis not only do we take (with modification) the systems Parsons develops but we also accept the view of these given above. We suggest that the study of communication is crucial to an understanding of the nature of the areas of mutual interaction and empirical interdependency between an emergent system and the system from which it emerges. It would seem that in order for emergent variables to be causally relevant they must "have information" on the system from which they derive and in turn "transmit information" back to that system as a means of control.

(b)

## THE "FOUR SYSTEMS" AND THEIR ARTICULATION WITHIN THE ACTION FRAME OF REFERENCE

In Pattern Variables Revisited[18], Parsons offers some theoretical propositions which derived from a full elaboration of the Action Frame of Reference. Among them the following are important for our purposes.

1) Parsons conceives of inter-connnections among the components of a system of action. He conceives of a hierarchy of control running from the cultural reference at the top of the hierarchy to the physical at the bottom. Accordingly the structure of systems of action is conceived as consisting in patterns of normative culture. These patterns may be conceived as internalized in personalities and behavioural organisms and as institutionalized in social and cultural systems.

2) Process in the system, if it is to be compatible with the conditions of stability, must conform in some degree with the rules of normative order which is itself both differentiated and integrated.

3) Co-ordinate with the importance of order as formulated in the hierarchy of control and the place of normative culture in action, is the pattern of temporal order imposed by the functional exigencies of systems. Co-ordinate with the normative priority of ends is the temporal priority of means; only when the prerequisite of a consummatory goal-state have been established in the proper temporal order can the goal state be realistically achieved.

4) To be stable in the long run, a system of action must establish a generalized adaptive relation to its environment. To preserve its own normative control in the face of environmental variability, it must be related selectively to the environment. There are two primary aspects of this adaptive relationship : (a) the level of generality of symbolic or "linguistic" organization of the orientation to environmental object systems and (b) the ways in which the boundary of the system is drawn in terms of inclusion-exclusion of objects

according to their meanings. The latter is synonymous with the conception of "control" in relevant respects.

Parsons points out - and this is important - that the propositions stated above are stated at a very high level of generality, deliberately designed to cover all classes of action. Verification would require specification to lower levels.

Parsons believes that the theory of action provides methods for successfully carrying out this specification, and conversely, generalization as well from lower-level uniformities to higher levels. Perhaps the most important key to this possibility is the conception of all systems of action as systematically articulated with others along system-subsystem lines. The basic system types designated as organisms, personalities, social systems and cultural systems must be regarded as subsystems of the general category of action system. Each of these in turn is differentiated into further subsystems at different levels of elaboration. Any subsystem is articulated with other subsystems by definable categories of input-output interchange, the processes, in sufficiently highly differentiated subsystems,being mediated by symbolic-type mechanisms.

The theoretical propositions and concluding remarks of Pattern Variables Revisited offer us a basic framework around which to organize an extensive body of material on human communication drawn from numerous sources.

Firstly, a communication system is seen as a special dimension of a more general system of action. Accordingly the hierarchy of control running from the cultural reference at the top to the physical at the bottom is present also in a communication system. Also, the structure of a communication system is conceived as patterns of normative culture internalized in organisms and institutionalized in social systems.

Secondly, in so far as process in an action system must conform to the rules of normative order it will be necessary to show, in a communication system, how the transmission of signals is organized relative to cultural-system norms. Hence, with regard to the hypothesis offered here, "semantic conditions" can be interpreted as being a special class of norms in communication systems.

Thirdly, the proposition which states that the temporal priority of means is co-ordinate with the normative priority of ends is applicable in a communication system. Again, with regard to the hypothesis put forward here, the "end" of the system can be regarded as the satisfaction of semantic conditions with respect to a given context and the "means" as the signals transmitted through the system over time.

Lastly, the proposition that states that a system, in order to preserve its normative control, must be related selectively to its environment can be carried over into this thesis and can be seen to be highly relevant to the problem of semantics. "Semantic conditions" were interpreted above as a special class of norms in communication systems. One of the central issues of semantics is that of the manner in which a communication system, through its patterns of signalling, selects certain objects and not others and of the manner in which signals from those objects are constituted as messages.

While this thesis does not attempt empirical verification it can still be regarded as operating on a lower level of generality than that which marks the propositions stated by Parsons. Firstly, communication systems are regarded as being constitutive of only certain aspects of general action systems. Secondly, it attempts to build a model which supports a hypothesis which is itself limited to only a certain number of variables and only a limited number of ways of combining them. Further, while this thesis does not itself attempt empirical verification certain of its substantive material, especially that given in Chapter III is in accordance with empirical studies.

The idea of Parsons which is the most important for our purposes is that which conceives the basic system types - organisms, personalities, social systems and cultural systems - as subsystems of action systems which are articulated with each other by input-output interchange, the processes being mediated by symbolic-type mechanisms.

This formulation is taken to be the basic framework of a communication system and as such offers a scheme for organizing a mass of seemingly unrelated work on human communication.

The Parsonian scheme and our own are reciprocal in this regard : it offers us a basic framework whereas we can offer a full elaboration of at least one important dimension of that framework.

## (c) THE "FOUR SYSTEMS" : DETAIL AND MODIFICATIONS.

In Parsons' view the organism, personality system, social system and cultural system, while analytically separable, nevertheless empirically interpenetrate one another.[19]

How Parsons conceives of the phenomenon of interpenetration may be illustrated in the way he elects to handle the ancient body-mind problem. Concrete human personalities always reside in concrete organisms, but to Parsons this does not imply that personality organization and process are therefore somehow reducable to physiological structure and process, and that the laws worked out at this organic level need only to be applied to the next level to arrive at a complete explanation. It merely means that, because the two orders of systems are empirically interpenetrating, there must be identifiable physiological mechanisms for all the processes operative at the physiological level.[19]

Why then two analytical systems instead of one? Partly, Parsons seems to argue, as a matter of analytical convenience and efficiency : you can't talk about everything at once, and you will make more progress by focussing on one aspect at a time. His more fundamental answer is : each order of system also represents in part an emergent empirical * system with its own unique organization, characterized by a selective inclusion of elements drawn from lower-order systems and by a distinctive pattern which it imposes on the relationships of the selected elements. Thus the personality system is distinctly a psychological and not a biological system; at its own level, it has its own system problems - relative to such functional exigencies as drive reduction, maintenance of repressions, integration, etc - its own boundaries and boundary maintenance problems, and its own equilibrium tendencies.[19]

By this distinction Parsons seeks to gain a point of leverage for analyzing the empirical relationships between the two systems. This is how he conceives the outputs of each system with respect to the other. The personality receives as outputs from the organism such facilities as motivational energy and perceptual capacity. In return, the personality system contributes a directional component and attitudinal set which function to focus perception and guide goal-seeking activities.[19]

The main objection of this thesis to such a formulation is that the attributes of the "personality system" are essentially the same as those of the human central nervous system, especially the brain. It makes sense to talk about an input-output exchange between the central nervous system and the rest of the human organism. The problem then becomes one of distinguishing different organic subsystems.

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*See footnote on page 32

What, we contend, is confusing and misleading is that while, on the one hand, on account of empirical interpenetration, there must be identifiable physiological mechanisms for all processes operative at the psychological level, on the other hand each order of system also represents in part an emergent empirical system with its own unique organization.

Whether "empirical" is taken to refer to a "real, concrete" system or to "formal" system (see footnote on page 32) the question can be asked as to why it is necessary for there to be physiological mechanisms for all the processes in a personality system which is at least partly emergent and which has its own unique organization. There would be no problem if the personality system were seen to be the equivalent of the central nervous system for then physiological mechanisms would be quite in order and it would be possible to indicate the points of linkage between the central nervous system and the rest of the human body.

We do not wish to "reduce" personality to physiological, or any other class of terms. However, if it is suggested that personality has any non-physiological attributes at all, then it can be asked "how does the interchange take place between the physiological and the non-physiological?" or "what channels connect the central nervous system of the organism to the non-organic, emergent aspects of personality (even those aspects which are responsible for organizing elements drawn from the organism)?" It seems reasonable to talk about a central nervous system being responsible for functional exigencies such as maintenance of repressions. The central nervous system is obviously organic but the complexity of the brain is of an entirely different order to the complexity of any other part of the human organism.

The problem of the interrelationship between the organism and the personality system presents overwhelming difficulties for a study of human communication. The present study would want to account for, not only the transmission of signals within a system but also for intersystem flows. It was found that as soon as either personality system - social system or personality system-organism interchanges, (or even intra-personality system transmission of signals) was considered, the whole idea had to be abandoned or alternatively "central nervous system" had to be substituted for "personality system".

It is possible that for certain analytical purposes the concept "personality system" might be acceptable. For the purposes, however, of analyzing a human communication system dynamically and in terms compatible with a concrete conception of mechanism, it is better dispensed with. Since Parsons is himself not very clear on the personality-system - organism question we do not do his scheme of a general action system injustice by dispensing with the personality system. The notion of an organic system is retained, however, and the central nervous system is seen as a highly important (for our purposes) subsystem within it.

Parsons conceives of the interrelationships of personality systems, social systems and cultural systems along essentially similar lines. Each is regarded as an analytically separate order of systems, partially independent, but partially interpenetrating the others.

## CULTURAL AND SOCIAL SYSTEMS

To Parsons it makes sense to think of cultural phenomena as forming systems in their own right, with their own laws of internal development and organization. Thus the cultural scientist may legitimately devote his attention to the study of linguistic systems without becoming much involved with sociological or social-psychological considerations. Cultural systems have emergent system properties of their own, and enjoy at least some measure of autonomy in their development.

But this does not mean that cultural systems ever become wholly detached or free-floating, as in the idealist view. Parsons has moved to a view which holds that cultural systems are special sorts of action systems, organized about the specific functional exigency of maintaining symbol-meaning systems.[19]

With respect to interpenetration, Parsons argues that all on-going social systems must have a culture in the sense of shared norms, meanings and objects. Still more impressive, in Parsons' view, is the interpenetrating relationship of institutionalization at the social level* and internalization at the personality level.[19]

Parsons writes in The Social System[20] that in anthropological theory there is not close agreement on the definition of the concept of culture. He writes, however, that three prominent keynotes can be picked out : first, that culture is transmitted; secondly, that it is learned and third, that it is shared. Culture is, on the one hand, the product of and, on the other hand, a determinant of systems of social interaction. We can add another characteristic of culture : it is stored.

The manner in which the model is drawn in the next two chapters is consistent with the Parsonian formulation with the proviso that culture is seen as internalized by organisms and not by personality systems.

Some of what Parsons argues with respect to social systems has already been implied by what has gone before. It is clear that the same concrete activities which are carried out by individual personalities (organisms) appear as performances in the social system. It is central to Parsonian theory, however, that social systems, although involved in extensive relationships of empirical interdependence and interpenetration both with personality systems and with cultural systems, also represent emergent entities with their own system problems, boundaries and equilibrium tendencies.

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* Devereaux has "cultural level" here, incorrectly, we think.

In Pattern Variables Revisited Parsons writes that the unit act involves the relationship of an actor to a situtation composed of objects, and it is conceived of as a choice among alternative ways of defining the situation. The unit act, however, does not occur independantly, but as one unit in the context of a wider system of actor-situation relationships; this system - including a plurality of acts - is referred to as an action system. The unit act is the logically minimal unit of analysis, but as such it can be conceived empirically only as a unit of an action system. Even for the analysis of one discrete concrete act, an extended set of similar acts must be postulated as part of the action system - for example, those comprising a particular role.*

In The Social System Parsons writes that for most purposes of the more macroscopic analysis of social systems it is convenient to make use of a higher order unit than the act, namely the status-role. Since a social system is a system of processes of interaction between actors, it is the structure of the relations between the actors as involved in the interactive process which is essentially the structure of the social system.

The system is a network of such relationships. For many purposes it is the participation of an actor in a patterned interactive relationship which is the most significant unit of the social system.

This participation has two principle aspects. On the one hand there is the positional aspect - that of where the actor in question is "located" in the social system relative to other actors. This is what is called his "status". On the other hand there is the processual aspect, that of what the actor does in his relations with others seen in the context of its functional significance for the social system. It is this which is called his role.

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* A corresponding problem exists in studies of communication where it is often more meaningful to deal with sequences of signals than with one individual signal taken out of context. In linguistic analysis, for example, while it is important to distinguish the

The distinction between status and role is related closely to the distinction between the two reciprocal perspectives inherent in interaction. On the one hand each actor is an object of orientation for other actors (and for himself). On the other hand each actor is oriented to other actors (role). Statuses and roles (the status-role bundle) are not in general attributes of the actors, but are units of the social system.

The relevance of this to our purpose is that the social sub-system of a communication system is conceived essentially as a network of relationships. In this network both the position of the organisms (which in the social system are the points of linkage) and the particular manner in which the signals they transmit or receive are ordered are highly important. That the same organism can both transmit and receive signals is significant for this corresponds to Parson's view of actors in some instances being objects of orientation and in other instances being oriented to other actors. Basil Bernstein shows that the type of code used in communication is a function of the organization of the statuses of the participants, (dealt with in his chapter in Communication and Culture, Ed: Smith).

A value pattern is always institutionalized in an inter action context. Therefore there is always a double aspect of the expectation system which is integrated in relation to it. On the one hand there are expectations which concern and in part set standards for the behaviour of the actor (ego) who is taken as a point of reference; these are his role expectations. On the other hand, from his point of view, there is a set of expectations relative to the contingently probably reactions of others - these are called "sanctions". The relation between role-expectations and sanctions is reciprocal. What are sanctions to ego are role-expectations to alter.

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minimal units (e.g. phonemes) interest is often on how these units are structured in higher order units (e.g. words and sentences): See Communication and Culture (Ed : Smith) p.p. 119ff. In the semantic studies of Carnap this problem is manifest in the treatment of "concatenation".

This "double contingency of expectations" * is of great importance to the hypothesis set forth here. In terms of this hypothesis an organism's expectations of a sequence of signals (received from other organisms) must conform to the organism's expectations of how these signals will relate, when decoded, to signals received from a given object world. At the same time the expectations the organism has of what signals might be received from the object world must conform to the expectations he has of what constitutes an adequate sequence of signals to transmit to other organisms. In the social system semantic conditions are satisfied when the expectations of the constituent organisms are matched both regarding signals from the object world and signals they transmit to and receive from each other viz-a-viz the object world.

Parsons defines "institution" as a complex of institutionalized role integrates (or status-relationships) which is of stratigic structural significance. It is considered a higher order unit of social structure than the role, and is made up of a plurality of interdependent role-patterns or components of them. "Collectivity" is a system of concretely interactive specific roles. An institution is a complex of patterned elements which may apply to an indefinite number of collectivities. Conversely, a collectivity may be the focus of a whole series of institutions.

While in the model to be developed here the distinction between collectivity and institution will not be explicitly dealt with - the undifferentiated concept "social system" is found to be adequate - it is recognized that this distinction might be useful empirically. Thus it should be possible to say that a pattern of communication might be common to a number of social groups. Conversely the same groups might be reorganized to conform to different patterns of communication.

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* The most elementary form of a social system is interaction in which the actions of the incumbents of each role are regulated by the double contingency of expectations (<u>General Theory of Action</u>).

## THE OBJECT WORLD

In The Social System Parsons defines the situation as consisting of objects of orientation, so that orientation of a given actor is differentiated relative to the different objects and classes of them of which his situation is composed. It is convenient, in action terms, to classify the object world as composed of three classes of "social", "physical" and "cultural" objects. A social object is an actor, which may in turn be any given other individual (alter), the actor who is taken as a point of reference himself (ego), or a collectivity which is treated as a unit for purposes of the analysis of orientation. Physical objects are empirical entities which do not "interact" with or "respond" to ego. They are the means and conditions of his actions. Cultural objects are symbolic elements of the cultural tradition, ideas or beliefs, expressive symbols or value patterns so far as they are treated as situational objects by ego and are not "internalized" as constitutive elements of the structure of his personality.

The view of the "object world" taken in this thesis is necessarily different from that offered by Parsons. For our purposes it can be agreed that objects constitute the situation of a system of communicating organisms. Indeed, in so far as "the situation" is fundamental to the Action Frame of Reference, it was thought legitimate to include the "object world" as a system along with other systems "emergent" from the Action Frame of Reference.

It is recognized here that objects only have status in reality when defined as such by humans. Nevertheless the materialist assumption is made that objects do have an existence independent of human definition and thus, when taken in connection with human orientation partially determine the way they will be defined. Thus, while it is agreed that a "chair" might be taken as an item of furniture, or organization of cells and atoms, an entity having a certain shape and colour etc it is held to be significant that, however defined, it could not be substituted by a "rose".

For present purposes, then, the object world is held to exist concretely (outside human reference) having an infinite number of possible objects (or classes of them) which might constitute an infinite variety of systems. However, an object world only becomes part of a human communication system when it becomes differentiated by the organisms which come into contact with it into discrete classes of objects organized into a finite number of systems. What is significant is that different organisms or groups of them might organize the same concrete object world into different classes of objects.

In the model conceived here it is assumed that the object world is unproblematical for the rest of the system. There exist only a finite number of objects and classes of objects. The problem is essentially that of selection from a given object world.

For present purposes the classification of objects into social, physical and cultural is unnecessary in the sense that any classification of objects would serve the same purpose. The classification of objects into flowers, bushes and trees would be equally acceptable as would be the classification of objects into letters of the alphabet.

In a communication system the primary significance of the object world is that it is a source of "information". The problem is that of determining how signals emitted from the object world are handled by the rest of the system.

It is recognized that organisms, networks of organisms or the culturally ordered signals which are transmitted and received by organisms may be construed as objects. It is, however, vital to make it clear that this has nothing to do with their status as elements in a communication system.

The object world, as a source of information might be physically either internal or external to the organic subsystem of the communication system. Thus trees are external while thoughts about trees are internal. Both trees and thoughts about trees are held to be classes of objects capable of serving as information sources.

To conclude the section on Talcott Parsons it is pertinent to present concisely the picture of a communication system derived from his work which serves as the basic sociological framework for the model to be worked out in the following chapter.

Basically a communication system is conceived as a hierarchy of subsystems. Running from the top of the hierarchy to the bottom is an order of control and running from bottom to top is a set of limiting conditions. At the top is the cultural system, below that the social subsystem, below that the organic subsystem and at the bottom is the object world. The object world serves as a source of information for the system while the cultural system provides the system with a set of goals and norms viz-a-viz the object world. Selection of both objects and norms takes place at the organic level and involves spatio-temporal expectations. Individual organisms communicate with other organisms according to how they are structured in the social system.

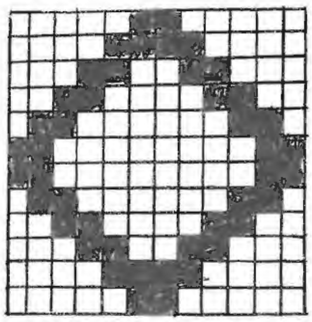
# CHAPTER 3

## Model Construction

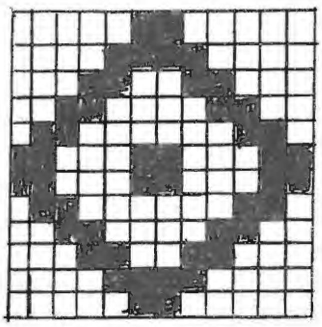
In this chapter it is our purpose to construct a model which incorporates three separate models with reference to a common problem. The three models are : 1) the sociological framework of a communication system (presented in the previous chapter); 2) Shannon's model of a general communication system; 3) a cybernetic feedback-control model. The common problem is a semantic one. Broadly stated it takes the form : what are the means whereby, in a human communication system, cultural phenomena are related to an object world in a perfectly congruous manner?

Once we have constructed the model we shall attempt to show in what manner it is common to a rather wide range of studies on human communication. To begin with, however, it is well to present, in the simplest possible way, the reasoning behind the model.

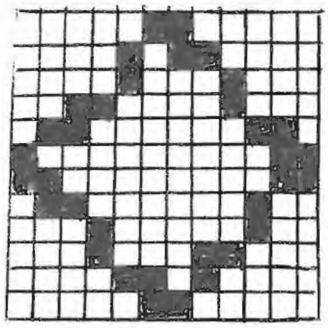
FIGURE I



REALITY



REPRESENTATION I



REPRESENTATION II

## A SEMANTICS - INFORMATION THEORY

In Figure 1 we have a "real" pattern and two representations of it. The first representation is consistent with reality but adds something. The second representation, while not inconsistent with reality, does not represent it adequately or accurately.

The point we wish to make is that it is possible to quantify a semantic problem. The pattern in "reality" comprises 44 dark squares distributed in a certain way on a 144 space matrix. The first condition that must hold for semantic congruence between "reality" and its representations is that the representations should each show 44 dark squares. In Figure 1 semantic conditions are not satisfied since "representation 1" has 48 dark squares and "representation 11" has only 34.

There are conditions other than quantity which must hold for semantic congruence. Thus the <u>order</u> of distribution of dark squares on the 144 space matrix must be the same in the case of reality and representations of reality.

Let us say that there are x possible ways of ordering 44 dark squares on a 144 space matrix. We might then say 44 dark squares have x degrees of freedom on such a matrix. In reality, however, there is no freedom - only one order of the 44 dark squares exists. Semantic congruence is achieved between reality and its representation when the range of freedom for the representation is reduced from x to unity.

This raises the question of coding. The range of freedom, x, also gives the number of symbols in a code which will reduce the uncertainty of which order is found in reality. With x number of symbols, only one will be the correct one for selecting the order which will correctly represent reality.

At this point let us jump ahead and state a requirement which must hold for there to be semantic congruence between reality and culture. Formally this requirement is only fulfilled when there are as many symbols in culture (or as many combinations of (a few) symbols) as there are states in reality.

Empirically this is impossible. Empirically the generality of language achieves great economy in specifying given states of reality. This is, we contend, at the price of uncertainty. Empirically semantic conditions are never satisfied unless language is specific and not general. This can only be achieved under artificial or experimental conditions where either reality is restricted or alternatively language, or culture is expanded.

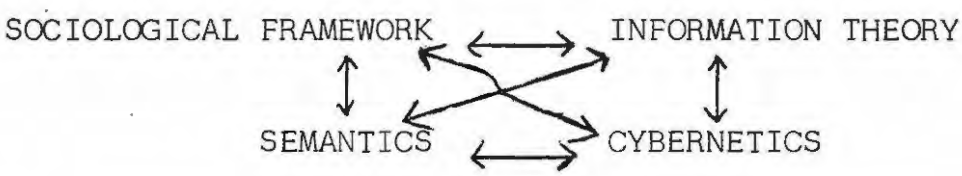
Language has powers of generality when one symbol is made to refer to more than one thing in reality. Where there is generality, however, semantic conditions cannot be satisfied. When you say "chair", I am completely in the dark as to whether it is red or green, wood or leather, two or three feet high or a professorship at a University. You might say chair 39PZ in which case it is perfectly clear that it is a red, leather chair in your house today. But I am still uncertain as to whether or not it is torn. If you restrict reality and say "torn or not, it does not matter," then I am put at ease and I know exactly what you mean by chair 39PZ.

That is the long and the short of it. To try to work out a method for achieving semantic congruence or certainty in a language which is general is an impossible task. We shall not undertake it here. Instead we shall assume a finite reality and a finite culture in which case semantic congruence can easily be achieved.

The inherent quantifiability of semantic problems leads to the idea that information theory is directly applicable to semantics. In the light of the above discussion of "reality" and "representations" of it information theory would be applicable in the sense that it is concerned with the number of signals that must pass through a channel connecting an information source to a destination in order to reduce the uncertainty at the destination as to what is in the information source. We need only substitute "reality" for "information source" and "representation" for "destination" to see why information theory is applicable to this problem. The information contained by any one signal depends on the number of possible outcomes of the source or the number of possible resolutions at the destination and the power which that signal has to represent an outcome from the source correctly at the destination. We stated above that there were x number of ways of ordering 44 dark squares on a 144 space matrix. This number, x, would, in information theory terms, bear on the amount of information inherent in the code which goes between reality and the patterns which represent it.

If it is not contested that information theory is applicable to the semantic problem, and if the manner in which we have stated that problem is reasonable, then the great advantage of information theory is showing under what conditions semantic conditions of perfect communication can be attained.

In the model to be constructed there are a number of underlying conceptual links. We have just elaborated on one of the links - that between semantics and information theory. In fact, the sociological framework of a communication system, information theory, cybernetics and semantics are conceptually capable of a high degree of interrelationship. We present below, first, a diagram of these interrelationships and then further discussion on them.




B SOCIOLOGICAL FRAMEWORK - INFORMATION THEORY

Claude Shannon writes that the fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point.[1] The significant aspect is that the actual message is one selected from a set of possible messages. He presents the following diagram.

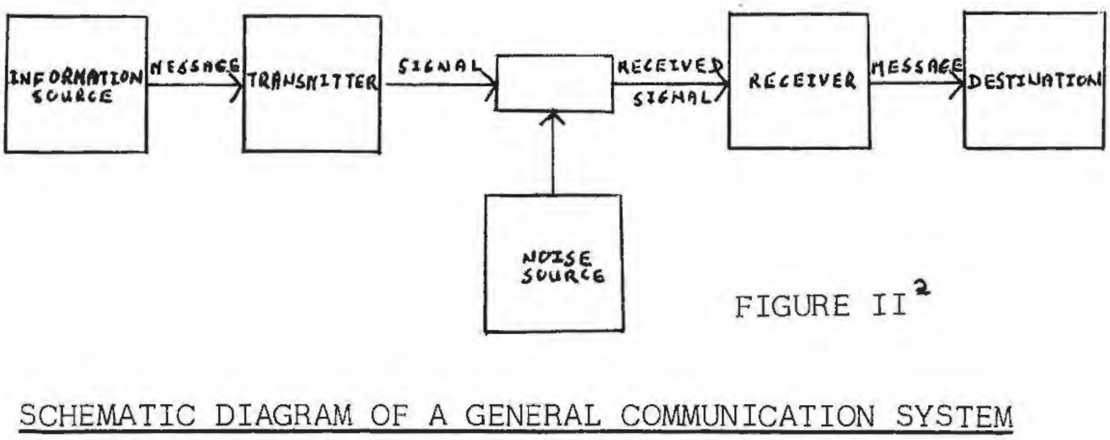



FIGURE II[2]

SCHEMATIC DIAGRAM OF A GENERAL COMMUNICATION SYSTEM

Warren Weaver describes the parts of the general communication system.

> The INFORMATION SOURCE selects a desired MESSAGE out of a set of possible messages. The selected message may consist of written or spoken words, or of pictures, music etc.
>
> The TRANSMITTER changes this MESSAGE into the SIGNAL which is actually sent over the COMMUNICATION CHANNEL from the transmitter to the RECEIVER. In oral speech, the information source is the brain, the transmitter is the voice mechanism producing the varying sound pressure (the signal) which is transmitted through the air (the channel).
>
> The RECEIVER is a sort of inverse transmitter, changing the transmitted signal back into a message, and handing this message on to the destination. When I talk to you, my brain is the information source, yours the destination, my vocal system is the transmitter, and your ear and the associated eighth nerve is the receiver.
>
> In the process of being transmitted, it is ........ characteristic that certain things are added to the signal which were not intended by the information source. These unwanted additions may be distortions of sound (in telephony, for example) or static (in radio), or distortions in shape or shading of a picture (television), or errors in transmission (telegraphy or facsimile etc.) All these changes in the transmitted signal are called NOISE.

If Shannon's model of a communication system is indeed general, it should apply to the human case and specifically to the model of a human communication system conceived in the last chapter. Ideally it should apply when the human model is put into operational terms. This we shall proceed to do now.

Operationally there is a great deal of variability in the way a human communication system might be presented. For instance, the cultural system might be seen as either internal or external to an organism. In Chapter 2 it was said that culture could be learned, transmitted, shared and stored. In the case of stored culture, this could be shown operationally as being neurologically held in either short or long-term organic memory or, alternatively, as being kept in libraries or in the form of tape-recordings, films, gramaphone records etc. Culture may be "learned" by an organism either from another organism or, say, from a book. It may be transmitted either to other organisms or to non-organic storage (e.g. a tape recorder) which may or may not be accessible to other organisms. With regard to culture being shared, it can be seen that in a network of interrelated organisms, some of the organisms might have "more" of it and others "less". Again, control of the allocation of culture may be vested in some of the organisms and not in others. Furthermore culture may be differentiated and hence certain organisms may be specialized in certain aspects of it.

Operationally a parallel problem exists with regard to the object world. The object world can be seen as either internal or external to the organism. The object world might be divided up and allocated to the different organisms in the social system. Direct control over the object world might be vested in only certain of the organisms. Other organisms might be related to an object world only through their relationships with organisms in direct contact with the object world.

The social system is seen as comprising a network of interrelated organisms. At minimum this network must contain at least two organisms. There is no limit to the number of organisms which might constitute a network. When a very large number of organisms are involved the system can become extremely complex although this is not necessarily the case as, for example, in radio broadcasting when, at least in the short term, there is a one-way flow of signals from one or a few organisms to many.

The organism, when viewed as part of a social-system network might be regarded as a "black box". In this regard all that is significant are the inputs into the organism and the outputs from the organism.

On the other hand if the nature of the enquiry is to how the inputs are acted upon to give rise to certain outputs and not others, it is pertinent to "open" the black box to study what occurs inside it.

For certain purposes it should be possible to isolate certain subsystems of the organism. For example the vocal system of one organism and the ears of another might be regarded as a system. Or the eye and the brain of the same organism could be regarded as a communication system.

While, in terms of the hypothesis offered here, the object world, the organism, the social system and the cultural system will all be taken into account, it is pertinent to note that not all of these systems are required for communication, in a general sense, to take place. It is possible to have communication without a social system. An organism can talk to itself, can read a book or can write poetry without the immediate presence of another organism. Mead would argue that these cases of "solitary" communication could not appear without social experience in the first instance. We agree with this view. However, once the organism has learned or internalized culture other organisms do not have to be physically present for communication to take place.

If we take stored culture and the object world to be external to the organism in a particular case then it would appear that the organism could receive signals from either without the presence of the other.

For the purposes of constructing the model central to this thesis it is assumed that the cultural system is physically external to the other systems. With regard to this assumption the following illustration is apposite. The foreman of a building operation might, in certain instances, be indifferent to whether he makes decisions according to an architect's plan before him or according to verbal instructions received from the architect himself. In the former case the cultural system is seen, on the particular occasion in question, to be the architect's plan and accordingly is taken to be physically external to both foreman and the workers affected by his decisions. When, however, the forman receives verbal instructions from the architect, then the cultural system in question is taken to be internal to the architect who is now taken as an organism constituting, together with the foreman and the workers, a social system. The former case is, however, assumed here.

It is also assumed that the object world is physically external to the other systems of a total communication system.

It is further assumed that not all the organisms constituting the social system have direct access to the object world or to the cultural system, but that at least one organism has direct access to the object world and that at least one organism has direct access to the cultural system.

It is also assumed that with regard to the particular model of a human communication system conceived here, the particular organisms can, as parts of the total system be dissimilar. They are dissimilar in two respects : firstly, with regard to the internal parts of the organism which are incorporated into the total system; secondly with regard to the place of the organism in the social system. In the first case it can be seen that some of the organisms might be concerned with seeing and writing, others with seeing and talking and others with hearing and feeling etc. In the second case it is evident that the organisms must be structured differentially in the social system network (unless it is circular).

What is of great significance here is that the terms of reference derived from Shannon's Schematic Diagram (Fig 11) are applicable to an operational description of a human communication system. The cultural system and the object world can be taken as information sources cum transmitters. The eyes, ears, nose, tongue and skin of an organism can be regarded as receivers, the brain of an organism as a destination in some instances and as an information source in others. Facial movements, the vocal system and the writing hand can be regarded as transmitters.

Thus, quite simply, Shannon's diagram can be used for indicating a number of sub-systems in a total human communication system. The links between an organism and a cultural system form one such sub-system , the links between an organism and an object world another and the links between any two organisms still another. The same diagram can be used for describing processes that go on within an organism.

It seems reasonable to couple together two of Shannon's diagrams as follows :

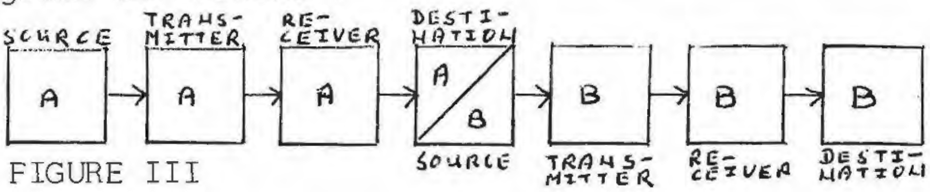



FIGURE III

In Figure 111 two communication systems are coupled together to form one larger communication system. The destination in system A acts also as the information source in system B. There is, of course, no reason apart from convenience, why we show only two and not more systems coupled together in this way.

The coupling together of discrete Shannon-type diagrams into a larger encompassing system gives us a means of showing how the component parts of human communication are articulated within a total system.

What is particularly significant is that we can equate the organisms expectations with the destination. These expectations can be viewed as a network of neurones in a certain state. The state of these neurones will be changed by signals imparted to them (energy). Thus the way messages (the organization of signals over time) are received at the destination of a mechanical system and the way they are received in a human brain are so alike as to warrant the application of the theorems of information theory to human communication. These theorems deal with channel capacity and the information content of signals when the destination (or the information source) contains a given number of items. If we assume that the organism's expectations are finite then we can measure the information content of the energy (signals) which activates or impinges on them by its power to reduce that state of uncertainty or excitation which existed in them prior to the reception of that energy. Similarly, if we regard in a particular instance the chain of neurones leading from the organism's sensory organs to a given part of the brain where another system of neurones is in an expectant state as a channel, we can regard the capacity of that channel in terms of the amount of energy it can transmit to satisfy the expectations or reduce the state of uncertainty.

It should be noted that what has just been written is intended as an argument rather than as a descriptive statement.

Restated the argument goes that if the parts of human communication can be shown to correspond to those of a general communication system in a homological manner then the theory which applies to the general model should also apply to the human model.

The fundamental problem of communication according to Shannon is that of reproducing at one point either exactly or approximately a message selected at another point. Cherry defines "message" as "an ordered selection from an agreed set of signs (alphabet) intended to communicate information".[3] We suggest that when the set of signs at the information source is the same as the set of signs at the destination (as, for example, is the case of telex machines) the problem of communication is relatively simple.

It might be objected that information theory cannot be applied to the human case since the set of signs (expectations) is the human brain is inherently different from the set of signs, say, in the object world. We can argue, however, that this should not preclude communication taking place between an object world and an organism in which case the set of signs at the information source is different from the set of signs at the destination. It is, we offer, possible to reproduce at one point a message selected at another when the sets of signs are of a different nature, provided that there are rules of transition from one set of signs to the other. This is a problem of cybernetics. Ross Ashby writes that a transition is specified by the two states and the indication of which is changed to which. A set of transitions is a TRANSFORMATION.[4] An example of a transformation is given by the simple coding that turns each letter of a message to the one that follows it in the alphabet, A being turned to B; so CAT would become DBU. In terms of this transformation CAT and DBU are the same message.

We suggest, then, that it is possible to reproduce a message selected at information source in a communication system at the destination even though the nature of the signs (items) at the two points are different.

## C SOCIOLOGICAL FRAMEWORK - SEMANTICS

Wittgenstein is perplexed by the following apparent enigma.[5] In reality we find a r b and in language ARB. Wittgenstein can understand how a stands to A and how b stands to B. But he cannot understand in what way A stands to R stands to B such that it is representative of the way in which a stands to r stands to b.

It is suggested here that this problem is solved in terms of a pragmatic frame of reference - one which includes the users of language. If we take the organism in the Action Frame of Reference to be the user then we see that the objects in reality a r b are, quite simply, selected by the sense organs of the organism which transmit signals to the organism's brain such that they act upon neurologically stored signs to produce the ARB of language. Wittgenstein's enigma is, pragmatically, a problem of coding.

It seems, according to Cherry,[6] to have been Charles Pierce who first stressed the essentially triadic nature of "meaningful" situations, situations involving relations between thoughts, signs, and designata (roughly "what is referred to"). This triadic nature has been examined in the now classic work of Ogden and Richards, THE MEANING OF MEANING, and represented by their well-known "triangle diagram" (see Figure 1V).

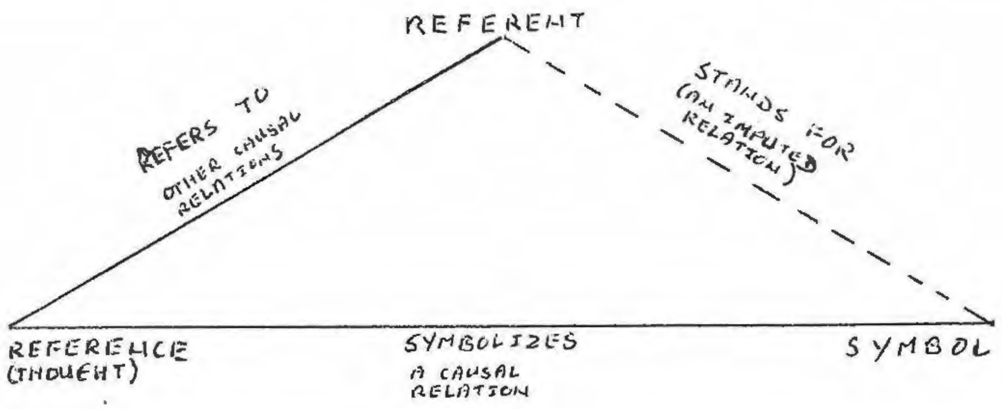



FIGURE 1V : OGDEN AND RICHARDS' "SEMANTIC" TRIANGLE[7]

Here, the idea of "meaning" is considered to involve three elements : a person having THOUGHTS, a SYMBOL, and a REFERENT. These three elements are represented by the three corners of a triangle. Thought-symbol corresponds to one side, thought-referent to a second side, whilst the third side, symbol-referent - to us the domain of semantics - represents a less direct and non-causal relation.

Figure V is Cherry's modification of the Ogden and Richards triangle. He writes that both the signal (or sign), and the referent set up a thought and become related in thought. He quotes Ogden and Richards: "Symbols

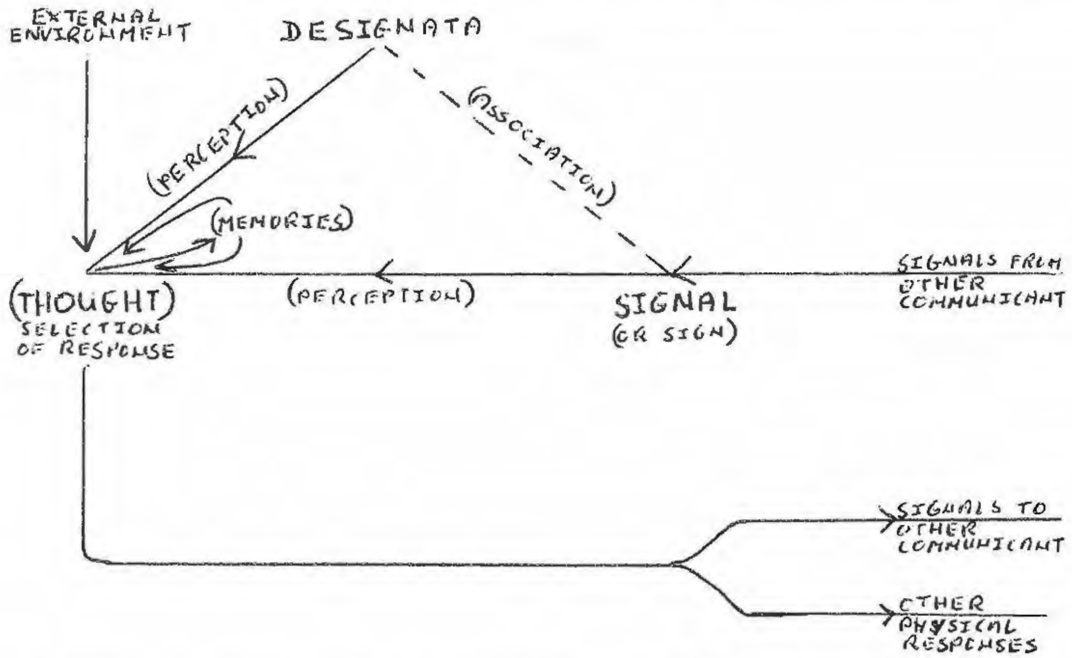



FIGURE V "MEANING OF WORDS" : A FUNCTIONAL FLOW DIAGRAM[8]

direct and organize thoughts ........". Speech cannot organize things; it organizes thoughts in people, and people organize things.

Cherry used the word DESIGNATUM - in our context, OBJECT - in a general sense, to imply "any attribute of the outside world (thing, property, event, relationship ) which is refered to when a signal is employed. However, reference is frequently made to non-existants (unicorn, phoenix, Julius Caesar); the designata in such cases correspond to memories, resulting from past experiences, or readings, tellings etc, for human language, unlike animal signs, can refer to the past. Figure V shows "memories" as part of the functional flow diagram - memories of designata or of signals from the past.

Ogden and Richards have made clear that the relationship between words and objects (expressions and designata etc) is an imputed or indirect relationship. There is always an intermediary between the two - thought, or, in our context, the operations of the human brain. Thus it is apparent that the semantic equation requires pragmatic solution.

Pragmatic solution of the semantic equation appears possible in terms of a sociological model of a communication system - especially taken in conjunction with Shannon's general model.

The sociological model of four hierarchically interrelated systems offers two perspectives of semantics : broad and specific. The broad view sees a semantic problem within the system as a whole. Thus, in our formulation, it exists between the cultural system and the object world. It is significant that in the operational statement of our model no direct links hold between the cultural system and the object world; thus strict comparison is afforded between Ogden and Richards' "semantic" triangle and the sociological model of a communication system given here. "Referent" in the semantic triangle corresponds to "object world", "symbol" corresponds to "cultural system" and "reference" corresponds to the organism. The comparison is completed when Cherry's modification is taken into account for, in Figure V, "signals from other communicant" and "signals to other communicant" correspond to our conception of "social system". The problem of meaning can be stated in terms of a sociological model of a communication system.

In so far as the total human communication system can be conceived of as comprising a number of articulated "Shannon-type" systems, it might be said that, on a pragmatic basis, a series of semantic links hold between the cultural system and the object world. A link is established by the transmission of signals in one of the Shannon-type systems. The series of links is complete when a chain of these systems link together the object world and the cultural system. The problem of semantics might, however, be stated with specific regard to the reception or the transmission of signals in a single Shannon-type system.

A contention in this thesis is that the pragmatic solution of the semantic problem depends on a full description of all the events which link object world to cultural system. Accordingly, it seems reasonable to speak of primary, secondary and tertiary semantic links or further, semantic links of the fourth, fifth and nth order. A primary link in this view is one which involves only one transitional state. This transitional state could refer to what happens when a transmitter produces signals or when a receiver picks up signals. In a primary link semantics coincides with coding. On the transmitter side semantics is concerned with encoding and on the receiver side with decoding. In a semantic chain of links of the nth order, however, such as might occur between the object world and the cultural system, a number of transitions occur, each depending on a code of, possibly, a different kind. In such a case semantics is a wider concept than that of coding for it would seem to be concerned with the preservation of a message over a number of transitional states. Thus the pragmatic formulation of the semantic problem must embrace the notion of numerous codes of widely differing types.

## D SOCIOLOGICAL FRAMEWORK - CYBERNETICS

Cadwallader states that the fundamental theme of cybernetics is always regulation and control in open systems. It is concerned with homeostasis in organisms and the steady states of social organizations. An open system, whether social or biological, in a changing environment either changes or perishes. In such a case the only avenue to survival is change. The capacity to persist through a change of structure and behaviour has been called "ultrastability."

Cadwallader writes[9] that a cybernetic model would focus an investigator's attention on such things as the following :

1 The quality and variety of information stored in the system.

2 The structure of the communication network.

3 The pattern of subsystems within the whole.

4 The number,location, and function of negative feedback loops in the system and the amount of time lag in them.

5 The nature of the system's memory facility.

6 The operating rules, or program determining the system's structure and behaviour.

The operating rules of the system and its subsystems are always numerous. Some relevant ones are

1 Rules or instructions determining range of input.

2 Rules responsible for the routing of the information through the network.

3 Rules about the identification, analysis, and classification of information.

4 Priority rules for input, analysis, and classification of information.

5 Rules governing the feedback mechanisms.

6 Instructions for storage in the system's memory.

7 Rules regarding the synthesis of information for the output of the system.

In general cybernetics is concerned with goal-seeking, self-adaptive systems. The human communication system conceived here is seen as being both goal-seeking and self-adaptive. This is entirely in accord with more general systems of action. Parsons writes that :

The concept of the institutionalization and/or internalization of the structure of superordinate systems - in a specific sense of the hierarchy of control of action systems - is one crucial feature of the relation of EVERY system or subsystem of action to its environment. He sees MEANING, in the cultural sense, as the master category of the structure of systems of action and hence places the cultural system at the top of the cybernetic hierarchy. What is important is that each system in the hierarchy should "actualize", for its specific conditions, the implications of the meanings institutionalized (or internalized) in the next higher system.[10]

In the terms of the model put forward here, the goal of the system of communication is simply to identify the objects of a given object world. If the system is to be self-adaptive towards that goal it must be able to assess whether or not success was achieved in identifying the objects and hence it is assumed that signals received from the cultural system can be checked against signals received from the object world in the brains of the organisms (or certain of them) in the system.

According to Parsons the normative control of the whole system of action lies in culture. Thus the "operating rules" mentioned by Cadwallader find their place, in a human communication system, in the cultural system. In terms of our model the cultural system specifies the objects to be identified and the operational rules of the system for identifying them.

We suggest that empirically these rules for operation are often implicit in a system of culture and not therefore formally stated. For the purposes of model construction, however, it is necessary to make explicit the types of norms and operating rules of relevance to the cultural sub-system of a human communication system.

The clue for showing how a general feedback theory is applicable to Parsons's formulation of an action system (and hence also to our formulation of a communication system) lies in Parsons' statement that the basic condition of the integration of systems of action is that each system in the series should spell out or "actualize", for its specified conditions, the implications of the meanings institutionalized (or internalized) is the next higher system.

We suggest that this statement implies that the specific goals of each system are set by the system above it and that each system in turn is limited by the parameters * set by the system below it. Goal in this sense is functionally the same as "reference signal" in the "Basic Feedback Control System" presented below and parameters functionally the same as "environmental variables".

"The Basic Feedback Control System" put forward by Powers, Clark and McFarland[12] deals primarily with the human organism. It will be shown here, however, that their model is easily extended to take into account the object world and the social and cultural systems as conceived here.

Powers, Clark and McFarland write that there are two major classes of feedback. One is the type which is wholly internal to a system, involving closed loops which do not cross the input or output boundaries of the system, and the other is the type in which the feedback path exists through the output boundary, passes through the environment (with attendant modification of the information) and re-enters at the input boundary, the rest of the loop being completed within the system. Both types of feedback can exist simultaneously, but only the external type is unequivocally perceivable as a feedback loop by an external observer.

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* Ashby[11] writes that every system is formed by selecting some variables out of the totality of possible variables. "Forming a system" means dividing the variables of the universe into two classes : Those within the system and those without. Given a system, a variable not included in it is a PARAMETER. In general, given a system, the parameters will differ in their closeness to it. Some will have a direct relation to it: change of their value would affect the system to a major degree.

Powers, Clark and McFarland are primarily concerned with externally connected feedback loops. They assume that in general the feedback is negative;* this is necessary, they write, if a feedback control-system is to exist.

Their general control system consists of three functions plus an environment function, and five variables. These are discussed in order from the input boundary, through the system to the output boundary, and through the environment back to the input boundary.

The input boundary consists of a function they call the "Feedback Function", abbreviated F in equations. The environment variable which is the input to this function they call Ve (which may represent many variables). The output variables of this function they call the feedback signal, "f", reserving the term "signal" for variables inside the system. The feedback signal is some function of Ve, the form of the function being determined by the properties of the input device. Mathematically, the relationship would be written f = F (Ve).

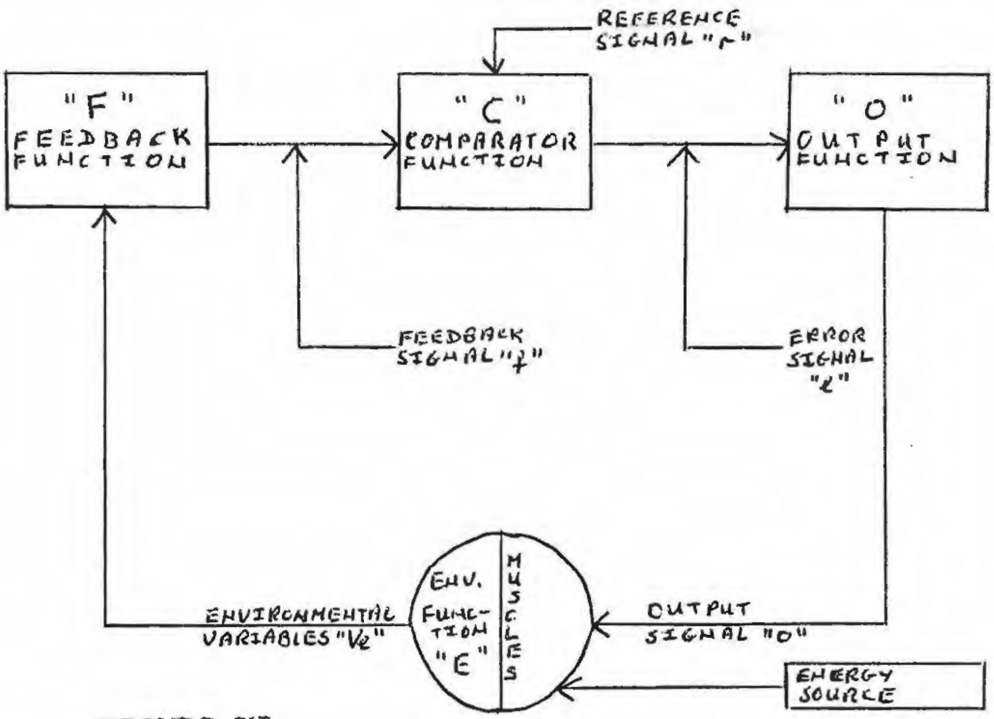


FIGURE VI

BASIC FEEDBACK CONTROL SYSTEM.

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* The concept "negative feedback" will become clear in the pages to follow. See in particular the last paragraph on Page 68..

The next function is the "Comparator Function" (C), which receives both the feedback signal f and a reference-signal, symbolized as "r". The Comparator Function subtracts f from r and its output signal is called the error-signal, "e", representing the discrepancy between f and r.

The function of the output boundary they call the Output Function (O), which receives the error signal as its input signal and produces the output-signal (or variable), "o". This would be written

$$o \quad O\ (e) = O\ (r - f)$$

The Comparator Function is often only implicit in the operation of the output functions, some devices being capable of responding directly to the difference between two input signals. For clarity the authors usually speak of the Comparator as a separate function and the error signal, e, as a real signal inside the system.

The output variable o is the input variable to the Environment Function, (E), which in turn produces as an output variable (or set of variables) Ve, the input to the System. Thus, the loop is completed (see Figure V1) Ve = E (o)

For this system to be a control-system, it is necessary that for any error signal, the operation of all the various functions be such as to tend to bring f closer to r (in other words, to reduce the magnitude of the error signal). This is exactly what is meant by "negative feedback". If the environment offers no resistance at all to the outputs, so that o is capable of altering Ve to any desired extent, then the system will come to equilibrium with the feedback signal equal to the reference-signal. If the reference-signal is altered by some (unnamed) agency, the system will automatically respond to the ensuing error signal by bringing f to the same (new) magnitude as r, thus erasing the error-signal and simultaneously reducing the output of the system to zero. For a system in this kind of environment, it can be shown that under all the conditions within the operating range of the various functions, the feedback signal will be caused by the actions of the system to "track" a slowly changing reference-signal. Thus the reference-signal is the obvious means by which the system can be controlled.

It is important to us that Powers, Clark and McFarland are able to identify the output signals of second-order systems with the reference-signals of first-order systems. They put it graphically - "the output of a second order system is ..... a goal toward which first-order systems automatically adjust their input signals ....... Thus, the second-order system acts, so to speak, by specifying for the first-order system the kind of sensation it is to seek; the first-order system adjusts its output until its input signals match as closely as possible, in the given environment, the "example" given by the reference-signal ........".

Let us take for the moment, Powers, Clark and McFarland's "first-order system" to be the organism in our model of a communication system. In this case the reference signal "r" is seen as derived from an output from a cultural system or from another organism. The environmental variables "Ve" (parameters) are in this case either the object world or another organism. Thus, assuming the model consists of a cultural system, an object world, two organisms, one of which, A, is articulated with the cultural system and the other of which, B, is articulated with the object world, and a social system in which the two organisms are articulated, then the following would be the sequence of signals for feedback to operate in the system as a whole.

Organism A receives a reference signal from the cultural system. This it takes as a goal which in this case specifies the identification of objects in an object world familiar to B. A, through its output function transmits a signal (or sequence of signals) to B which takes them as a reference signal or goal. B, through its input function selects signals (feedback signals) from the object world. After comparing these with the signals received from A, it transmits error signals as an output to A which receives them as an input to its feedback function which produces feedback signals to be compared with the initial reference signals received from the cultural system.

In terms of the hypothesis put forward here, semantic conditions are satisfied if the feedback signals from the object world to B correspond exactly to the reference signals received from A.

The absence of error signals to A then is taken by A as fulfilling the conditions set down by the goal provided culturally. The feedback loop of the whole system is thus closed and since A does not produce any error signals the whole set of processes can start again in the identical manner until either errors are produced ( due, say, to a change in the object world, the cultural system, or in one of the organisms) or until other factors external to the system intervene.

## E CYBERNETICS - INFORMATION THEORY

The general communication system presented by Shannon is not a self-adaptive or goal seeking system. The feedback control system presented by Powers, Clark and McFarland is self-adaptive and goal seeking. Yet the two systems have a certain basic feature in common. In both systems signals are transmitted and received. The difference between cybernetics and information theory is that cybernetics is concerned with control and hence makes the basic distinction between reference and feedback signals whereas information theory is concerned with the information content of signals and the capacity of the channels through which they are transmitted.

Cybernetics and information theory are reciprocal in this regard. Information theory can offer a means of measuring the information content of signals in a feedback control system and for estimating the minimum channel capacity requirements for such a system. Cybernetics can provide a means for incorporating the component parts of a general communication system into a system which is goal-seeking and self-adaptive.

A key point to be made here is that, in Shannon's terminology the transmitter selects a message from a number of possible messages at the information source. We can ask "What is the basis for the particular selection made?" It would appear that cybernetics could provide the answer. It is significant that in the feedback control system "Ve" may represent many variables. Presumably these variables are not acted upon randomly; instead there is a systematic basis for selection of variables. The basis for selection is provided by the outcome of comparison of feedback with reference signals. It may be said that the system will reach a state of equilibrium when it has selected a group of variables which are finite and unchanging.

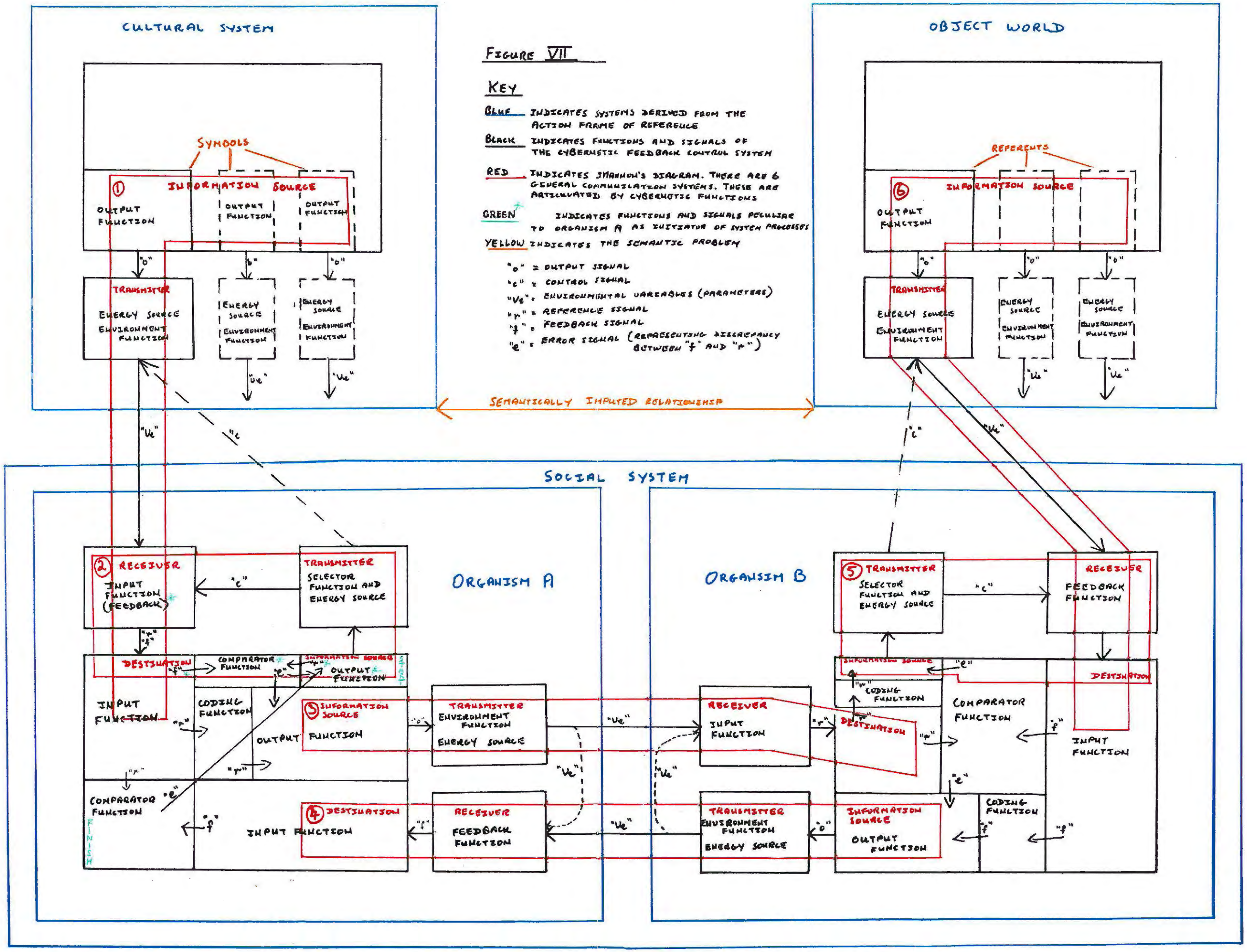
## F CYBERNETICS - SEMANTICS

It may also be said that with regard to our hypothesis semantic conditions are satisfied only when the communication system is, cybernetically, in a state of equilibrium. If we take the environmental variables to be referents (designata) and the reference signals to be symbols (signals) (see Figures IV AND V) then semantic conditions (congruence between symbols and referents) are satisfied when feedback signals are equal to reference signals and no error signals are produced.

### BASIS FOR INTEGRATION OF THE MODELS

We have three separate models and a common problem which applies to each. Each of the models supports each of the others. This state of affairs seems to warrant the construction of one large encompassing model. We will undertake the construction of this model under the following heading. Before we do this, however, we offer the following statement as a basis for integrating the models.

> In a human communication system comprising a cultural system, a social system, organisms and an object world the problem of semantics refers to the congruence between the cultural system and the object world. In the human communication system there is a normative order of control running from the cultural system at the top to the object world at the bottom. The communication system seeks the goal of maintaining congruence between the cultural system and the object world. It is self-adaptive towards that goal and is as such also a feedback-control system. The cultural system provides normative control by supplying organisms with reference signals. Feedback from the object world is compared with these reference signals. Information theory supplies a means of assessing the amount of information in reference and feedback signals. For information theory to apply the number of possible combinations of reference signals must be known and the number of possible variables (objects) in the object world must also be known for this is necessary for the computation of the amount of information contained by feedback and reference signals. It can be said that semantic conditions are satisfied when the


CULTURAL SYSTEM
SYMBOLS
① INFORMATION SOURCE
OUTPUT FUNCTION
TRANSMITTER
ENERGY SOURCE ENVIRONMENT FUNCTION
OBJECT WORLD
REFERENTS
⑥ INFORMATION SOURCE
SEMANTICALLY IMPUTED RELATIONSHIP
SOCIAL SYSTEM
ORGANISM A
ORGANISM B
② RECEIVER
INPUT FUNCTION (FEEDBACK)
SELECTOR FUNCTION AND ENERGY SOURCE
DESTINATION
COMPARATOR FUNCTION
CODING FUNCTION
③ INFORMATION SOURCE
④ DESTINATION
INPUT FUNCTION
RECEIVER
FEEDBACK FUNCTION
⑤ TRANSMITTER
FINISH
FIGURE VII
KEY
BLUE INDICATES SYSTEMS DERIVED FROM THE ACTION FRAME OF REFERENCE
BLACK INDICATES FUNCTIONS AND SIGNALS OF THE CYBERNETIC FEEDBACK CONTROL SYSTEM
RED INDICATES SHANNON'S DIAGRAM. THERE ARE 6 GENERAL COMMUNICATION SYSTEMS. THESE ARE ARTICULATED BY CYBERNETIC FUNCTIONS
GREEN* INDICATES FUNCTIONS AND SIGNALS PECULIAR TO ORGANISM A AS INITIATOR OF SYSTEM PROCESSES
YELLOW INDICATES THE SEMANTIC PROBLEM
"o" = OUTPUT SIGNAL
"c" = CONTROL SIGNAL
"Ve" = ENVIRONMENTAL VARIABLES (PARAMETERS)
"r" = REFERENCE SIGNAL
"f" = FEEDBACK SIGNAL
"e" = ERROR SIGNAL (REPRESENTING DISCREPANCY BETWEEN "f" AND "r")

amount of information in reference signals equals the amount of information in feedback signals. This can only happen in a stationary state when organisms' expectations of both reference and feedback signals conform to the possible permutations of each.

FIGURE SEVEN

Figure VII is a functional, operational block diagram integrating into a systematic whole, the general communication system, the human communication system and the feedback control system which have been discussed above.

Figure VII applies to flows of signals from the cultural system to an organism, from an object world to an organism, between organisms and within organisms.

The areas delimited in red and labelled (1) to (6) each contains a discrete general communication system comprising "information source", "transmitter", "receiver" and "destination". Each of the six systems are joined as subsystems of the total communication system. In Area (1), the information source and the transmitter are elements in the cultural system and the receiver and the destination are elements in organism A. On arriving at the destination in area (1) the signals are coded and become the information source in area (3). In area (3) the information source and transmitter are elements in organism A and the receiver and the destination are elements in organism B.

The reverse is the case in area (4) where the information source is an element in organism B and the destination part of organism A. In area (6) the information source and transmitter send signals from the object world which are received and passed on to a destination in organism B. On arriving at destination in area (6) signals are coded and become the information source in area (4). The communication system in area (5) is internal to organism B. The receiver and destination in area (5) are shown diagramatically to be the same as the receiver and destination in area (6), but they are functionally different.

The information source in area (5) derives from coded signals from the destination in area (3). Area (2) is internal to organism A. The receiver and destination in area (2) are shared by area (1).

While the information source in area (2), organism A, is taken to initiate the processes of the total communication system, the problem of communication for the total system is to establish how messages are transmitted from the information source in area (1) (cultural system), through the system and finally arrive at the destination in area (4), organism A.

It was suggested above (p.63 ) that in a semantic link involving only one transitional state, the problem of semantics is, in the case of signal output or transmission, the same as the problem of encoding and in the case of signal reception or input, the same as that of decoding. Viewed in this manner, semantics is relevant to each of the six area taken separately. Narrowing the focus still more, semantics is relevant to the following states of transition in each of the areas :

1) Information source to output signal
2) Output signal to transmitter
3) Transmitter to output signal, control signal or "Ve".
4) "Ve", output or control signal to receiver
5) Receiver to feedback or reference signal
6) Feedback or reference signal to destination.

In a much broader fashion, however, semantics can be seen as relevant to the correspondence between a cultural system and an object world. The relationship between object world and cultural system is an imputed one in exactly the same sense as the imputed relationship between referent and symbol in the Ogden and Richards diagram (P.60 ). As arrived at above (P.62 ), it is necessary, when analyzing such a relationship pragmatically, to take it through the social system. This is done in Fig. VII. There the semantic relationship between the cultural system and the object world is seen to involve at minimum 21 and at maximum 33 semantic links. The former figure was arrived at by counting the six semantic links in each of areas(1), (4) and (6), by counting the coding function between the destination of area (6) and the information source of area (4) as one semantic link, and by counting the signals transmitted from the destinations of areas (1) and (4) to the "comparator function" as two semantic links. The former figure does not assume a feedback control system. The latter figure was arrived at by taking areas (1), (3), and (4) to have six semantic links each, areas (5) and (6) to have ten between them, by giving three semantic links to the coding functions and by taking as two semantic links the inputs from destinations in areas (1) and (4) into the comparator function in organism A. This latter figure assumes a feedback control system on an error-free basis and hence does not include inputs into and outputs from the comparator function in organism B. The comparator function in organism A is counted because this is where signals deriving from the object world finally meet signals deriving from the cultural system; this is where a "semantic cycle" is closed. The links in the communication system of area (2) are not counted as the function of this system is purely to get the total system "under way". It does not influence the relationship between the cultural system and the object world except in initially selecting a cultural system transmitter.

In Figure VII the elements of Powers, Clark and McFarland's general feedback control system have been loosely but consistently interpreted. In the first place, since four orders of systems are represented, it was necessary to duplicate the functions and signals shown in their diagram (Figure VI) in each of the systems represented. With this duplication there were some attendant modifications and additions.

In the Powers, Clark and McFarland model the input boundary consists of a Feedback Function. In Figure VII it was found necessary to retain a general notion of the input boundary as well as including the "Feedback Function" form of it in view of the fact that not all inputs into the system are in the form of feedback but also come in the form of goals. Thus, in Figure VII there are, in addition to Feedback Functions, Input Functions of a more general type. The receiver in Organism A - Area (2) - serves both as a general input function for the social system and also as a specific feedback funtion for the Comparator function of Area (2). The receiver in area (5) serves as a feedback function for the social system as well as for the comparator function in area (5).

Powers, Clark and McFarlands comparator function remains the same in Figure VII. In each case the comparator function receives both reference and feedback signals and transmits error signals. In the Powers, Clark and McFarland model the output function transmits output signals to an environment function which has an energy source. The environment function produces in turn variables (Ve) which are inputs to the system. In Fig VII to each system any other system is environment. Hence, in the cases of cultural system to social system, object world to social system and organism B to organism A, the characteristics of the Output Function-Environment Function - Feedback Function Chain in Powers Clark and McFarland's model are retained. In Figure VII, however, output functions transmit output signals to selector functions (additional functions not given by Powers, Clark and McFarland) as well. Selector functions transmit, in turn, control signals to an input/feedback function in organism A and to a feedback function in organism B in the sense of determining what set of "Ve's" are to be accepted as inputs.

Another function added in Fig VII is the coding function. The coding function transforms signals received at the destination of a Shannon-type system into another set of signals which become the information source of another Shannon-type system. This occurs on the diagram between the destination of area (1) and the information source of area (3), between the destination of area (3) and the information source of area (5) and between the destination of area (6) and the information source of area (4). It is recognized that coding also takes place in each semantic link in a Shannon-type system, although this is not made explicit diagramatically.

The coding functions shown in Figure VII are responsible for routing reference and feedback signals through the system. Throughout the system reference signals are goals introduced from the cultural system which determine for the social system what objects are to be selected from the object world and the feedback signals from the object world are the criteria which the social system uses for establishing whether or not the goals have been satisfied.

There is one exception to the above statement on reference and feedback signals. It is assumed that the information source in area (2), organism A, gets the system "moving" by initially specifying the "Ve's" to be selected from the cultural system. It does this through outputs to a selector function which controls what the organism receives. At the same time it sends reference signals into the comparator function (*) in area (2). "Ve's" entering the receiver common to areas (1) and (2) become reference signals for the social system and feedback signals for area (2), organism A. Hence both general input and feedback functions are combined in one receiver. The feedback signals are those which enter the comparator function (*) and the reference signals are those which are coded for output through area (3) and which are also passed into the other comparator function in organism A. The feedback signals are compared with the initial reference signals in the comparator (*). If there is a discrepancy between the two, error signals are sent to the output functions in areas (2) and (3). The output function in area (3) will stop operating until receiving new "r" signals from the coding function. The output function (*) in area (2) will send further signals to the selector function which correct for the initial error made, thus bringing f* closer into line with r*.

The feedback and reference signals in area (2) are operationally the same as those in area (5) but functionally different. Those in area (2) function to "start" the system by facilitating the selection of suitable reference signals from the cultural system (on, perhaps, the basis of factors outside the communication system such as goals, roles etc of, say, an economic or religious nature). Those in area (5) function as part of the feedback control system of the total communication system.

In Figure VII system processes come to a halt when feedback signals, starting with inputs into the feedback function in area (5) finally reach the comparator function (bottom left hand corner) in organism A. There they are compared with the reference signals (which entered the system when the discrepancy between the f* and r* signals were reduced to zero and which have been delayed in the comparator since.

If there is no discrepancy between these two sets of signals then semantic conditions have been satisfied for the whole system. If there is a discrepancy then an error signal is sent to the output function*. The error signal might indicate either inadequacies of the cultural system or changes in the object world and the system would adjust by selecting other "Ve's" from the cultural system or other "Ve's" from the object world in subsequent cycles. We are here concerned, however, primarily only in those events which must occur for semantic conditions to be satisfied.

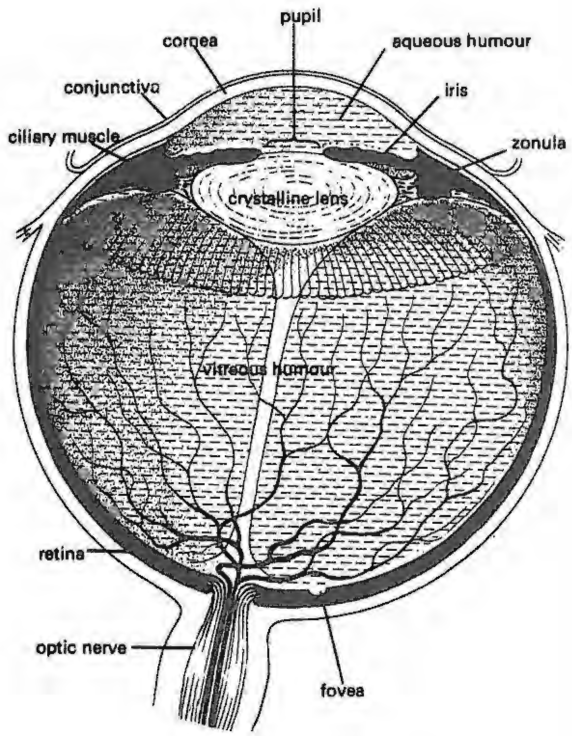
Figure VII in incomplete in a number of respects. Firstly, with regard to "noise", the only type of noise that can be shown is "semantic noise". This would come about either through incorrect selections from the object world or the cultural system or from actual lack of correspondence between the two. In either event semantic noise is reflected in the system by means of appropriate error signals and the system can adjust accordingly. There can be other sources of noise, however, which could take a number of forms such as defects in the system, interfering energy sources and goals which compete with the purely semantic ones. Noise might enter at numerous different points in the system. The system might or might not be able to distinguish between errors due to semantic noise and errors due to other sources of noise.

Secondly, the element of time is not shown in Figure VII. It is important that events in the system are ordered sequentially. Thus reference signals must be delayed in comparator functions until feedback signals are received. Further, in certain parts of the system signals may be a function of time. Delays might be highly significant.

Lastly additional feedback loops might have been incorporated in Figure VII. It can be seen that, for example, the "Ve's" given as outputs by organism A could, in addition to being received by organism B, be fed back into organism A through a feedback function for comparison with an initial reference signal (See dotted lines connecting transmitter area (3) to receiver area (4) and transmitter area (4) to receiver area (3). An illustration of this is the case of an organism hearing what it says or seeing what it writes.

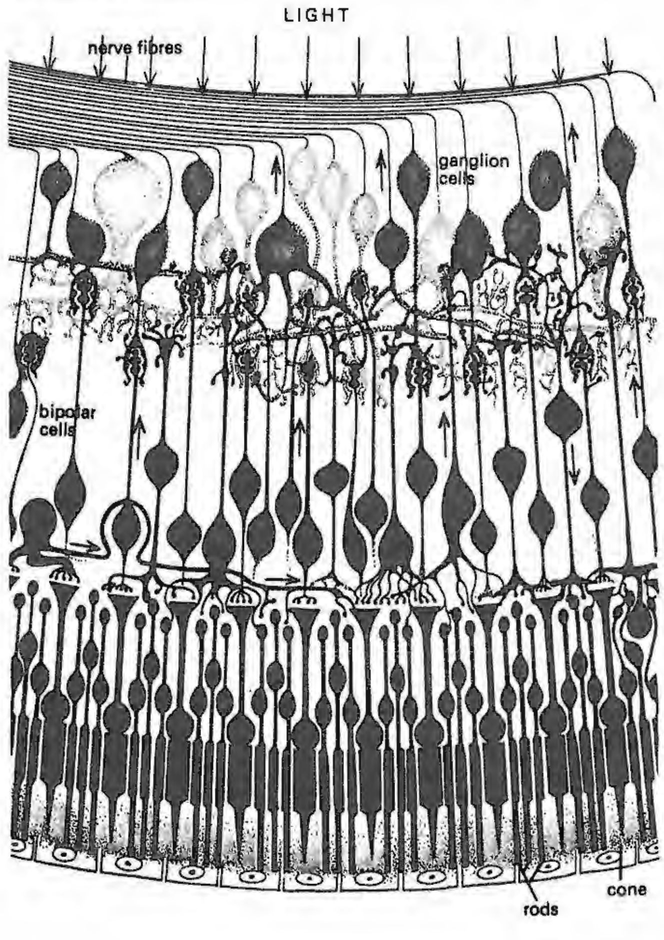
## FIGURE VIII [13]

The human eye. The most important optical instrument. Here lies the focusing lens, giving a minute inverted image to an incredibly dense mosaic of light-sensitive receptors, which convert the patterns of light energy into the language the brain can read – chains of electrical impulses.




## FIGURE IX [14]

The retina. Light travels through the layers of blood vessels, nerve fibres and supporting cells to the sensitive receptors ('rods' and 'cones'). These lie at the back of the retina, which is thus functionally inside-out. The optic nerve is not, in vertebrate eyes, joined directly to the receptors, but is connected via three layers of cells, which form part of the brain externalised in the eyeball.



So far we have shown the consistency of three different models with regard to the hypothesis offered here - Shannon's model of a general communication system, Powers, Clark and McFarland's model of a general feedback control system and a modified version of Parsons' model of a general action system. Further, the pragmatic view of semantics, taken broadly as encompassing a whole chain of links between culture and objects or narrowly as applying to one transition is seen to be consisted with a model (Figure VII) which incorporates and integrates models taken separately from action theory, cybernetics and information theory.

In the pages that follow the object will be to further elaborate the model in the sense of showing its consistency with material relating to specific parts of it.

THE ORGANISM

(a) The Eye

In Figure VII any of the receivers shown as elements in organisms A and B could be an eye or a pair of eyes.

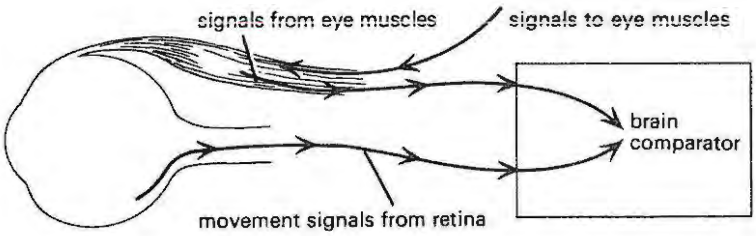
In Figure VII receivers are shown as receiving "Ve's" from the environment. In visual communication "Ve's" consist of combinations of light waves ranging from roughly 16 to 32 millionths of an inch in length. In the human eye light travels to receptors which lie at the back of the retina.

Since it is important for the communication system that certain "Ve's" are selected and not others, it is necessary that control be imposed on the receivers so that they do not receive "Ve's" randomly. In Figure VII areas (2) and (5) show selector functions transmitting control signals to receivers. In the case of receivers in areas (3) and (4) selectors are not shown but they can be assumed to exist.

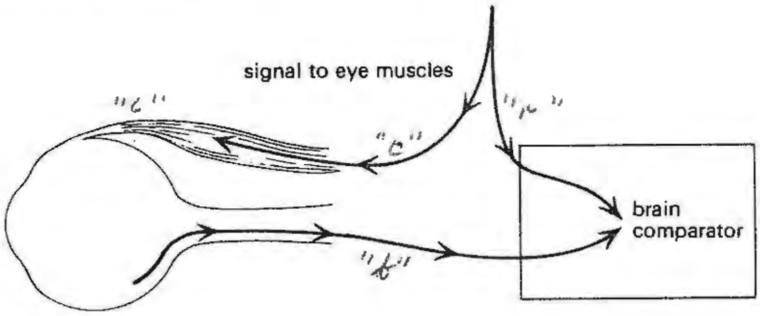
It appears that the control and feedback signals shown in areas (2) and (5) are functionally representative of signals to the eye muscles from the brain and signals through the optic nerve to the brain.

## FIGURE X'5

Why does the world remain stable when we move our eyes? The *inflow theory* suggests that the movement signals from the retina (image/retina system) are cancelled by (afferent) signals from the eye muscles. The *outflow theory* suggests that the retinal movement signals are cancelled by the (efferent) command signals to move the eyes, through an internal monitoring loop. The evidence favours the outflow theory.




INFLOW THEORY




OUTFLOW THEORY

The facing diagram illustrates this two-way signalling with regard to the stability of the world as perceived by the human organism.

(The symbols "r", "o", "c" and "f" have been superimposed on Gregory's diagram to show its close correspondence to areas (2) and (5) in Figure VII).

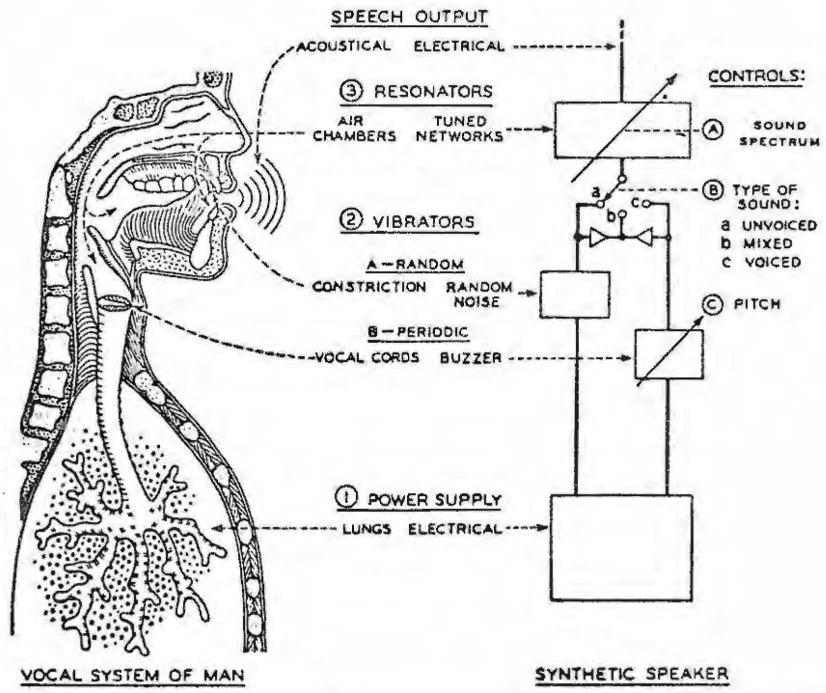
Cherry writes[16] that when reading we do not move our eyes smoothly along the printed line, but in an irregular sequence of rapid jerks. At each POINT OF FIXATION, the eyeball is (almost, not absolutely) stationary for an interval of approximately one-quarter second for adults; the saccades, or jerks, from one point to another are rapid, and the eye spends 90 per cent of the time fixated.

From tachistoscope* experiments it appears that visual perception, during reading, takes place almost entirely during the times of fixation. Though the eyes see a sharp letter only at the point of fixation, there is little doubt that it receives clues as to the general shape or contour of words in the neighbourhood - including words AHEAD, giving the reader some visual aid to prediction. Such PERIPHERAL vision is important and may provide clues which partly determine the point of location in the next fixation.[16]

It would seem, writes Cherry, that the intake of visual information is controlled by a FEEDBACK action, and that we have, in these instrumental means of measuring points of fixation, an ideal way of exploring this intake of information. If the points fixated on the printed text be regarded as giving the succession of input signals, and the perception regarded as an output response, then the points of fixation and length of saccades may depend upon this output; that is to say, the point to which vision is shifted, in any one saccade, may be the result of a prediction based upon preceding perceptions.[16]

* With an instrument known as a TACHISTOSCOPE, photographs, printed letters and words, diagrams and drawings may be flashed upon a screen for very short intervals of time which may be controlled precisely.

FIGURE XI (b)[17]




Functional Comparison of Synthetic Speaker with the Human Vocal System.

Cherry's account of points of fixations and saccadic movements appears to be consistent with the functions and signals shown in Figure VII. It seems as though the feedback signals shown in areas (2) and (5) are transmitted during periods of fixation and that the control signals cause the saccadic movements during which the feedback signalling is momentarily halted.

(b) <u>The Vocal System</u>

In Figure VII the human vocal system would seem to be correctly represented by the "transmitters" in areas (3) and (4). As shown in Figure XIa the speaking mechanism is itself divisible into a number of subsystems. A functional comparison of the human vocal system with a synthetic speaker is given in Figure XIb

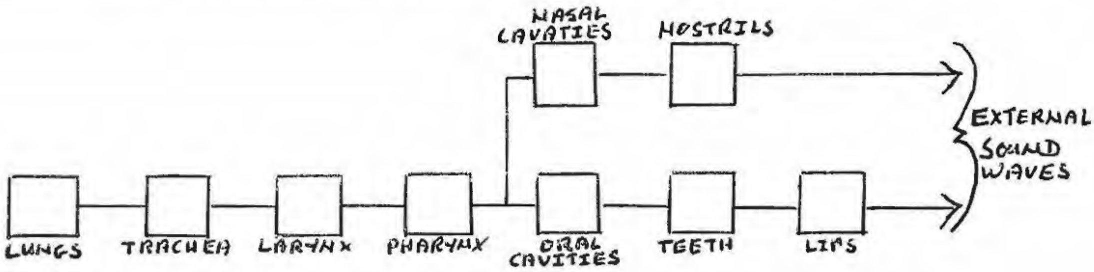



FIGURE XIa: <u>BLOCK DIAGRAM OF VOICE MECHANISM</u>[17]

The means whereby "o" signals, transmitted from the brain (the information source-output function in areas (3) and (4), Figure VII) to the vocal system, produce external sound waves ("Ve's") having certain characteristics is shown functionally in Figure XII.

Wilson and Wilson define the word "control": to exercise an influence over something, to guide, direct or restrain it. In a conventer, the power control controls or modulates the energy from the zero-entropy* power source.

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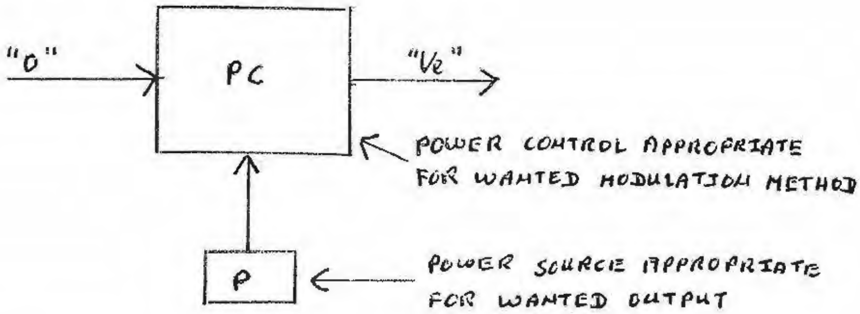
* "Zero-entropy" energy is completely predictable energy that furnishes no information whatsoever.[18]




A SIMPLE CONVERTER

FIGURE XII[19]

To produce information-carrying energy, a power control can change the variables describing the zero-entropy power source.[20] It can change the space structure or the time structure or both.

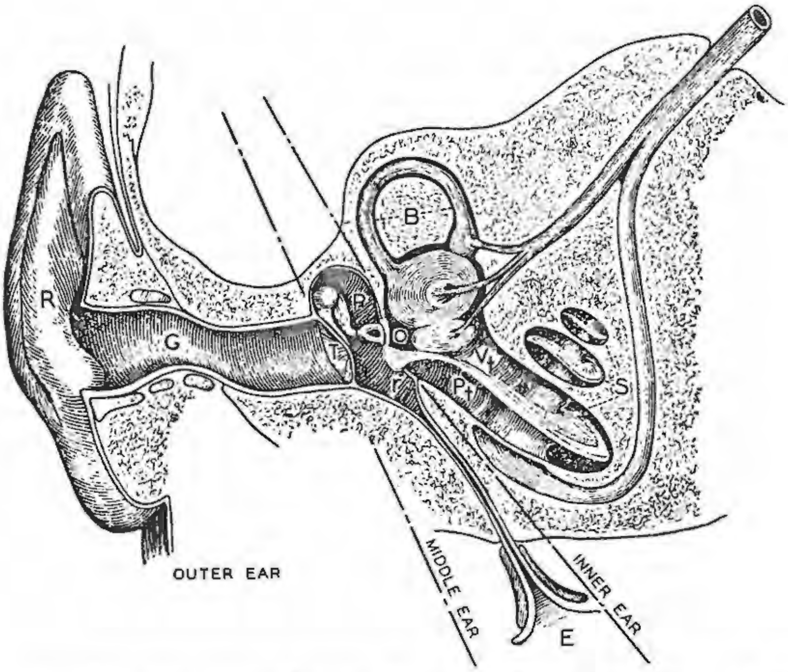
With respect to the vocal system of a human communication system, the lungs may be regarded as a source of zero-entropy power (as shown in Figure XIb) which is acted upon by the other parts of the vocal system to produce in the environment sound waves having certain combinations of frequencies of a non-zero-entropy type. The movements of the vocal system providing this power control are determined by output signals from the brain (information source) through the medium of the motor nervous system.

## (c) The Hearing Mechanism

In the case of vision the receivers shown in Figure VII were regarded as human eyes or pairs of human eyes. Similarly, in the case of hearing any of the receivers shown in Figure VII might be regarded as an ear or a pair of ears.

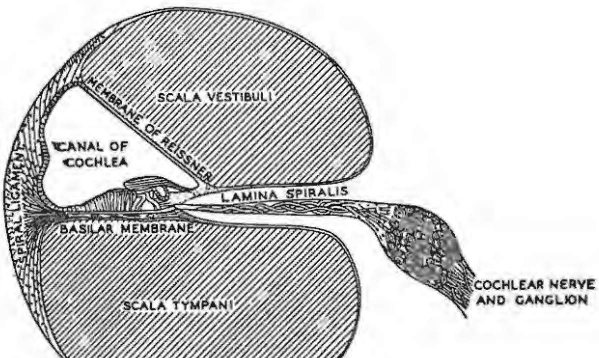
We can point to an important distinction between hearing and vision with regard to Figure VII. In the case of vision we were able to show the selector function acting directly on the receiver by means of signals in an intra-organic channel. It would, however, also be possible to show the selector function acting directly on the environment (object world or cultural system) in order to select a suitable set of "Ve's" thus forming an external feed-back loop such as is drawn in Figure VI.

## FIGURE XIII (a)[21]




SEMI-DIAGRAMMATIC SECTION THROUGH THE RIGHT EAR (CZERMAK): *G*, EXTERNAL AUDITORY MEATUS; *T*, MEMBRANA TYMPANI; *P*, TYMPANIC CAVITY; *o*, FENESTRA OVALIS; *r*, FENESTRA ROTUNDA; *B*, SEMI-CIRCULAR CANAL; *S*, COCHLEA; *Vt*, SCALA VESTIBULI; *Pt*, SCALA TYMPANI; *E*, EUSTACHIAN TUBE; *R*, PINNA.

## FIGURE XIII (b)[21]




COCHLEA IN TRANSVERSE SECTION. OBSERVE ESPECIALLY THE CANAL OF THE COCHLEA WHICH IS A PART OF THE MEMBRANOUS LABYRINTH. (Testut.)

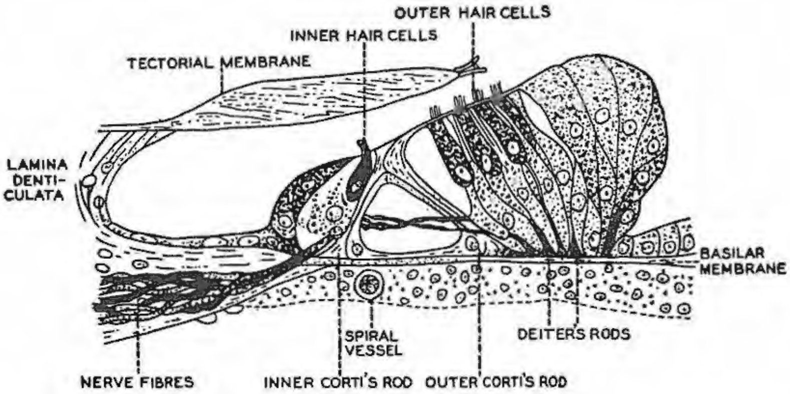
An example of the first case (internal selection) is when someone reads a page opened before him. An example of the second case (external selection) is when one turns a page.

It seems that in the case of hearing the selector function can operate only externally and then only in certain instances, for example, in selecting a channel on the radio, turning up the volume of a record player or, in a social system, when a teacher commands the class to keep quiet or asks a pupil to read aloud. In many instances the organism has no control over the sounds reaching its ears.

The hearing mechanism is articulated with the vocal system. The ears of an organism can receive "Ve's" in the form of sound produced by the vocal system of either the same or otherwise another organism. In the social system shown in Figure VII the ears of organism A receive sound produced by the vocal system of organism B and vice versa. At the same time it is possible for the ears of organism A to receive the "Ve's" produced by the vocal system of organism A and similarly in the case of organism B. This is shown by the broken black lines spanning areas (3) and (4). This has certain important consequences. Firstly, if we take an organism in isolation it describes the phenomenon of soliloque. Secondly, if we take two (or more) organisms in a social system it provides a functional explanation of the mechanisms whereby, according to George Mead, an organism, by means of the significant vocal gesture, calls out in itself the same response that it calls out in the other(s).

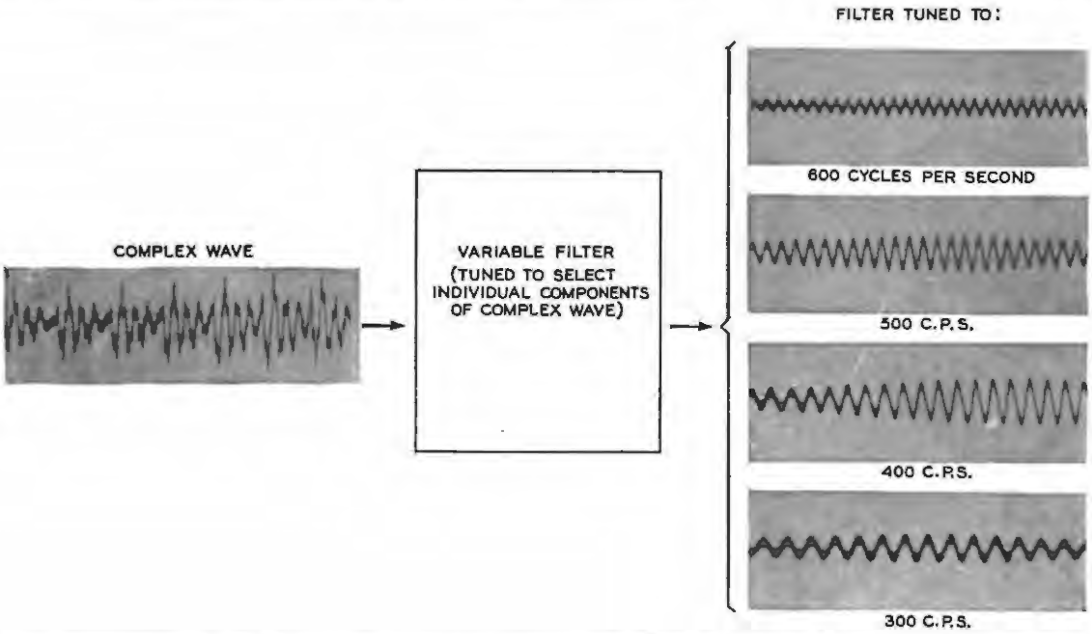
Figure XIIIa shows a schematic diagram of the parts of the ear with the inner ear much enlarged. The cochlea which is really the end organ of hearing is shown in transverse section in Figure XIIIb. The Auditory nerve enters the base of the cochlea. The cochlea is divided along its length into three parts by the basilar membrane and Reissner's membrane. The three parts are canals called the canal of cochlea, scala tympani and scala vestibuli. The membrane of Reissner is a very thin flexible membrane which readily passes any sound waves. Thus the canal of cochlea and the scala vestibuli may be considered as a single chamber filled with fluid.

FIGURE XIII (c) [21]




CORTI'S ORGAN (after Retzius). THE TECTORIAL MEMBRANE IS SHOWN CONTRACTED IN THE PROCESS OF HARDENING THE TISSUE, AND TORN AWAY FROM THE PLATEAU OF CORTI.

FIGURE XIV [22]




***Illustrating the selection of different individual components in a complex wave by changing the tuning of an analyzing filter.***

The scala tympani is partitioned from the other two chambers by the lamina spiralis (a bony projection) and the flexible basilar membrane. It is seen in Figure XIIIb that if any vibratory energy is communicated from one side of the partition to the other, it must vibrate the basilar membrane. On top of the basilar membrane lies the organ of Corti, which contains the nerve terminals in the form of small hairs extending into the canal of cochlea (See Figure XIIIc).

Figure XIV shows how a complex wave is analyzed into simple oscillations by means of a filter made up of tuned electrical circuits, that will pass oscillations only in a particular frequency range. At left is shown an oscillogram of a complex wave. At right are shown the simple waves selected by the filter for the settings indicated.

It appears to us that the basilar membrane corresponds functionally to the filter shown in Figure XIV, different areas along the length of the membrane being sensitive only to certain frequencies in the audible spectrum. Thus different groups of nerve endings are stimulated according to their position along the membrane, allowing the brain to interpret the signals transmitted to it accordingly.

From our point of view the basilar membrane is particularly important in that it is the mechanism whereby sensory nerves leading to the brain are excited.

Fletcher writes[13] that the pitch of a tone is determined both by the position of its maximum stimulation on the basilar membrane and also by the time pattern sent to the brain. The former is probably more important for the high tones and the latter for the low tones. The loudness is dependent upon the number of nerve impulses per second reaching the brain and possibly somewhat upon the extent of the stimulated patch. The experience called by psychologists "volume" or "extension" is probably identified with the length of the stimulated patch on the basilar membrane. This extension is carried to the brain and forms a portion of excited brain matter of definite size.

It is, then, this size that determines our sensation of the volume of a tone. The low pitched or complex tones have a large volume, while the very high pitched tones have a small one.[13]

Fletcher writes that for every sound reaching the ear, a space stimulation pattern corresponding to the time pattern of the sound in the air is produced on the basilar membrane. This space pattern is transferred to the brain by a nerve cable containing about 3,000 individual nerve fibres. The space pattern is dependent upon both the kind of sound and also the intensity with which it is applied to the ear.[14]

(d) Other receivers and transmitters

Speech, vision and hearing are obviously not the only organic processes in human communication. The motor-nervous activity responsible for writing, carving, painting, the playing of musical instruments, hand-signals, facial expressions and body movements is of great importance. All these activities can be represented in Figure VII by the transmitters in organisms A and B.

Similarly, on the sensory side the receivers in organisms A and B can represent the end-nerve complexes responsible for Ve's being received as inputs and sent to the brain as tactile and olfactory information. The operation of the taste buds can be represented in a similar way.

If space allowed an elaborated account could be given of all the sensory and motor organs which can act as elements in a human communication system. While the empirical importance of, for example, the sense of touch is recognized as enabling the organism to make a whole range of fine discriminations such as hardness, softness, roughness, smoothness and so on, it is thought that the accounts given of hearing, vision and the vocal system are sufficient in providing detailed examples of how certain parts of a human communication system work.

It is recognized that empirically more than one receiving or transmitting mechanism can be involved simultaneously in receiving or producing Ve's. Thus it is possible for an organism to both look at and feel an object thus deriving at once two different types of information on it.

Again, it is possible for an organism when talking to use at the same time its hands as instruments of expression. In the model given here combinations such as these are not explicitly taken into account in the interests of simplicity although, should the purposes require it, a "receiver" or "transmitter" in Figure VII might conceivably be taken to contain more than one organ.

### (e) The Human Brain

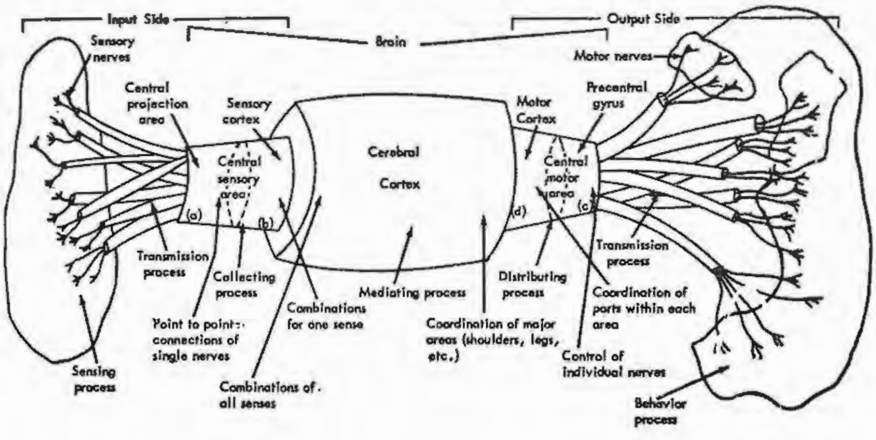
The human brain can be described as an electronic recording machine, with built-in sub-assemblies having both permanent and circulating memories, the functioning of which is modulated by a biochemical multi-directional or broadcasting process via a thalamocortical clearing center.[25]

The nerve cells in the brain consist of CELL BODIES, each having a long thin process - or AXON - conducting impulses from the cell. The axons may be very long, sometimes extending from the brain down the spinal cord. The cell bodies also have many finer and shorter fibres, the DENDRITES, which conduct signals to the cell. The cells, with their interconnecting dendrites and their axons, sometimes seem to be arranged randomly, but in some regions of the brain they form well ordered rows, especially in the visual region.[26]

The neural signals are in the form of electrical pulses, which occur when there is an alteration in the ion permeability of the cell membrane. At rest, the center of the fibre is negative with respect to the surface; but when a disturbance occurs, as when a retinal receptor is stimulated by light, the center of the fibre becomes positive, initiating a flow of current which continues down the nerve as a wave.[26]

FIGURE XV

**SCHEMATIC DIAGRAM OF THE CENTRAL NERVOUS SYSTEM**



Nerves are joined by synapses, which are junctions where chemicals are released which serve as triggers. Most, and perhaps all neurones have both excitatory and inhibitory synapses which act as switches.[26]

Immensely minute and complex in detail, fairly simple in basic outline, the main parts of the nervous system are shown in Figure XV, which is a highly simplified, schematic diagram.[27]

The sensory nerves at the left make a point-to-point connection between the sense organ and the outer section (a) of the central sensory area (known as the central projection area). That is, each receptor cell in the eye, ear or skin is connected directly to a specific point in the central sensory area of the brain.[27]

On the right, the outer section of the motor area (known as precentral gyrus) shows a similar point to point connection to the muscles. Any particular muscle can therefore be made to move by electrically stimulating its connecting nerve in the brain.[27]

Section (b) represents the inner portion of the central sensory area which co-ordinates incoming sensory signals of each type. Each signal from the eye, for example, corresponds to only a single dot in the whole field of vision. Until these dots are reconstructed into a pattern approximating that which confronted the eyes, the only "pattern" available to the brain would be something like a scrambled mosaic. The visual section of the cortex creates a co-ordinated picture out of the incoming spots. Signals from tactile nerves are similarly co-ordinated here. By combining signals from various parts of the skin it is possible to tell the shape, texture, hardness, and so forth, of an object in a way which no single nerve or unco-ordinated group could do. The other senses are similarly co-ordinated here into a single, total "picture" for each sense.[27]

The next step is to combine and compare the incoming "pictures" from ALL the senses. This is apparently done in the sections of the cerebral cortex which adjoin the sensory cortex. We can identify many things by one sense alone, but combinations of senses are sometimes needed.

By way of example it would involve the manner in which the pattern of firing in the visual cortex brought about by the sighting of a tree would select in another part of the brain (probably the temporal lobe) that structure of neurones which, when excited, would set off a series of signals giving rise to the spoken word "tree".

The relevance that the neurological ordering of signals has to linguistics is, similarly, that an utterance is produced by effecting motor organs. The motor organs are effected by a very large number of discrete signals. Thus there must be a direct correspondence between the way output signals to the motor organs are ordered and the linguistic units which constitute the utterances (spoken or written). On the input side, only certain orders of signals will be linguistically meaningful to the organism.

With regard to action theory the neurological ordering of signals seems to be directly relevant to the Parsonian statement that co-ordinate with the normative priority of ends is the temporal priority of means. The implication for neurology is that on both the input and the output side signals transmitted to and from the brain cannot be random but must be ordered according to the end of the organism.

Information theory is directly concerned with the way in which messages are encoded into physical signals and decoded from those signals. Thus the application of information theory to the human organism must be directly influenced by theories on how signals are ordered neurologically.

## II <u>MEMORY</u>

It appears to us that information from cultural systems, social systems or object worlds can be neurologically stored. In action terms, this stored information would constitute the expectations of an organism viz-a-viz the cultural system, other organisms and the object world. The stored information plays a triple role in determining what signals from the environment (Ve's) are to be selected (in those cases where there is choice), in serving as an information source in the production of an output by the organism and in serving as a coding function in transforming information ordered in one way to information ordered in another way.

## III LEARNING

As mentioned in Chapter I (P. 7 ) the model developed here assumes both that learning has taken place and continues to take place. This implies that the requisite information is stored in the organisms, structuring their expectations in such a way that semantic conditions can be satisfied. That learning continues to take place implies that new information can be stored such that if changes in any part of the system take place the organism's expectations will be restructured accordingly and equilibrium will be restored in the sense that semantic conditions can once again be satisfied.

With regard to the three problems of the neurological ordering of signals, memory and learning further elaboration is called for. We start with learning and memory.

Alfred Kuhn[28] writes that we simply do not know what is different in the brain after learning. There are a few things, however, we do know with reasonable confidence. First, all neurones operate basically by electric current. Second all nerves discharge on an all-or-none basis, there being no intermediate state. Third, learning takes place at the synapses, apparently by some process which reduces resistance to the nerve current. Fourth, the arrangement of neurones in the cortex is extremely complex, so that each nerve is connected directly or indirectly with every other.* Fifth, no particular idea, concept or perception is located in any particular part of the cortex, and if it is reasonable to speak of the physical location of an idea at all, each occurs simultaneously in numerous parts of the brain.

In 1926 Eugenio Rignano wrote

> It is easy to show in a number of cases that when an organism, after the cessation of a stimulus, has attained the secondary indifferent state (the condition of living substance before a given stimulus reaches it is the primary indifferent state) it has undergone a permanent change.[30]

---

* This is disputed by Ross Ashby.[29]

> I call this effect of stimuli "engraphic action", because it is, so to speak, carved in or impressed on the living substance; to each change of the living substance I give the name of the "engram" of the stimulus which produces it, and I term "mneme" the whole number of the engrams which the organism has inherited or acquired during its individual life; ..........[3c]
>
> The result of engraphic action, in consequence of the permanent change which it produces in living matter, is that the state of excitement which a given stimulus has produced in the past may be reproduced, not only by a repetition of the same stimulus, but also by other influences to which on this account Semon has given the name of "ecphonic stimuli" or "ecphonic influences." Thus for instance if the stimulus a when it first occurs produces the reaction A and the stimulus b only the reaction B, the reaction (A & B) when it occurs for the first time can only be called forth by the stimulus (a & b). But when this same reaction (A & B) is evoked as a mnenomic response, that is as an effect of the engram produced by a former stimulus (a & b) then this response can be called forth by the stimulus a alone, or by the stimulus b alone, either of these stimuli now acting as on "ecphonic" stimulus.[3c]

Harold Burr writes[31] that it is not impossible that memory is nothing more or less than the continuous operation of a reverberating circuit in the neurones of the cortex. And Norbert Wiener writes that in a system containing a large number of neurones, circular processes can hardly be said to be stable for long periods of time. Either they run their course, dissipate themselves and die out, as in the case of memories belonging to the specious present, or they embrace more and more neurones in their system, until they occupy an inordinate part of the neurone pool.

Current research, writes Magoun,[32] is exploring the possibility that the unique organ of the body, devoted chiefly to the storage and retrieval of information and to control, namely the brain, may depend for its memory and learning functions upon modification of neuronal RNA, of which the ubiquitous Nissl substance of the nerve cell has been found to be composed.

Such specified and replicated RNA is proposed, in turn, to provide the template for elaboration of neural transmitter substances, responsible for consequent patterns of postsynaptic firing or inhibition.[32]

Magoun goes on to say that earlier explanations of the memory process rested heavily upon the maintenance of nerve impulses in reverberating circuits, along with plastic changes at the synapes, involving swelling, outgrowth or multiplication of presynaptic terminals. More recently Holger Hyden has summarized some of his thinking about the establishment of a memory trace as follows : "The modulated frequency (of nerve impulses) generated in a neurone by a specific stimulation is supposed to affect the RNA molecule and to induce a new sequence of nucleotide residues along the backbone of the molecule. This new distribution of components will then remain : the RNA has been specified. This leads also to a specification of the protein being formed through the mediation of this RNA.[32]

By a combination of this specific protein with the complimentary molecule, the transmitter substance at the synapse is activated at the points of contact with the next neurone. This allows the coded information to pass on to this next neurone in the chain. The reason for the response of this next neurone is that the pattern which had once been specified through a modulated frequency now responds to the same type of electrical pattern whenever it is repeated. The specific RNA and protein are constantly produced in the neurone. From a statistical point of view, the molecules can be estimated to furnish the necessary permutation possibilities to store the memory experience of a lifetime.[32]

Crossman has done experimental work in the application of information theory to the study of human immediate memory, regarding immediate memory as an information store of limited capacity. His experimental results suggest that a subject's immediate memory capacity is set jointly by : (1) the need to retain (selective) information as to the item occuring at each position in an original list, and (2) the need to "label" each position so that the original order can be reconstructed on recall (order information).[33]

A model having these two limitations can be conceived as follows. The brain has a number of distinct storage devices or "addresses" but no means of identifying them. It also has a limited number of entitities - digits - that can be used to represent items to be remembered. Digits can be put into addresses, and recovered at will. When a list is presented, the brain, hearing and recognizing each successive item, uses the result of each recognition together with a prearranged code, to allocate certain digits to an address: one or more digits are then added indicating its position in the original list. When the subject is asked to recall the list, all the addresses are searched, the group of digits is then recovered, decoded and used to construct the original list.[33]

There are many cases, writes Crossman, where some degree of prior organization reduces or eliminates the need to retain order - information. London telephone numbers, for instance, invariably have three letters and four digits. Similarly, for English text, grammatical rules provide a strong structural framework and this may enable the span to be increased even more than the ordinary selective redundancy would predict.[33]

Crossman concludes that immediate memory has neither a constant INFORMATION CAPACITY in Shannon's sense, nor is it limited to a NUMBER of items, as Miller suggests. The truth lies between the two, and appears to involve the serial order or "location" of list items as a basic variable, together with list-length and vocabulary size.[33]

Let us now look at the ordering of signals in the human nervous system in greater detail. We turn first to Gregory Batesons account of codification.

Bateson writes[34] that codification must be systematic. Whatever objects or events internal to the individual represent external objects or events, there must be a systematic relationship between the internal and the external, otherwise information would not be useful. The engineer's term for nonsystematic elements in codification is "noise".

Codification must be such that relationships are preserved. While it is impossible for a man to have inside himself a tree corresponding to the external tree that he perceives, it is possible to have internal objects or events so related to each other that their relations reflect relationships between parts of the external tree. Very profound transformations occur in any codification. We may expect, for example, to find in some cases that spatial relations in the external world will be represented by temporal relations in the processes of mind : when the eye scans an object, the shape of the object is certainly transformed into a temporal sequence of impulses in the optic nerve. And in other cases, temporal sequences will be represented as spatial relations in the brain : a memory of past sequences must surely be so codified.

Bateson points out that engineers are able to describe several known possible varieties of codification, with which we can compare and contrast what seems to happen in human beings. Broadly there are three important kinds.[34]

First, there is what engineers call "digital" codification. In this type the input already differs very profoundly from the external events about which the machine is "thinking". In fact, for such machines it is necessary to have a human being who will codify the external events in terms of their arithmetical RELATIONS.[34]

Second, there is the type of calculating machine which the engineers call "analogic". In these machines the external events about which the machine is to think are represented in the machine by a recognizable model. In such machines changes in the external system can be represented by corresponding changes in the internal model. Bateson contends that it is doubtful whether any analogic mechanisms exist in the human central nervous system.[34]

Third, there are a few machines which are capable of codifying information in units comparable to what psychologists call Gestalten. An example of such a machine is the recently invented device which reads aloud from printed matter.[34]

The essential characteristic of such machines is that they can identify formal relations between objects or events in the external world and classify groups of such events according to certain formal categories. A message denoting the presence or absence of an event which fits a certain formal category is then transmitted, possibly by a single signal within the machine. The last possibility of summarizing a complex message in a single "pip" is the advantage which Gestalt codification provides. An enormous economy of codification within the machine can thus be achieved.[34]

A fundamental difference between codification by Gestalten and enumerative digital codification can be illustrated by contrasting codification which occurs in the type of machine which will transmit a half-tone block picture over wire with the type of codification in the process we call vision. The machine transmits billions of messages. Each message is the presence or absence of a "pip", such presence or absence denoting the presence or absence of a dot in the original half-tone block. The shower of impulses originating in the retina and travelling in the optic nerve is in some ways not unlike the shower of pips transmitted by the machine, but in the brain this neural shower impinges upon a network which has the characteristic of being able to discriminate formal relations within the shower - these formal relations being, in fact, related to those which exist in the original picture. The human being is thus able to categorize large areas of the picture in terms of Gestalten.[34]

The existence, writes Bateson, of Gestalt processes in human thinking seems to be the circumstance which makes us believe that we are able to think about concrete objects, not merely about relationships. And this belief is further fortified by our use of language, in which substantives and verbs always stand for externally perceived Gestalten. When, however, it is realized that the recognition of Gestalten depends on the formal relations among external events, then it is evident that thinking in terms of "things" is secondary - an epiphenomenon which conceals the deeper truth that we still think only in terms of relationships.[34]

We may summarize the external relationships by constructing Gestalten in our minds, but still it is the relationships in the afferent neural showers which provide the basis of our Gestalten.[34]

Our initial sensory data are always "first derivatives", statements about DIFFERENCES which exist among external objects or statements about CHANGES which occur either in them or in our relation to them. Objects and circumstances which remain absolutely constant relative to the observer, unchanged either by his own movement or by external events, are in general difficult and perhaps always impossible to perceive. What we perceive easily is difference and change - and difference is a relationship.[34]

This last paragraph is consistent with the kind of reasoning we put forward here. According to this reasoning semantic conditions are only satisfied when there is complete certainty. With complete certainty there is no information. Conditions allowing complete certainty occur only when there is no change. The satisfaction of semantic conditions requires a stationary "system". Hence Bateson's statement that objects and circumstances which remain absolutely constant relative to the observer are in general difficult and perhaps always impossible to perceive, takes on new meaning.

John von Neumann considers[35] the nervous system as a digital mechanism, one that transmits messages which are made up of signals possessing the all-or-none character. In other words, each elementary signal simply is or is not there. A particularly relevent illustration of this fact is furnished by those cases where the nervous system is required to transmit a continuous quantity.

Assume, for example, that a pressure (clearly a continuous quantity) is to be transmitted. It is well known how this trick is done. The nerve which does it still transmits nothing but individual all-or-none impulses. What appears to happen is that it transmits pulses at a frequency which varies and which is within certain limits proportional to the quantity in question, and generally a monotone function of it. The mechanism which achieves this "encoding" is, therfore, essentially a frequency modulation system.[35]

The details are known. The nerve has finite recovery time. In other words, after it has been pulsed once, the time that has to lapse before another stimulation is possible is finite and dependent upon the strength of the ensuing (attempted) stimulation. Thus if the nerve is under the influence of a continuing stimulus (one which is uniformly present at all times, like the pressure being considered here) then the nerve will respond periodically, and the length of the period between two successive stimulations is the recovery time referred to earlier, that is, a function of the strength of the constant stimulus (the pressure in the present case). Thus, under a high pressure, the nerve may be able to respond every 8 milliseconds, that is transmit at the rate of 125 impulses per second; while under the influence of a smaller pressure it may be able to repeat only every 14 milliseconds, that is, transmit at the rate of 71 times per second. This is very clearly the behaviour of a genuinely yes-or-no organ, of a digited organ. It is instructive, however, that it uses a "count" rather than a "decimal expansion" (or "binary expansion" etc) method.[35]

Formal Neural Networks

Von Neumann views the neuron as a "black box" with a certain number of inputs that receive stimuli and an output that emits stimuli. He assumes that the input connections of each of these can be of two types, excitatory and inhibitory. The boxes themselves are also of two types, threshold I and threshold II. These concepts are limited and circumscribed by the following definitions. In order to stimulate such an organ it is necessary that it should receive simultaneously at least as many stimuli on its excitatory inputs as correspond to its threshold and not a single stimulus on any of its inhibitory inputs. If it has thus been stimulated, it will, after a definite time delay (assumed to be always the same) emit an output pulse. This pulse can be taken by appropriate connections to any number of inputs of other neurons (also to any of its own inputs) and will produce at each of these the same type of input stimulus as the ones described above.[35]

It is, of course, understood that this is an oversimplification of the actual functioning of a neurone.

McCulloch and Pitts have used these units to build up complicated networks which may be called "formal neural networks." The important result of their work is that any functioning which can be defined at all logically, strictly and unambiguously in a finite number of words can also be realized by such a formal neural network.[35]

In his exposition of the McCulloch-Pitts logical neurone Elwyn Edwards[36] begins with an element which transmits pulses in one direction only and which can fire only once every millisecond (one thousandth of a second). The input of the neurone may be a receptor, which will be denoted by a square, or a synapse, denoted by a large circle. The output end may be either an effector, denoted by a square with a diagonal, or any number end-bulbs, denoted by small circles. A few neurons are illustrated in Figure XVI. The nomenclature is that of J.T. Culbertson (1958).

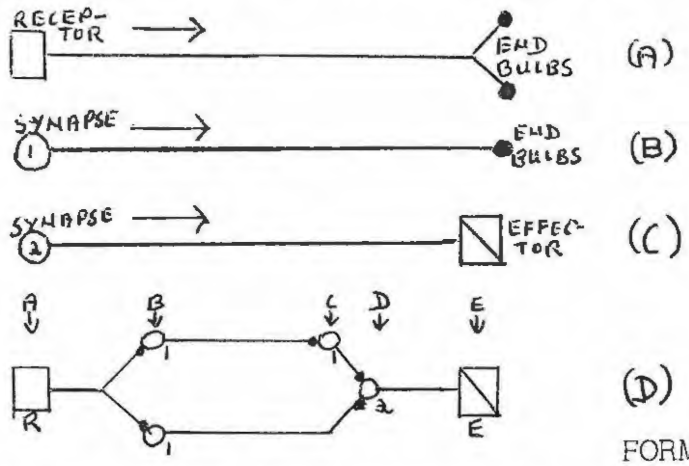



FIGURE XVI[36]
FORMAL NEURAL NETWORKS

In order for the effector in Figure XVl (D) to receive a pulse, it is necessary for both the end-bulbs connected with its synapse to fire simultaneously. For this to happen, it will be necessary for the receptor to be activated twice with an interval of 1 ms between activations. Let us suppose that the receptor is a telegraph key, and we shall buzz the number 45 in binary on it. The binary pattern of 101101 will appear in different parts of the network at subsequent instants, and we can show a pulse diagram as in Figure XVI (E) which represents what is happening at different parts in the circuit at different times.[36]

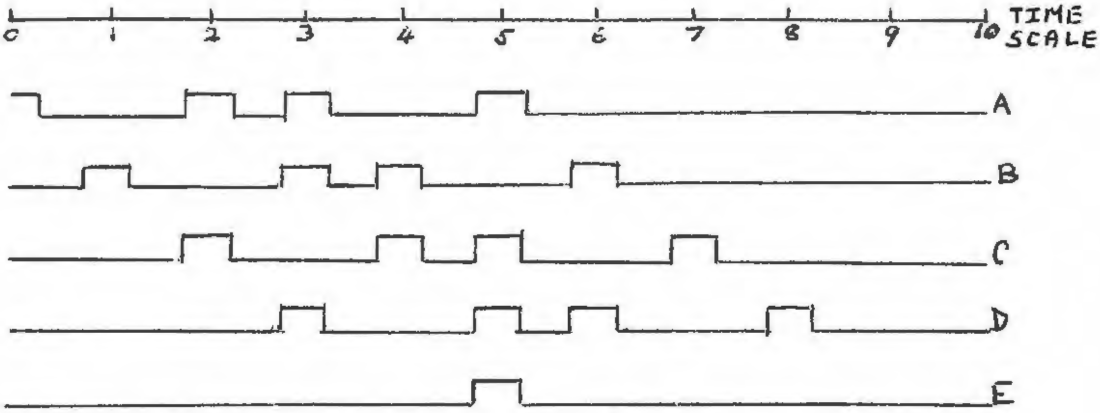



FIGURE XVIE[36]: PULSE DIAGRAM

Pulses arriving at the final synapse by means of the lower route will arrive there at the same time as pulses arriving at point C in the upper route. In order for the effector to be activated we must have simultaneous pulses at C and D. This will be seen to occur once, 5 ms after we begin to buzz.[36]

The most interesting examples of neural networks from our point of view are those which are sufficiently "intelligent" to recognize patterns. The network of Figure XVI (F) is constructed in such a way that the effector will be activated if and only if the pattern 101101 is entered simultaneously by way of receptors R1 to R6 respectively.[36]

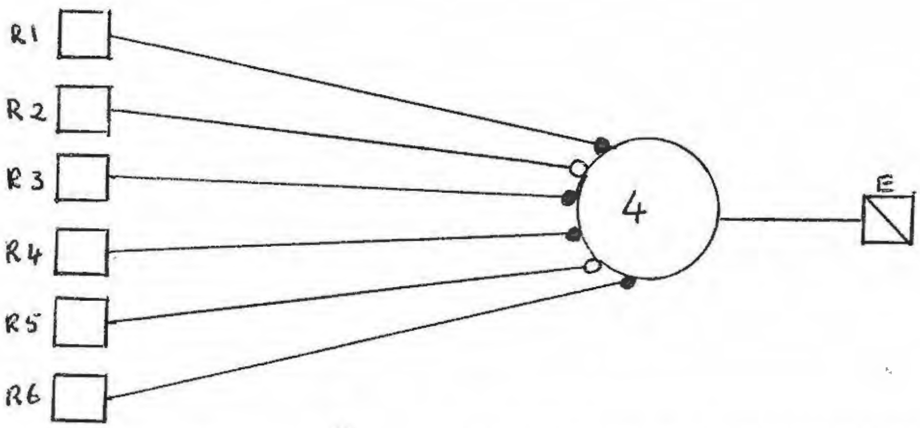
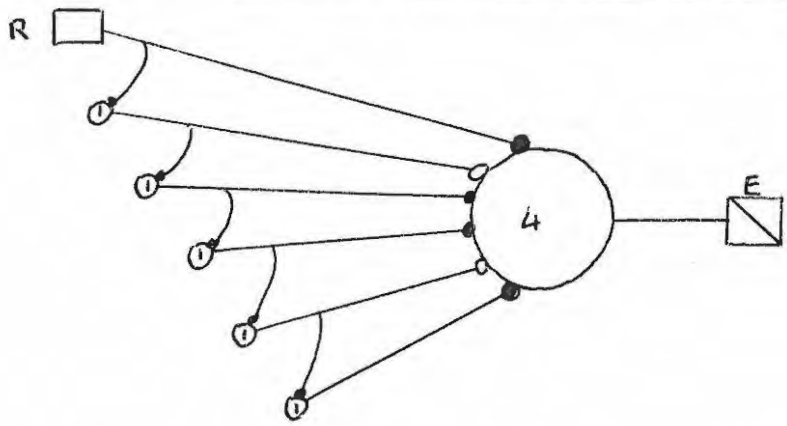



FIGURE XVIF[36]: SPATIAL PATTERN RECOGNTION NETWORK.

In Figure XVI (G) we have a system which causes the effector to be activated if and only if the pattern 101101 is presented to the single receptor in successive intervals of 1 ms.

FIGURE XVIG[36]: TEMPORAL PATTERN RECOGNITION NETWORK




Formal neural networks are highly suggestive for the main problems of this thesis. As far as action theory is concerned, it offers clues as to how the organism handles inputs received from any of the other systems emergent from the action frame of reference. It can be suggested that the way neural nets are structured in the brains of organisms constitutes their expectations.

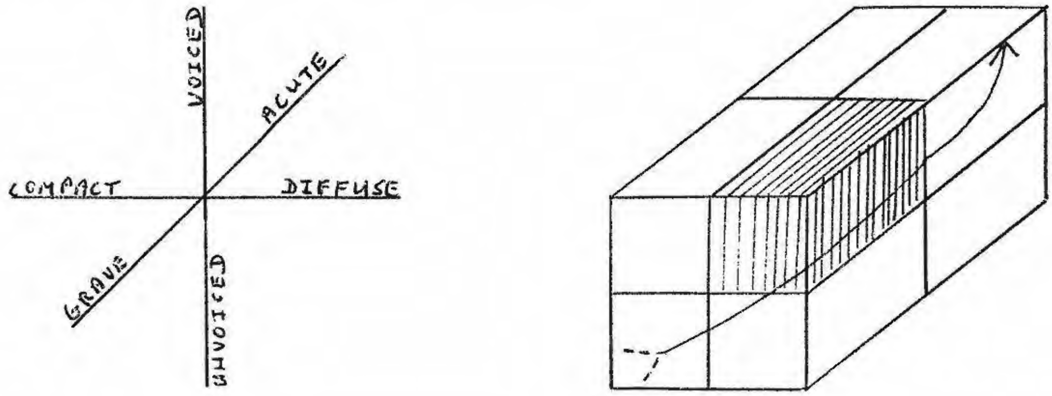
Formal neural networks have relevance to semantics. We saw, in Figure VII, that semantic conditions are satisfied when feedback signals equal reference signals in comparator functions. We can suggest that in terms of formal neural network theory comparison appears to operate automatically in the sense that if the correct signals are received in the right sequence then certain patterns of neural firing will occur in complete accordance with the existing neural structure. The failure of certain neurones to fire or the firing of neurones out of accordance with the pre-existing structure will indicate discrepancies between the expectations of the organism and signals received from the outside world. Such a discrepancy can result in a change in the neural organization. This of course is directly concerned with both learning and memory and is cybernetically accounted for by error signals leading to new selections.

There would appear to be correspondence between neural patterns and units of different types such as the "bit" in information theory, linguistic units and units in action theory such as "role". Let us start with linguistic units.

Fletcher writes[37] that different classifications of the spoken sounds of English may be made, depending upon the purpose one has in mind. The International Phonetic association uses a basic alphabet of sixty different letters and also numerous modifiers which serve to distinguish several hundred sounds. This provides greater resolving power but is too complicated. Upon considering the manner of formation of the speech sounds and studying their physical characteristics ....... 39 speech sounds which can be readily distinguished by an average English-speaking person were chosen by the Bell Laboratories for experimental articulation studies. These speech sound elements are divided into six classes : pure vowels, dipthongs, transitionals, semi-vowels, fricative consonants and stop consonants. The two classes of consonants are further divided into the groups designated voiced and unvoiced. Fletcher also shows how each of these sounds is produced. To produce the sound ū, for example, the lips are rounded and there is formed a large resonating chamber in the front part of the mouth, and a smaller and less important one in the throat cavity.

Professor Roman Jacobson has provided us with "Distinctive features" which reduce the phonemes of a language to a corresponding small number of variables and which relate to the physiological and articulatory processes of speech. The distinctive features are independent of one another; that is, no one of them can be expressed as combinations of the others. They represent co-ordinates of a space of n dimensions. In Figure XVIII (A) three are drawn (n = 12 in Jacobson's system). Each of the axes has two quantized regions so that the whole 12-dimension space may be divided up into hypercubes ($2^{12}$ in number) as in Figure XVII (B). Each cube then represents a conceivable phoneme, or "bundle of features" though, with any specific language, some will be "forbidden". A point placed anywhere within one of these cubes then represents the "state of the system", a particular phoneme; as this point is moved about from cube to cube it represents the spelling out of chains of phonemes or segments of recorded speech.[38]

Each different path represents a different sequence. The utterances of one person would be represented by a continuous trajectory through this n-dimension space threading one phoneme-cube after another.[38]




(a) Three mutually orthogonal axes of "Distinctive Feature" (or language) - space

(b) The space divided into cube-cells (8 shown here) representing the trajectory of an utterance.

FIGURE XVII[38]

Of prime importance here is that speech can be seen as a series or sequence of signals which are chosen from a finite number. It would appear that writing can be regarded similarly. Pulgram notes[39] that "phoneme" is a class name, hence a phoneme cannot occur. What does occur are phones, that is phonetic realizations, articulated sounds. All phones identifiable as member of a phoneme are its allophones. Phonemes are distinctive classes of speech sounds. Just as we speak of speech communities using different languages as dialects, so we have writing communities using various alphabets. Each alphabet has A CERTAIN FIXED NUMBER of distinctly shaped classes of symbols, usually called letters, which are graphemes. They correspond to phonemes in that they are classes serving to provide the function of distinctiveness. Each hic et nunc realization of a grapheme, which may be called a graph, can be recognized as belonging to a certain class and therfore deciphered by the reader.

All graphs so identifiable are allographs ofa given grapheme. Although the number of phones in each dialect cannot be limited the number of phonemes are. Although the number of graphs in each alphabet cannot be limited, the number of graphemes are.[37]

Robert E. Pittenger and Henry Lee Smith point out[40] that kinesics, or gestures and motions, are not instinctive human nature but are learned systems of behaviour differing markedly from culture to culture. Kinesics has its own minimal units. Overall patterns of movement can be subdivided into component sets of movement in various body areas - for instance, the face, arms, legs. The minimum discernable isolate which can be significantly differentiated from other though similar, isolates is seen as the basic building block from which the sets are composed in combination with other isolates.

It goes without saying that speech, writing, the movements of the face and body etc are intimately bound up with the workings of the central nervous system. The relationship between the units of linguistics and neural patterns might fruitfully be explored by the use of formal neural networks.

We saw above (P. 93) that the shape of an object is transformed into a temporal sequence of impulses in the optic nerve and that (P. 84) a space stimulation pattern of the time pattern of the sound in the air is produced on the basilar membrane and transferred to the brain.

We suggest that once learning has taken place in the organism its expectations are structured in such a way that certain patterns of sound or light are recognized automatically by networks such as those in Figure XVI F and G as having or not having the distinctive features of speech or writing. The particular order in which these distinctive features or units are arranged will be given in the brain by the order in which effectors such as those in Figure XVI fire.

If we go back to Figure VII we see that "Ve's" are both received and produced by organisms. We have shown how, when these "Ve's" are signals falling into classes such as phoneme or grapheme, they are recognized by the organism. We can build a little model to show how the organism produces such "Ve's".

We saw (Figure XV ) that there is a point to point connection between neurones in the precentral gyrus and the muscles. We know from Fletcher that there is a direct correspondence between speech sounds produced and movements of parts of the vocal system. It also seems obvious that there is a direct correspondence between allographs and the movements of the writing hand. Let us assume that in a language there are only eight phonemes or graphemes. Let us also assume that there are only three moving parts in the vocal system or in the writing hand. Since eight speech sounds (or letters) are characteristically produced there must be eight sets of control signals from the motor cortex to the vocal system (hand). Since there are only three moving parts it follows that there must be an appropriate neural code which channels the eight sets of control signals into different combinations of three sets of signals reaching the effector neurones (in this case the motor nerves responsible for muscular movement). Figure XVIII shows how this is done and thus offers a formal and oversimplified explanation of the process whereby language units, stored in neurones and chosen (in terms of the cybernetic control system) for output are produced and ordered into sequences of different kinds such as words and sentences.

FIGURE XVIII[41]

PRODUCTION OF SPEECH

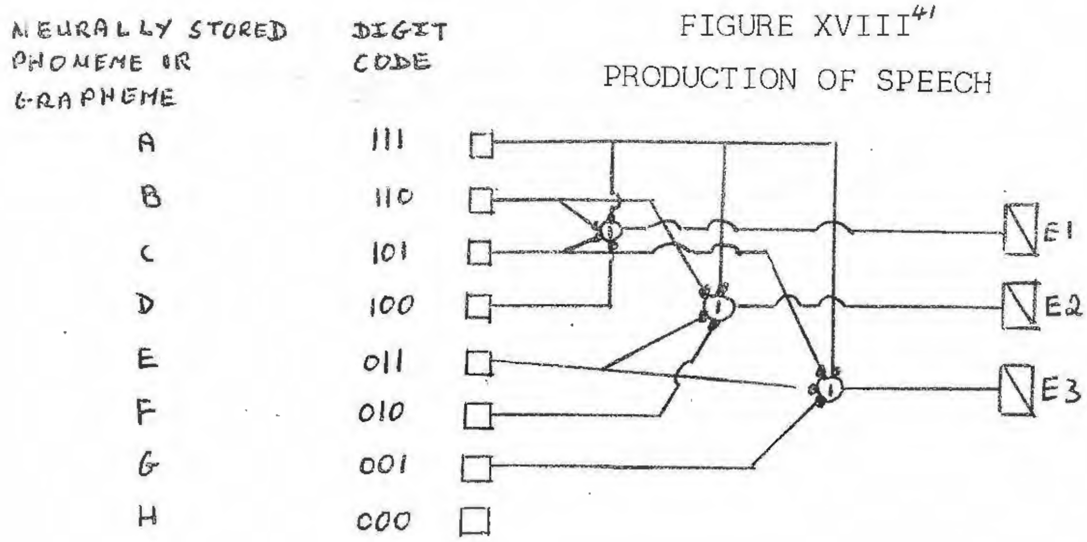


FIGURE XIX (a)[42]

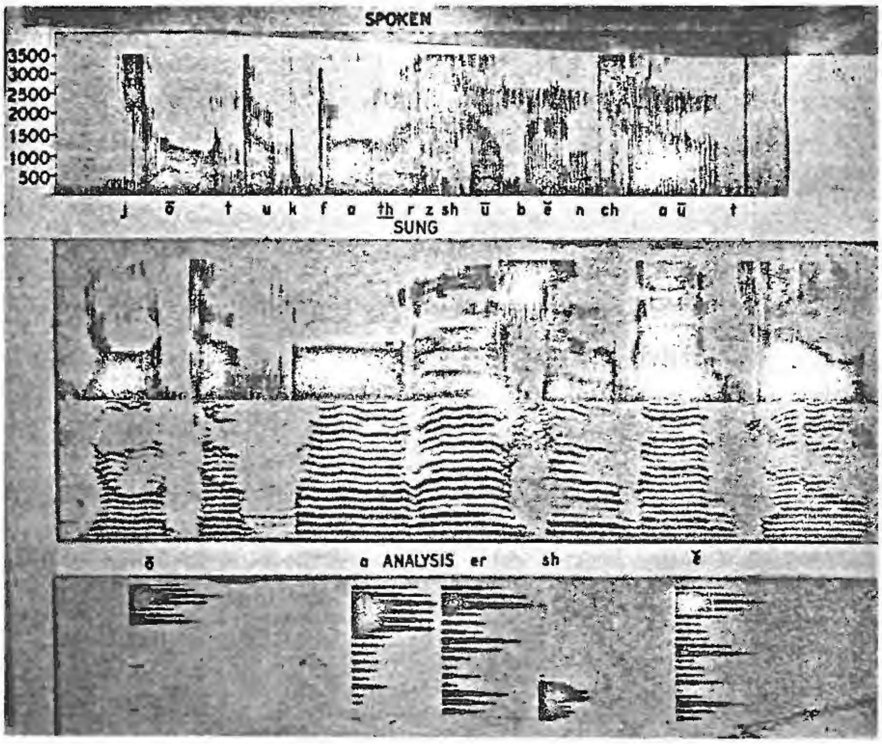
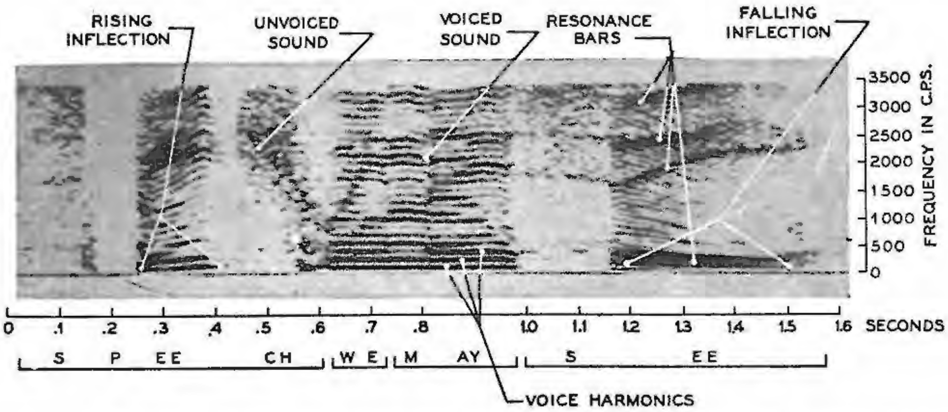



FIGURE XIX (b)[43]




***Sound spectrogram of the words "Speech we may see" using a narrow-band analyzing filter (45 cycles) to portray harmonic structure.***

In Figure XVIII effectors 1, 2 and 3 will be activated when A is selected. If B is selected then effectors 1 and 2 will be activated. If G is selected only effector 3 will be activated and if H is selected none of the effectors will be activated, and so on.

With regard to the specific model being developed here we can regard linguistic and kinesic units as types of "ve's" produced by an organism. The point is taken here that these units are co-ordinate with the human motor nervous system. They can also be regarded as co-ordinate with the units of both physics and action theory. The unit act of action theory and the role which is an ordered sequence of unit acts are general units. Broadly we could regard the phoneme as a specific case of a unit act and a larger sequence of phonemes, for example a sentence as a role. Thus the units of action theory can be regarded as co-ordinate with the human nervous system in the same way as linguistics units can. On the other hand, the units produced by an organism can be seen as corresponding to the units of physics which is, ultimately, concerned with energy. A specific instance of this is seen with regard to human speech and is illustrated graphically by the "sound spectograph" (see Figure XIX).

In Figure XIX(A) is shown the spectogram of the sentence "Joe took father's shoe bench out"taken with a sound, or speech spectograph. The top chart of this figure is for the case when the sentence is spoken and a 300-cycle filter is used in the spectograph. The vertical axis represents "frequency" and the horizontal axis "time" and the relative blackness is a function of the intensity of the component frequencies. The second chart gives a spectogram of the sung sentence as does the third chart which resulted from the use of a narrow band filter. In the lowest chart is shown the analysis for the sounds ŏ,a,ɛr, sh and ĕ. The horizontal extent of the lines represent the relative intensity level in decibels of the various components.

By means of Figure XIX (B) we are able to see a correspondence between Jacobson's distinctive feature "voiced-unvoiced" and the physical units of time and frequency in cycles per second. Figure XIX (B) portrays the harmonic structure of the words "speech we may see".

Of prime importance in both the output and the input of organic "Ve's" such as speech and writing is the fact that the units, whether linguistic or physical can be seen to constitute a class which is finite. This imposes both natural (in the case of physics) and cultural (in the case of language) constraints on both the inputs and the outputs. On the output side any "Ve's" produced must be selected from the possibilities allowed by a finite class. On the input side, the organism, by virtue of neural learning, can expect to receive "Ve's" which fall within a definite class.

The fact that organismic inputs and outputs can be seen to fall within a given class has direct significance for information theory and action theory. In information theory central concern is with selection from finite classes and indeed, the information carried by a signal is measured by the power of that signal to make selections from a given class. Action theory is directly concerned with choice and selection and the standards according to which choice is made. Norms specify the choice to be made under given circumstances. Presumably, if roles are structured sequences of unit acts then norms specify in what manner they are to be structured and this implies constraints upon the selections which are possible from (known classes of) unit acts.

With reference to Figure VII we have so far dealt with the organism, its receivers, its transmitters, its various functions such as coding and comparison and the "Ve's" it receives and produces. Let us now move on to the social system.

## B <u>THE SOCIAL SYSTEM</u>

A social system can, we hold, contain any number between two and an infinitely large number of organisms. Here we are concerned more with micro than macro-analysis and so the study is limited to consideration of the small group. We turn now to an investigation of the ways in which organisms can be structured into social systems which are , in our scheme, one of the primary subsystems of communication systems.

## (a) CHANNELS

A social system comes into being only when the outputs of one organism are received as inputs by another. One organism produces "Ve's"; another receives them. Broadly, "Ve's",environmental variables, are patterns in the distribution of energy over time and space. These patterns must be of such a nature that they can both be produced and received by organisms. The channels linking organisms may be said to comprise the physical limits imposed on energy which fulfill this condition. Thus, for communication, it is no good having an organism creating variations in the energy system around it if these variations cannot be discerned by another organism. And it is no good having an organism capable of a range of discriminations if another organism is incapable of affecting patterns of energy which would correspond to that range.

It is possible to draw up a fairly obvious classification of the types of outputs which organisms can produce and of the types of inputs they can receive. Another fairly obvious classification can be drawn of the ways of linking the outputs to the inputs. The links between the outputs and the inputs (i.e. Those cases in which the range of variations which an organism can produce correspond to the range of discrimination of an organism) can be called social system channels. A classification of outputs, inputs and channels is given below.

TYPES OF OUTPUT

(1) VOCAL
(2) KINESIC (any form of bodily movement; e.g. dancing, walking, scratching, smoking).
(3) MANIPULATIVE
 (A) DIRECT (e.g. the "kick" under the table, erotic).
 (B) INDIRECT (e.g. writing, typing, printing, photography, playing musical instruments)

TYPES OF INPUT

(1) VISUAL
(2) ACOUSTIC
(3) TACTILE
(4) OLFACTORY

TYPES OF CHANNEL

| OUTPUT | | INPUT | |
|---|---|---|---|
| VOCAL | → | ACOUSTIC | |
| VOCAL PLUS INDIRECT MANIPULATIVE | — MECHANICAL DEVICE → | ACOUSTIC | (e.g. telephone, tape recording). |
| | | VISUAL | (e.g. sound spectogram). |
| KINESIC | → | VISUAL | |
| KINESIC | — MECHANICAL DEVICE → | VISUAL | (e.g. kinemat - ography) |
| DIRECT MANIPULATIVE | → | TACTILE | (feel villain's hands on neck) |
| | → | ACOUSTIC | (hear knuckles crack) |
| | → | OLFACTORY | (smell brandy on villain's breath ) |
| INDIRECT MANIPULATIVE | → | VISUAL | (written) |
| | → | ACOUSTIC | (musical instru- ment) |
| | → | TACTILE | (flaggelation) |
| | → | OLFACTORY | (cooking) |

To make some more obvious statements ..... It can be said that while at least one channel must link organisms for a social system to exist, more than one channel may be used simultaneously. Thus, face-to-face conversations are characterized by the vocal-acoustic and kinesic-visual channels. In erotic activity, vocal-acoustic, kinesic-visual, direct manipulative-tactile, direct manipulative-acoustic and direct manipulative-olfactory channels are all utilized.

It can be seen that certain messages might be spread throughout the range of channels in that only certain of their constitutive signals are transmitted through each. In other cases, the content of the messages might be such as to prohibit the use of certain channels. Alternatively, in further instances, the availability of outputs of only certain types might determine which channel is used. Obviously in the case of blind or deaf organisms certain channels are ruled out. On the output side the choice of channel might be determined by message content or the types of input that can take place. If only acoustic inputs were possible, there would be no sense in the use of the kinesic-visual channel. In the case of dumb or paralytic organisms certain outputs are immediately counted out and this restricts the choice of channel.

Of considerable importance here is the fact that message content might require the use of certain channels or of certain combinations of channels.

When many organisms are involved in communication interesting variations of channel usage emerges. In radio broadcasting, for instance, there is the case of one or a few vocal (and also, perhaps, indirect manipulative) outputs channelled, through mechanical devices to many organisms which receive them as inputs. When a choir gives a private audition to one person there is the case of, say, ten vocal outputs linked in a channel to one acoustic input.

In live theatre there is a fairly complex social system with vocal-acoustic and kinesic-visual channels linking actors with actors, actors with members of the audience and the audience with actors ( coughs, applause, movements - or lack of them)

With regard to the social system any set of "Ve's" transmitted through a channel can be regarded as a unit act. Bales, Strodbeck, Mills and Roseborough have worked out a way of recording unit acts and their frequency. In their study entitled "Channels of Communication in small Groups,"[44] they report on how observations were collected in a study of groups ranging in size from three to ten persons in which conversations generally proceeded so that one person talked at a time and all members in the group were attending the same conversation.

In this sense the groups might be said to have a "single focus", that is, they did not involve a number of conversations proceeding at the same time, as is found at a cocktail party or in a hotel lobby. This single factor is probably a limiting condition in that larger groups or other types of groups with multiple foci are probably somewhat different with regard to certain aspects of channel frequency.[44]

The authors recorded each act in the intercommunication process. If the act was verbal the unit was usually the simple subject-predicate combination. If the act was non-verbal, the unit was the smallest overt segment of behaviour that had "meaning" to others in the group. With this method of recording, the number of units would be many for a lengthy speech given by a group member while a laugh, a nod, or a fidget each constituted a unit. The originator of each act, as it occured, was recorded. At the same time, the recipient of each act was recorded. For example, an act directed from person 1 to person 2 is recorded : 1-2. For convenience, a number was assigned to each member of the group, and the symbol O was used to designate the group as a whole without distinction as to separate persons. Any member of the group could be an originator or a target of a particular act, but the group as a whole could only be a target. The relation between any two members (including both directions, e.g. 1-2, 2-1) or between any member and the group as a whole (e.g. 1-0) the authors called a "channel of communication."[44]

Bales et alia placed the originators so as to designate a series of rows of a matrix and the targets to designate a series of columns. A matrix of N rows and N + 1 columns resulted where N= number of members in the group. The tubulation matrix for a three-man group is illustrated below.

TABLE Ia[44]

| ORIGINATOR | TARGET | | | | TOTAL INITIATED |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 0 | |
| 1 | — | 1-2 | 1-3 | 1-0 | |
| 2 | 2-1 | — | 2-3 | 2-0 | |
| 3 | 3-1 | 3-2 | — | 3-0 | |
| TOTAL RECEIVED | | | | | |

The first ordering operation consisted of tallying entries as scored by the observer in the appropriate cell in the tabulation matrix and finding the totals for each row and column.[44]

The second ordering operation consisted of ranking the members according to the frequency of their respective originations. The person originating the greatest total number of acts is placed in the first row, and so on. A matrix ordered according to the basic initiating ranks of its members is called an <u>ordered</u> INTERACTION MATRIX. The following table is an example. It is an aggregate matrix for 18 sessions of a 6-man group.[44]

TABLE Ib[44]

| PERSON ORIGINATING ACT | TO INDIVIDUALS | | | | | | TOTAL TO INDIVIDUALS | TO GROUP AS A WHOLE | TOTAL INITIATED |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | | 0 | |
| 1 | | 1238 | 961 | 545 | 445 | 317 | 3506 | 5661 | 9167 |
| 2 | 1748 | | 443 | 310 | 175 | 102 | 2778 | 1211 | 3989 |
| 3 | 1371 | 415 | | 305 | 125 | 69 | 2285 | 742 | 3027 |
| 4 | 952 | 310 | 282 | | 83 | 49 | 1676 | 676 | 2352 |
| 5 | 662 | 224 | 144 | 83 | | 28 | 1141 | 443 | 1584 |
| 6 | 470 | 126 | 114 | 65 | 44 | | 819 | 373 | 1192 |
| TOTAL RECEIVED | 5203 | 2313 | 1944 | 1308 | 872 | 515 | 12205 | 9106 | 21311 |

Bales' ordered interaction matrix does not tell us very much about communication apart from the fact that there are systematic ways of recording exchanges in a group. For our purposes it is worth noting two things here. Firstly the matrix could be broken down by channel so that the number of acts originating or being received in any one channel could be measured separately. Secondly, while any one organism may transmit signals to the "group as a whole", on the receiver side the "group as a whole" should be regarded as a number of individual organisms so that, in the example given, the figures in the second column from the right should be multiplied by five. This would conform to the notion that "Ve's" produced by one organism can be received by a very large number of organisms.

The concept of "channel capacity" would seem to be appropriate here. Discussion of channel capacity will, however, be deferred to the following chapter where it will be treated in terms of information theory.

(b) NETWORKS

The establishment of channels between organisms does not generally occur randomly. Most groups are structured in the sense that certain organisms expect to receive "Ve's" only from certain other organisms and in return transmit "Ve's" only to certain selected organisms. If the group is completely structured and there is no pattern flexibility in it then it can be predicted on the basis of full probability just what exchanges will take place, or, rather, what exchanges will not take place. The particular network in which organisms are arranged structures the possible exchanges among them. The network might come into being either because of physical constraints or as a result of a system of norms internalized by each of the organisms. What is significant is that a network, once established, will influence the patterns of "Ve's" that are transmitted. Different networks will allow different possibilities. Leavitts study "Some effects of Certain Communication Patterns on Group Performance"[45] is particularly pertinent in this regard and accordingly we shall now look at his work in some detail.

Leavitt begins by noting that co-operative action by a group of individuals having a common objective requires, as a necessary condition, a certain minimum of communication. This does not mean that all the individuals must be able to communicate with one another. It is enough, in some cases, if they are touched by a network of communication which also touches each of the others at some point. The ways in which the members of a group may be linked together by such a network of communication are numerous; very possibly only a few of the many ways have any usefulness in terms of effective performance. Which of all feasible patterns, asks Leavitt, are "good" patterns from this point of view? Will different patterns give different results in the performance of group tasks?[45]

In a free group, writes Leavitt, the kind of network that evolves may be determined by a multitude of variables. The job to be done by the group may be a determinant, or the particular abilities or social ranks of the group members; or other cultural factors may be involved.[45]

Even in a group in which some parent organization defines the network of communication,[49] as in most military or industrial situations, the networks themselves may differ along a variety of dimensions. There may be differences in number of connections, in the symmetry of the pattern of connections, in channel capacity (how much and what kind of information), and in many other ways.[45]

Leavitt explored experimentally the relationship between the behaviour of small groups and the patterns of communication in which the groups operated. He did this for small groups of a constant size, using two-way written communication and a task that required the simple collection of information.

## SOME CHARACTERISTICS OF COMMUNICATION STRUCTURES

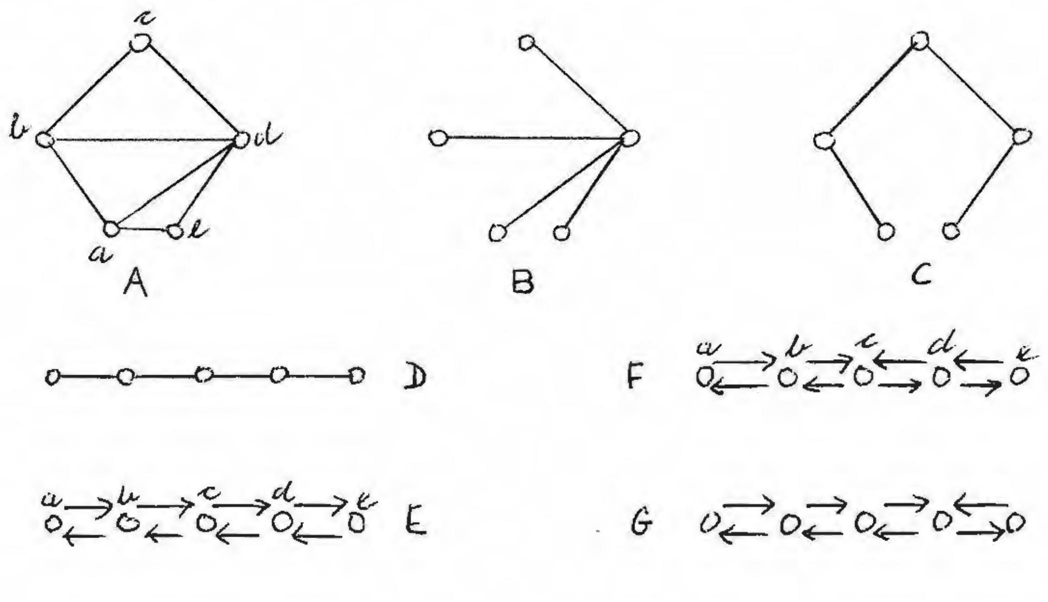
The stimulus for Leavitts research lies primarily in the work of Bavelas. In Bavelas' study the structures analyzed consist of cells connected to one another. If persons are made analogous to "cells" and communication channels analogous to "connections", we find that some of the dimensions that Bavelas defines are directly applicable to the description of communication patterns.

Thus one way in which communication patterns vary can be described is by the sum of the neighbours that each individual member has, neighbours being defined as individuals to whom a member has communication access. So, too, the concept of CENTRALITY, as defined by Bavelas, is of value in describing differences within and between structures. The most central position in a pattern is the position closest to all other positions. Distance is measured by the number of communicative links which must be utilized to get, by the shortest route, from one position to another.[45]

Sum of NEIGHBOURS is a summation, for the entire pattern of the number of positions one link away from each position. Similarly, SUM OF DISTANCES is the SUMMATION, for all positions, of the shortest distances (in links) from every position to every other one.[45]

The dimensions mentioned do not themselves uniquely define a pattern of communication. What defines a pattern is the WAY the cells are connected, regardless of how they are represented on paper. In essence, Leavitt's criterion in this : if two patterns cannot be "bent" into the same shape without breaking a link, they are different patterns. A more precise definition of unique patterns would require the use of complex topological concepts.[45]

FIGURE XX[45] : SOME COMMUNICATION PATTERNS



Consider the pattern depicted as A in Figure XX. If at each dot or cell (Lettered a, b, etc) we place a person; if each link (line between dots) represents a two-way channel for written communications; and if we assign to the five participants a task requiring that EVERY member get an answer to a problem which can be solved only by pooling segments of information originally held separate by each member, then it is possible to consider A PRIORI the ways in which the problem can be solved.[45]

Pattern Flexibility - First we note that the subjects need not always use all the channels potentially available to them in order to reach an adequate solution of the problem. Although pattern A ( Figure XX) contains potentially seven links or channels of communication, it can be solved as follows with three of the seven channels ignored.

STEP I : a and e each send their separate items of information to b and d respectively.

STEP 2 : b and d each send their separate items of information along with a's and b's respectively to c.

STEP 3 : c organizes all the items of information, arrives at an answer, and sends the answer to b and then to d.

STEP 4 : b and d then send the answer to a and e respectively.[45]

The use of these four channels yields pattern C (figure XX). The original seven-link pattern A can be used as a four-link pattern in various ways. For instance, each of the four subjects diagrammatically labelled c,b, a and e might send his item of information to d who would organize the items, arrive at an answer, and send it back to each respectively. Use of these particular four channels would yield the pattern B in Figure. 20. The problem could also be solved by the subjects using five, six or all of the seven potential channels.[45]

Operational Flexibility. - Secondly, with the specification that a given number of links be used, any pattern can be operated in a variety of ways. Thus the pattern D (Figure XX) which has no pattern flexibility, can be used as shown in F, with information funnelled into c and the answer sent out from c. It is also possible to use it as in E, with e as the key position or as in G. There are operational differences that can be characterized in terms of the roles taken by the various positions. Thus in F, c is in the decision-making position. In E it is e or a. Some patterns can be operated with two or three decision makers.[45]

It is worth noting that the model developed in this thesis and expressed diagrammatically in Figure VII is compatible with the Leavitt study. While only two organisms are shown in Figure VII there is no reason why the social system could not be expanded to include more than two organisms which could then be linked in any of the patterns that Leavitt works with.[45]

THE DEFINITION OF MAXIMUM THEORETICAL EFFICIENCY

At this point Leavitt states the task used in his experiment. To each subject (see Figure XXI) was given a card on which there appeared a set of five (out of six possible) symbols. Each S's card was different from all the others in that the symbol lacking, the sixth one, was a different symbol in each case.

SIX SYMBOLS USED: ○ △ ◇ □ + *

| TRIAL NO. | SYMBOL MISSING FROM: WHITE | RED | BROWN | YELLOW | BLUE | COMMON SYMBOL |
|---|---|---|---|---|---|---|
| 1 | △ | ◇ | * | ○ | □ | + |
| 2 | ◇ | ○ | □ | △ | + | * |
| 3 | + | * | □ | △ | ◇ | ○ |
| 4 | □ | ◇ | △ | * | + | ○ |
| 5 | ○ | * | + | △ | □ | ◇ |
| 6 | △ | ○ | □ | * | ◇ | + |
| 7 | □ | + | ○ | △ | ◇ | * |
| 8 | ◇ | * | □ | + | ○ | △ |
| 9 | * | ◇ | □ | △ | ○ | + |
| 10 | + | ○ | □ | * | ◇ | △ |
| 11 | ○ | + | △ | ◇ | * | □ |
| 12 | * | ○ | □ | △ | + | ◇ |
| 13 | △ | ○ | ◇ | □ | + | * |
| 14 | □ | ◇ | + | * | △ | ○ |
| 15 | + | ○ | □ | ◇ | * | △ |

FIGURE XXI[45]

Thus, in any set of five cards there was only one symbol in common. The problem was for every member to find the common symbol. To accomplish this each member was allowed to communicate, by means of written messages, with those other members of the group to whom he had an open channel (a link). Every separate written communication from one S (A) to another (B) was considered one message. Any S who had discovered the answer was allowed to pass the answer along.

MINIMUM NUMBER OF COMMUNICATIONS

For any pattern of nSs; the minimum number of communications (c), is given by c = 2 (n - 1). Theoretically, then, with NUMBER OF MESSAGES AS THE SOLE CRITERION, any pattern of nS is as efficient as any other n - sized pattern.

THE MINIMUM TIME REQUIRED FOR SOLUTION.

If we assume "standard" 'S's" all of whom work, think and write at the same speed, it is possible to calculate the limit set by the communication pattern on the speed with which the problem can be solved. Toward this end, we can arbitrarily define a TIME UNIT as the time required to complete any message, from its inception by any S to its reception by any S.[45]

Although some patterns require fewer time units than others, they may also require more message (m) units. This phenomenon, effectively the generalization that it requires increased messages to save time units, holds for all the patterns Leavitt examined. It is, however, true, writes Leavitt, that certain patterns requiring different times can be solved in the same number of message units.[45]

SOME POSSIBLE EFFECTS OF VARIOUS PATTERNS ON THE PERFORMANCE OF INDIVIDUALS

Leavitt writes that there are two general kinds of reasons which dictate against his theoretically perfect performance from real people. The first of these is the obvious one that people are not standardized.

There are also the forces set up by the patterns themselves to be considered. The problem becomes one of analyzing the forces operating on an individual in any particular position in a communication pattern and then predicting how the effects of these forces will be translated into behaviour. It is Leavitt's belief that the primary source of differential forces will be CENTRALITY. This is so because centrality reflects the extent to which one position is stratigically located relative to other positions in the pattern. The availability of information necessary for the solution of the problem will be of prime importance. Centrality is a measure of one's closeness to all other group members and, hence, is a measure of the availability of the information necessary for solving the problem.

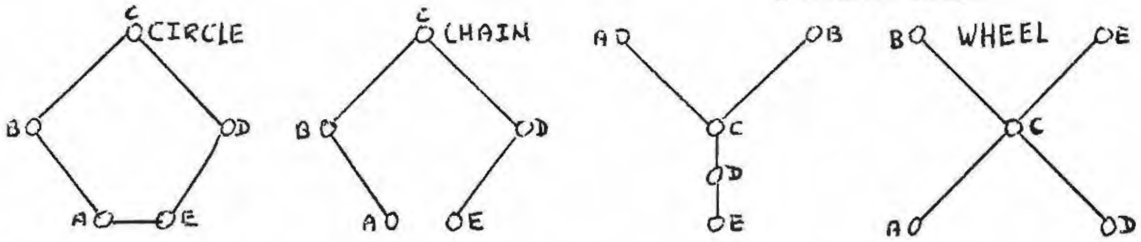
Before proceeding to a description of Leavitts experiment it is worth pointing out that it is relevant to the present work in two respects. Firstly, as pointed out above, it indicates some of the possible variations in the patterns of organisms in social systems. Secondly, the task given to the subjects of the experiment can be taken as an exercise in semantics, particularly as conceived here, in the sense that each of the subjects is concerned with matching two sets of data according to "culturally" derived norms.

The task Leavitt set to his subjects was that of discovering the single common symbol from among several symbols. When ALL FIVE men indicated that they knew the common symbol, a trial was ended, and another set of cards, with another common symbol, was then given to the subjects and another trial was begun.

The subjects were seated around a circular table so that each was separated from the next by a vertical partition from the center to six inches beyond the table's edge. The partitions had slots permitting subjects to push written message cards to the men on either side of them.[25]

The four five-man patterns selected for this research are shown in Figure XXII.

FIGURE XXII[45]




These four patterns represented extremes in centrality (as in the circle vs the wheel), as well as considerable differences in other characteristics (Table II).[45]

TABLE II

| PATTERN | NO. OF LINKS | MOST CENTRAL POSITION | SUM OF NEIGHBOURS | SUM OF DISTANCES | MIN. TIME UNITS | MIN. MESSAGES |
|---|---|---|---|---|---|---|
| CHAIN | 4 | C (6·7) | 8 | 40 | 5 (8M) | 8 (5t) |
| Y | 4 | C (7·2) | 8 | 36 | 4 (8M) | 8 (4t) |
| WHEEL | 4 | C (8·0) | 8 | 32 | 5 (8M) | 8 (5t) |
| CIRCLE | 5 | ALL (5·0) | 10 | 30 | 3 (14M) | 8 (5t) |

RESULTS

The data which Leavitt accumulated are broken down in the pages that follow into

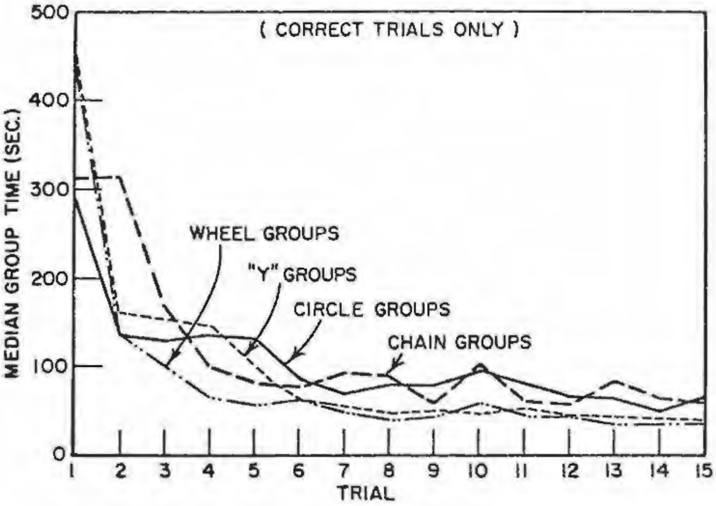
( i) a comparison of total patterns and
(ii) a comparison of positions within patterns.[45]

(i) DIFFERENCES AMONG PATTERNS

The WHEEL operated in the same way in all five cases. The peripheral men funneled information to the center where an answer decision was made and the answer sent out. This organization had usually evolved by the fourth or fifth trial and remained in use throughout.[45]

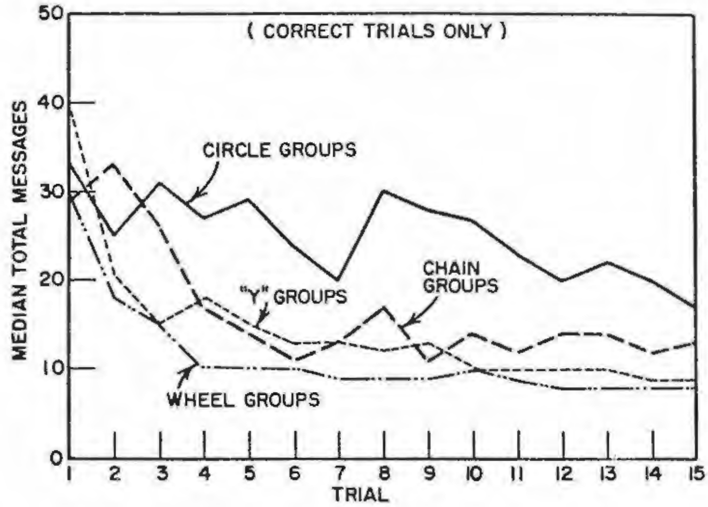
The Y operated so on to give the most central position, C, (see Figure XXII and Table II) complete decision-making authority. The next most central position, D (see Figure XXII) served only as a transmitter of information and of answers.

FIGURE XXIII (a)[45]




Median group-times per trial.

FIGURE XXIII (b)[45]




Median messages per trial.

TABLE IV[45]

***Errors***

| *Pattern* | *Total Errors (15 Trials)* Mean | Range | *Total Errors (Last 8 Trials)* Mean | Range | *Final Errors* Mean | Range | *Mean No. of Trials with at Least One Final Error* |
|---|---|---|---|---|---|---|---|
| Circle | 16.6 | 9–33 | 7.6 | 1–18 | 6.4 | 2–14 | 3.4 |
| Chain | 9.8 | 3–19 | 2.8 | 0–11 | 6.2 | 1–19 | 1.8 |
| Y | 2.6 | 1–8 | 0 | 0 | 1.6 | 0–5 | .8 |
| Wheel | 9.8 | 0–34 | 0.6 | 0–2 | 2.2 | 0–7 | 1.2 |

p Values Ci–Y $<.02$

In at least one case, C transmitted answers first to A and B only then to D. Organization for the Y evolved a little more slowly than for the wheel, but, once achieved, it was just as stable.[45]

In the CHAIN information was usually funnelled in from both ends to C, whence the answer was sent out in both directions. There were several cases, however, in which B or D reached an answer decision and passed it to C. The organization was slower in emerging than the Y's or the wheels, but consistent once reached.

The CIRCLE showed no consistent operational organization. Most commonly messages were just sent in both directions until any S received an answer or worked one out. In every case, all available links were used at some time during the course of each trial.[45]

DIRECT MEASURES OF DIFFERENCE AMONG PATTERNS

TIME The curves in Figure XXIII (a) are for CORRECT trials only. In most cases, the medians shown are for distributions of five groups, but in no case do they represent less than three groups.[45]

The variability of the distributions represented by these medians is considerable. In the fifteenth trial, the distribution for the circle has a range of 50-96 seconds; for the chain, 28-220 seconds; for the Y, 24-52 seconds, and for the wheel, 21-46 seconds. Moreover, much of the time that went to make up each trial was a constant consisting of writing and passing time. Any differences attributable to pattern would be a small fraction of this large constant and would be easily obscured by accidents of misplacing or dropping of messages.[45]

Despite all these factors, one measure of speed did give statistically significant differences. A measure of the FASTEST SINGLE TRIAL of each group indicates that the wheel was considerably faster (at its fastest) than the circle. (Table III).[45]

TABLE III[45]

| FASTEST SINGLE CORRECT TRIAL | | | | |
|---|---|---|---|---|
| | CIRCLE | CHAIN | Y | WHEEL |
| MEAN | 50·4 | 53·2 | 35·4 | 32·0 |
| MEDIAN | 55·0 | 57·0 | 32·0 | 36·0 |
| RANGE | 44–59 | 19–87 | 22–53 | 20–41 |

The medians in Figure XXIII(b) represent a count of the number of messages sent by each group during a given (correct) trial. It seems clear that the circle pattern used more messages to solve the problem than the others.

In addition to the differences in errors, there are differences in the proportion of total erros that were corrected. Although more errors were made in the circle pattern than any other, a greater proportion of them (61%) were corrected than in any other pattern. Too, the frequency of unanimous five-man final errors is lower, both absolutely and percentage-wise, for the circle than for the chain.[45]

MESSAGE ANALYSIS

The messages sent out by all S's were collected at the end of each experimental run and their contents coded and categorized.

It was found that circle members send many more informational message than members of the other patterns. Circle members also send more answers.

The same tendency remains in proportion to total errors as well as absolutely. The circle has a mean of 4.8 recognition-of-error messages for a mean of 16.5 errors; the chain has a mean of 1 recognition-of-error messages for a mean of 9.8 errors.[45]

## (ii) POSITIONAL ANALYSIS OF THE DATA

Observation of the experimental patterns indicated that every position in the circle is indistinguishable from every other one. No one has more neighbours, is more central, or is closer to anyone than anyone else. In the wheel, the four peripheral positions are alike and so on. Despite the impossibility of differentiating these positions from one another, Leavitt set up the data as if all positions in each pattern were actually different from one another.[45]

### MESSAGES

As seen from Table V, the most central positions send the greatest number of messages, the least central ones the fewest.[46]

TABLE V[45]

NUMBER OF MESSAGES SENT BY EACH POSITION.

| | | A | B | C | D | E | DIFF. | P |
|---|---|---|---|---|---|---|---|---|
| CIRCLE | MEAN<br>RANGE | 78.4<br>64-101 | 90.0<br>63-102 | 83.6<br>60-98 | 86.2<br>60-122 | 81.0<br>72-90 | A-B | <.30 |
| CHAIN | MEAN<br>RANGE | 24.8<br>20-34 | 70.8<br>43-112 | 82.4<br>45-113 | 71.8<br>42-101 | 27.6<br>22-43 | C-E | <.01 |
| Y | MEAN<br>RANGE | 28.0<br>20-44 | 23.8<br>21-28 | 79.8<br>65-104 | 63.8<br>43-78 | 25.6<br>21-37 | A-C<br>D-C<br>D-E | <.01<br><.20<br><.01 |
| WHEEL | MEAN<br>RANGE | 29.4<br>19-48 | 26.2<br>17-40 | 102.8<br>78-138 | 26.6<br>17-39 | 30.2<br>22-43 | C-E | <.01 |

One of the things that immediately stands out from on examination of the messages is an apparent peculiarity in the INFORMATIONAL MESSAGE category. Although the most central man in the chain sent more informational messages (52) than the other positions in that pattern, the same is not true of the most central men in the Y and the wheel. In the Y, it is position D, the next-most-central position, that sends most; while in the wheel all positions are about equal. This peculiarity becomes quite understandable if we take into account (a) the kind of organization used in each pattern and (b) the fact that these figures represent the entire 15 trials, some of which occurred before the group got itself stably organized. In the wheel, the Y, and the chain, the center man really needed to send NO informational messages only answers; but in the EARLY trials, before his role was clarified, he apparently sent enough to bring his total up to higher than the level of the rest.[45]

It can also be noted that the number of ORGANIZATIONAL MESSAGES (messages which seek to establish some plan of action for future trials) is negatively correlated with positional centrality. The most peripheral men send the greatest numbers of organizational messages, the most central men least.[45]

Leavitt arrives at the following conclusions.[45]

1) The communication patterns within which the groups worked affected their behaviour. The major behavioural differences attributable to communication patterns were differences in accuracy, total activity, satisfaction of group members, emergence of a leader, and the organization of the group. There may also be differences among patterns in speed of problem solving, self-correcting tendencies, and durability of the group as a group.

2) The positions which individuals occupied in a communication pattern affected their behaviour while occupying those positions.

One's position in the group affected the chances of becoming a leader of the group, one's satisfaction with one's job and with the group, the quantity of one's activity, and the extent to which one contributed to the group's functional organization,

3) The characteristic of communication patterns that was most clearly correlated with behavioural differences was CENTRALITY. Total pattern differences in behaviour seemed to be corelated with a measure of centrality Leavitt labelled the PERIPHERALITY INDEX. Positional differences in behaviour seemed to be correlated with the positional peripherality indices of the various positions within patterns.

4) Leavitt tentatively suggests that centrality affects behaviour via the limits that centrality imposes upon independent action. Independence of action, relative to other members of the group is, in turn, held to be the primary determinant of the definition of who shall take the leadership role, total activity, satisfaction and other specific behaviours.

Leavitt feels that where centrality and, hence, independence are evenly distributed, there will be no leader, many errors, high activity, show organization and high satisfaction. Where one position is low in centrality relative to other members of the group, that position will be a follower position, dependent on the leader, accepting his dictates, falling into a role that allows little opportunity for prestige, activity, or self-expression.[45]

Within the social system, the number of variables which might be brought to bear on the system of communication is astronomical. The patterns studied by Leavitt are limited in so far as his experiment was controlled to handle only certain groups of a given structure with imposed artificial limitations. In the field of the study of small groups many other patterns have been taken into account. Schramm[46] and Larsen and Hill[47] give some indication of the manner in which small-group communication is linked to mass communication, thus bridging the gap between micro and macro analysis.[48]

## (c) THE SOCIAL SYSTEM AND SEMANTICS

In some groups only certain of the members might have direct access to the object world in question. Further, the object world might be differentially allocated to these members. This has significancefor semantics. Let us suppose that the object world comprises a class O of objects A,B,C,D. One organism has access to objects A and B and a second to objects C and D. Thus a third organism requiring information on the whole class would have to communicate with both the other organisms. If, in terms of semantics, the class "O" stands for objects A,B,C and D, then it is possible to conceive of semantic specialization and division of labour in a social system.

In some respects the problem that Leavitt set to his subjects could be regarded as a semantic problem.

We saw that each subject was given a card on which appeared a set of five (out of six possible) symbols. Each subject's card was different from all the others in that the symbol lacking, the sixth one, was a different symbol in each case. The problem was for every member to find the common symbol. In a way the solution of this problem would satisfy semantic conditions in that each member would have full information on the class. Thus it is possible to infer from Leavitt's study that different communication networks would promote or restrict the satisfaction of semantic conditions in that the number of errors or the time taken to solve the problem varied from pattern to pattern.

We have indicated above that the notion of choice is important to semantics. A message represents a choice of all signals which have arrived from an object world and thus corresponds to only certain selected elements in the object world. If the object world is divided up and allocated to different organisms in the social system than it would appear that a corresponding range of choice exists in the social system. Information from the object world has been neurally stored in in either long or short-term memory of the organisms which constitute the social system. If exactly the same information is available or is stored in each of the organisms then it makes little difference which of them is placedin any position in a network.

If, however, the short or long-term memory systems of the organisms refer to different aspects or parts of the object world then it is vital that the network into which they are structured is such that, in the cybernetic sense, lower-order organisms can transmit feedback signals to higher order organisms which transmit reference signals. We can say that higher order organisms have choice in which lower-order organism to send reference signals to. This choice is of direct relevance to semantics for, depending on the lower-order organism chosen the feedback signals might or might not correspond to the reference signals sent.

We can state that semantic conditions in the social system are perfect only when, firstly, the network of organisms is such to permit feedback signals to be transmitted to the organisms sending reference signals and secondly when the lower-order organisms expect, on the basis of full probability to receive certain reference signals from higher-order organisms in certain definite positions in the network and when higher-order ones expect, on the basis of full probability to receive feedback signals from organisms in expected positions in the network. Thus, for semantic conditions to be satisfied in the social system of a communication system it is necessary that the netowrk is completely inflexible with regard to patterning and to operation in the sense that all processes within it can be expected to occur on the basis of full probability. Flexibility can only be allowed if the constituent organisms are entirely substitutable.

The situation exists in the social system, then, that freedom for organisms to choose other organisms with which to communicate will allow information to pass through the social system at the cost of uncertainty. This is intolerable if semantic conditions are to be satisfied.

From the Leavitt study we can infer that the efficiency of a group in attaining a state which satisfies semantic conditions is to a considerable extent a function of the pattern or network of communication.

It appears that in the social system of a human communication system at least three types of choice are theoretically open to the individual organisms. There is choice in which the individual organism must decide which of the other organisms it is to receive signals from or transmit signals to. There is choice of channel. On the input side the organism can choose to receive signals visually (the movement of other organisms, writing), audially and tactually.

On the output side the individual organism can transmit written signals, spoken or sung signals, kinesic signals or signals produced through a mechanical device. There is also choice as to content.

In the Leavitt study only one channel or medium was allowed - the written. Thus, in that study the group can be seen as highly structured in that at least one of the areas of choice was restricted. Certain of the patterns further limited another type of choice - i.e. freedom to select organisms with which to establish channels.

The choice open to the organisms in the social system is of direct concern to our hypothesis. It will be shown in the next chapter that semantic conditions are only theoretically perfect in a situation of no choice. From the standpoint of semantics choice of organism is as important as the choice of content, for,depending on the learning that has taken place in organisms there might be imperfect conditions for efficient decoding with some organisms and perfect conditions with others. Similarly, choice of channel is equally important since certain channels might impose limitations on content which prevent the transmission of semantically necessary messages. In certain instances it might be necessary that more than one channel is used simultaneously. It can be appreciated that if signals are transmitted over a channel which is not customarily used this in itself might introduce uncertainty regarding message content.

Newcomb[50] views every communicative act as a transmission of information, consisting of discriminative stimuli, from a source to a recipient. The discriminative stimuli have a discriminable object as referent.

Thus, in the simplest possible communicative act one person (A) transmits information to another person (B) about something (X). Newcomb symbolizes such an act as A to B re X.

A-B-X is regarded as a system. Definable relationships between A and B, between A and X and between B and X are viewed as interdependent. Newcomb presumes that a given state of the system exists when a given instance of A to B re X occurs.

Newcomb writes that to the degree that A's orientation towards X is contingent upon B's orientation toward X, A's co-orientation will be facilitated by similarity of his own and B's orientation toward X. The advantage of symmetry is that of ready calculability of the other's behaviour; the more similar A's and B's orientations, the less the necessity for either of them to translate X in terms of the other's orientations, the less liklihood of failure or error in such "translations".

Westley, Malcolm and MacLean,[51] in working out a conceptual model for communications research trace out some consequences of Newcomb's model. In particular they attempt to show in what manner Newcomb's model can apply to both face-to-face and mass communication.

The authors write that face-to-face communication involves more sense modalities than mass communication. It also provides immediate "feedback" - that is, information from B back to A about the changed condition of B.

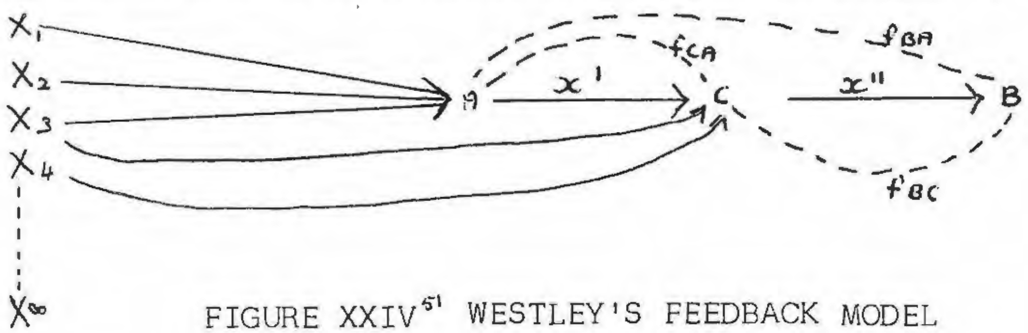



FIGURE XXIV[51] WESTLEY'S FEEDBACK MODEL

In Figure XXIV the messages C transmits to B (x") represent his selections from both messages sent to him from A (x') and his own selections and abstractions from Xs in his own sensory field which may or may not be Xs in A's field. Feedback not only moves from B to A (fBA) and from B to C (fBC) but also from C to A (fCA). Clearly, in the mass communication situation, a large number of C's receive from a very large number of A's and transmit to a vastly larger number of B's, who also receive from other C's.

The authors point out that the model can apply to a number of different levels. That is, the role of B, for instance may be that of a person, or a primary group, or a total social system.

Feedback is a concept crucial to this model. It is pointed out that feedback assures the system character of the ABX (or ABCX) relationship. If A is to utilize his experience in influencing B, he must have information about any changes in the condition of B attributable to his communication. C is equally concerned with effects on B if he is to make realistic adjustments in his role as B's agent.

The principal elements in the Westley model are :

A's (Advocacy Roles ) - a personality or social system engaged in selecting and transmitting messages PURPOSIVELY.

B's (Behavioural System Roles). This is what is usually meant by the "receiver", "the public" etc. - a personality or social system requiring and using communications about the condition of its environment.

C's (Channel Roles). C's serve as the agents of B's in selecting and transmitting information B's require especially when the information is beyond the immediate reach of B.

X The totality of objects and events "out there". x' is these objects and events as abstracted into transmissable form : "Message's" about Xs and AX relationships.

CHANNELS. The means by which X's are moved by way of A's and via C's to B's. Channels include "gates" manned by C's who in various ways alter messages.

ENCODING. The process by which A's and C's transform Xs to x's. Decoding is the process by which B's interiorize messages.

FEEDBACK. The means whereby A's and C's obtain information about the effects of messages on B's.

It appears that there are some basic similarities between our Figure VII and the model put forward by Westley, Malcolm and MacLean.

While the organisms in our model are not attributed with specific roles such as "advocacy", "behavioural system" and "channel" it has been made explicit above that organism A (in Figure VII) is structured differently from organism B viz-a-viz the total system.

There appears to be a correspondence between "X" (the totality of objects and events) and our "object world". In Figure VII only organism B is shown to have access to the object world so it appears that that organism functions as an "A" in Westley's sense.

What is of importance to the hypothesis offered here is that there is, in the social system, correspondence between the "Ve's" from the object world and "Ve's" from organism B to organism A (Figure VII). In Westley's terminology there should be correspondence between x" and x', X3, and X4 (Figure XXIV).

A further prerequisite for the satisfaction of semantic conditions is that the set of expectations in each of the organisms relating to the range of possible Xs which might be selected must be uniform. Exactly the same categories must be neurally stored in each of the participating organisms. Actually the categories might differ according to the specialized role of the organism in the social system. Semantic condtions are satisfied, however, when each organism can expect the message it receives from any other organism and is able to decode the message into the same set of categories as the first organism used in encoding the message. If the dimensions are the same for the participating organisms than any message transmitted and received will be non-ambiguous.

Triandis[52] in an experimental study on the dimensions used by two persons when examining events in their environment found that the greater the attribute similarity, the greater the communication effectiveness. This would bear out what was written in the last paragraph. Triandis has written that the effectiveness of people's communication is greater when they share common norms. And he stated the hypothesis that when people form a group they develop common norms. This increases their attribute similarity as well as other kinds of cognitive similarity. The greater degree of cognitive similarity results in greater communication effectiveness within the group.

Arising out of this study and other studies by Triandis are the following generalizations : each person employs a number of dimensions when he considers a particular event. Which dimensions he will employ depends, to some extent, on his membership in various groups. He also assigns a particular event to a position on his dimension that is, in part, determined by his group membership. A significant fact is that the dimensions used by each person are often correlated (e.g. things that are "good" are also "clean"). When persons A and B consider a particular event there will be an overlap in their dimensions. The greater the overlap, the more likely it is that they will communicate. If A uses a dimension that B does not normally employ, B will understand what A is saying to the extent that some of his dimensions correlate with the dimensions used by A. A may also be able to understand B if he is acquainted with B's idiosyncratic dimensions and the way B places events on these dimensions.

Triandis used a measuring device called the "semantic differential". Since the semantic differential, developed by Osgood, is of obvious relevance here, we shall briefly investigate it.

In The Measurement of Meaning - Osgood proposes that "semantic space" is a measurable entity. He suggests ways and means of measuring it. Osgood sketches a communications model which does not deviate basically from our own. He writes that beyond sensory reception skills and motor transmitting skills, the human communicator is equipped to learn symbolic, representational processes or meanings. On the input side, certain patterns of signals in the channel, as SIGNS, acquire association with certain representational mediators and hence have SIGNIFICANCE; on the output side, these mediators acquire selective association with certain motor skills (speaking writing, etc) which thereby express INTENTIONS. He refers to the process whereby signs in messages select among representational mediators as DECODING; the process whereby representational mediators select among motor expressions in messages is referred to as ENCODING.

Osgood proposes the semantic differential as an index of certain aspects of MEANING. In human communication meaning is critically involved at both the initiation (the intentions being encoded by the source) and the termination (the significances being decoded by the receiver) of any communicative act.

The meaning of a word in ordinary speech is influenced by the context of other words with which it occurs. Speakers select adjectives to modify nouns and adverbs to modify verbs, and they arrange word sequences to change meanings in desired directions and to desired degreees, thereby greatly expanding the discriminatory power of the communication system. An experiment by Osgood (1954) demonstrated that the probabilities of various associative responses to a given stimulus word can be arranged by varying the antecedent verbal context.

Osgood was interested in the degree to which the meanings of combinations are predictable from knowing the meanings of their components. Accordingly he devised nine scales, three to represent each of the major factors isolated in his "factor analytic" work:

evaluation (valuable-worthless, admirable-deplorable, good-bad); potency (robust-delicate, intense-mild, powerful-powerless); and activity (quick-slow, active-passive and restless-quiet). These scales were used to test each of two words in a word-pair at first separately and then in conjunction in order to see to what extent, according to the scales, the one word has a modifying influence on the other.

Osgood writes that many linguists and philosophers would say that two people first disagree on the "meaning" of a sign before they can disagree on the diverse emotive and other reactions to it. Agreement must be reached on the "referent" of the linguistic sign. Osgood points out that his data is, in fact, replete with cases where individuals differ in their semantic differential profiles for the same sign-vehicles. He asks : "What then is the problem?" If we agree that the "meaning" of "thunder" for A and B must in some sense be the same because they are obviously referring to the same object or event, and if one were to claim that the representational mediation process as he has defined it is a SUFFICIENT condition for language encoding, then the semantic differential profiles that might be derived from A and B should correspond in some way.

Osgood states that this claim cannot be made : A and B will probably experience no more referential confusion on "thunder" (where their profiles disagree on most factors) than they do on "blueberry pie" (where their profiles agree closely, let us say). In other words he feels he must admit that distances in semantic space as between individuals judging the same concept are not indicative of degrees of REFERENTIAL agreement - if, indeed, one can speak of degrees of such agreement.

Osgood's work is important in that it broadens the idea of meaning and puts it on a measurable basis. Indeed, it is important to stress the value of the concepts of semantic space and semantic differentials as these, in an empirical study can be established arbitrarily. As a result it is possible to say that while there might be an infinitely large number of different types of meaning, a study may legitimately restrict itself to an investigation of a small, finite number which can be tested by semantic differential scales devised specifically for that purpose.

It might appear that the semantic differential cannot be used to measure referential, or denotative meaning directly, and referential meaning would seem to be semantic in the sense we have been using that term. In fact, Osgood gives us to understand that the semantic differential is primarily a device for measuring connotative meaning. We suggest, however, that the difference between connotation and denotation can be resolved. This can be demonstrated as follows. A cross-tabulation can be made of denotative and connotative dimensions as follows :

TABLE VI

| DENOTATIVE | CONNOTATIVE | | | |
|---|---|---|---|---|
| | GOOD | BAD | LARGE | SMALL |
| APPLES | | | | |
| STEAK | | | | |
| TOMATOES | | | | |

It is possible to rearrange this cross-tabulation as follows:

| | | |
|---|---|---|
| GOOD, | LARGE | APPLES |
| GOOD, | SMALL | APPLES |
| BAD, | LARGE | APPLES |
| BAD, | SMALL | APPLES |

| | | |
|---|---|---|
| GOOD, | LARGE | STEAK |

And so on.

Accordingly it should be possible to devise a semantic differential scale which incorporates on one dimension denotative and connotative factors. This should afford a means of measuring the congruity between the sets of categories stored in each of the organisms of a social system, congruity which is essential for the satisfaction of semantic conditions in the social system.

The next study we turn to is entitled "Some Effects of Feedback on Communication."[53] While the study's importance for an understanding of feedback in a social system is obvious, our main interest in it here (from the point of view of semantics) is that it shows how information derived from a finite group of objects by one organism is restructured by another organism.

The experiments reported by Leavitt and Mueller, the authors of the study, are concerned with the transmission of information from person A to person or persons B. Thus it seems that they can be seen as directly relevant to our own model (Figure VII). Leavitt and Mueller's work deals with only one of the many relevant variables, the variable of feedback. The question is : how is the transmission of information from A to B influenced by the returns of information from B to A? They write that it is apparently taken for granted in industry, in the lecture hall, and in radio that it is both possible and efficient to transmit information from A to B without simultaneous feedback from B to A. On the other hand, the information theories of the cyberneticists to some extent, trial and error concepts in learning theory suggest that for A to hit successfully some target, B, requires that A be constantly informed of A's own progress.

If we take the human memory mechanism into account, we need not require that there be contemporaneous feedback between A and B. It may not even be necessary that there be any feedback from B2, if feedback from a similar B1 has already occurred.

Language may be thought of as a tool originally learned with feedback, but currently useful in a multitude of situations without simultaneous feedback. But if the material-to-be-communicated is relatively new and relatively precise, previously learned language may not be enough. Accurate transmission may require some additional contemporaneous feedback.

In addition to the hypothesis that contemporaneous feedback should increase the accuracy of transmission from A to B, Leavitt and Muller put forward the hypothesis that the completion of the A B circuit produces other effects in the A B relationship. Feedback from both A and B can increase the certainty of B that he is getting the intended information, and the certainty of A that he is getting it across.

We may note here that the concept of certainty is of relevance to our model in so far as when the system of expectations of the organisms in a social system are in a state of certainty, semantic conditions may be said to be satisfied.

Leavitt and Mueller chose as their material-to-be-communicated in their experiements a series of geometric patterns. The patterns were all composed of six equal rectanguler elements, but the relationships of the elements to one another differed from pattern to pattern (See Figure XXVa for sample pattern). A's (the instructor's) job was to describe orally one of these abstract patterns to the members of his class as accurately as possible, accuracy to be measured from the students' reproductions of the described (but unseen) patterns.


FIGURE XXV : SAMPLE PROBLEMS

a : Sample of problems used in Exp. I
b : Sample of problems used in Exp. II.

Two instructors were used, and four groups of students (total student N=80), with each instructor describing four patterns to each student group. There were four conditions of feedback :

1. ZERO FEEDBACK in which instructors sat behind a movable board to describe the patterns. No questions or noises were permitted from the students.

2. The VISIBLE AUDIENCE condition in which students and instructor could see each other but in which no speaking by students was allowed.

3. A YES-NO condition in which the visible audience was permitted to say only "yes" or "no" in response to questions from the instructor.

4. A FREE FEEDBACK situation in which students were permitted to ask questions, interrupt etc.

In their results, Leavitt and Mueller found that the mean accuracy score for ALL patterns increased steadily from ZERO to FREE FEEDBACK. With ZERO FEEDBACK the mean was 4.7 out of a possible 6. The range of means for the eight different patterns given under this condition was 3.1 to 5.9. Under the VISIBLE AUDIENCE condition the mean score was 5.3 with a range from 4.5 to 5.9. Under the YES-NO condition the mean score was 5.5, the range 5.0 to 5.8. With FREE FEEDBACK the mean was 5.6 and the range 5.1 to 6.0.

The mean time required to give instructions under the four conditions were : ZERO FEEDBACK, 229 seconds; VISIBLE AUDIENCE, 249 seconds; YES-NO 316 seconds; FREE FEEDBACK, 363 seconds.

Although the data indicated that FREE FEEDBACK does yield more accurate results than the other conditions, can it not be argued that FREE FEEDBACK is more effective simply because it requires more time? Would the time required decrease if FREE FEEDBACK were used continuously?

Though FREE FEEDBACK is helpful at first, is it of any use after the student and the instructor have had an opportunity to straighten out their language difficulties?

In an attempt to answer some of these questions Leavitt and Mueller designed another series of experiments. The purpose of these experiments was to compare the two extreme conditions, FREE FEEDBACK and ZERO FEEDBACK, over a longer series of trials. Using eight new geometric patterns, all made up of six elements (See Figure XXVB), they selected ten instructors and ten separate groups of students ranging in size from six to twenty-four.

It was found that FREE FEEDBACK starts at almost the maximum level of accuracy and stays there. ZERO FEEDBACK changes in the direction of greater accuracy from trial to trial. As far as time is concerned, the reverse was found : ZERO FEEDBACK remains more or less constant, while FREE FEEDBACK time declines progressively.

Free feedback requires more time, but there is evidence that this time differential decreases with increased understanding between the sender and receiver. Apparently the use of continuing FREE FEEDBACK could lead directly into ZERO FEEDBACK, for once the common areas of misunderstanding have been clarified, contemporaneous feedback will no longer be necessary.

The accuracy and time measures have implications for semantics. The diagrams (Figure XXV A and B) can be taken as the object world. If they are reproduced accurately by the receiver in the Leavitt and Mueller experiments, this can be taken as a case of semantic consistency. It means that the messages transmitted by the sender could be decoded in terms of a suitable frame of reference or set of categories by the receiver, a frame of reference which corresponds sufficiently with that of the sender to permit an accurate representation of the object world. We suggest that feedback from receiver to sender permits the sender to encode messages according to the most suitable of alternative frames of reference which might be known to receivers.

It might appear that both accuracy and time may be functions of the complexity and the number of items in the object world. In the Leavitt and Mueller study there were six items, or objects, related to each other in specific ways. It seems reasonable to assume that if there were, say, twelve items related to one another in a more complex fashion than that shown in Figure XXV A and B, then either the amount of time required for the transmission of suitable messages would increase or alternatively the level of accuracy would drop.

The transmission of messages in a social system would seem to involve in a large number of instances (particularly when feedback is required) human immediate memory. From Crossman's work it would appear that some of the limits to immediate memory are, in our terms,

1) the size of the object world (the number of discrete, identifiable objects within it).

2) the complexity of the object world (the manner in which it is ordered)

3) the size and complexity of the neurally held system of categories which serves as a framework for decoding messages relating to the object world and for restructuring it.

It appears to us that if the set of internal categories of A is larger and more complex than that of B, then B will not be able to decode messages from A in a semantically proficient manner and, further, feedback from B to A will indicate this to A in that it is likely to be distorted or deficient in information.

## (d) CONCLUDING DISCUSSION ON THE SOCIAL SYSTEM

At half-past eight every morning, the same eight people including the lift-operator take the lift from the ground floor up to the tenth floor of an office block.

For the two minutes that the lift is in motion the eight people can be regarded as a micro social system. In terms of physical space the position each of them takes up will partly determine the network of communication set up. However, factors outside the immediate system might determine the positions initially set up and also the subsequent channels of communication. Thus the lift operator will take up a position at the controls and the men in the lift will take up positions at the back in order to allow the women to leave first. Apart from the lift operator all the people in the lift work in the same organization on the tenth floor. They comprise the boss, his secretary, the general secretary, his assistant, two typists and the Greek translator. Every morning, the boss, after initial "good mornings" to the lift operator, the general secretary's assistant, the Greek translator and the typists, speaks in undertones to the general secretary about his plans for the day and asks his secretary questions as well as giving her instructions. The Greek translator engages in idle exchange of conversation with the typists and the general secretary's assistant remains silent, but listens to the remarks of the boss. If there is a lapse of silence the lift operator announces the cricket score or comes out with some witticism.

The point to be made is that the eight people in the lift comprise a genuine micro-system even though the particular links in this system are determined either by the socio-economic position of the members in the macro society outside (e.g. the lift operator - boss link is limited in time and content) or the positions of the members in the organization on the tenth floor (e.g. the links between boss and general secretary and between typists and Greek translator). We are concerned here solely with the micro-system and the social space within it.

Because of the restriction of this study to micro-systems we are concerned with status not as a correlate of socio-economic class in the macro sense but with status as defining the position of a member of the micro-system. At this point it is pertinent to draw attention to the Parsonian conception of status-role outlined in Chapter II. The participation of an actor in a social system has two principle aspects. On the one hand there is the positional aspect - that of where the actor is located in the social system relative to other actors. This is what is called his STATUS.

In the Meadian sense this is "taking of the role of the other". The implication for leadership is that leader must have high "role taking" ability and must be organically well equipped for this.

Now, in simple terms, it is possible for a person to "know all the facts" without being in a position of control. The converse, however, is not possible in a communication system. The person of high centrality and high status must know, if not all the information stored in the other members, at least the major frames of reference around which this information can be organized.

The above does not seem inconsistent with the cybernetic-type communication system drawn in Figure VII. In Figure VII we saw that selection and control are essential to a self-checking system and so it stands to reason that the organism with the greatest degree of choice (of channel, of other members, of messages) would be in the most favourable position to control to the system.

We suggest also, that the degree of centrality is an index of potential power of an organism in a communication system. In empirical, on-going systems the greatest power may possibly not be exercised by the most central member. Yet theoretically this position is the one where most power can be exercised.

We have spoken predominantly of power in the social system. Let us extend this notion to the whole of the communication system. In this case it can be seen that the power of an organism in the object world envolves the extent of control over the identification, selection and categorization of objects. The power of an organism in a social system is, as we have seen, concommitant with centrality and the freedom of selection. It envolves control over other organisms and, in the organizational and cybernetic sense is hierarchical. The power of an organism in the cultural system envolves the organism's ability to select from alternative reference signals (as used in Figure VII) and the organism's ability to order signals into different types of messages.

Whereas power is a feature of the communication system in a cybernetic sense, quantity and the control of quantity of information is a feature of the system in the semantic sense. There is, we suggest an optimum number of signals which when transmitted through any part of the system, will be sufficient to satisfy the semantic conditions.

Above this optimum amount messages contain redundant signals and are non-economical. Below this optimum not all the signals are included which are necessary for the message to be decoded at the destination into patterns which match those at the source. Information has been lost and thus, in a broad sense, reality is not fully represented as found.

We suggest that whereas quantity is not a measure of power or centrality it can, from the point of view of the system as a whole, be controlled by those organisms in the most powerful or most central positions.

The Bales, Strodtbeck, Mills and Roseborough "ordered interaction matrix" suggests a way of measuring quantity in the social system. Quantity can be seen as an attribute of roles in so far as we conceive of a role as an ordered series of signals. The greater the number of signals of a given unit transmitted or received by a given organism, the more quantitative is his role in the social system.

Since status and role are generally thought of as the static and dynamic aspect of the same thing it might appear that role, which is quantifiable should also be a measure of status. In the light of the above this would be misleading for we considered that an organism of highest status and centrality need not necessarily transmit or receive the highest number of signals, but should have the greatest degree of control and range of choice.

In the social system of a communication system it would seem that status involves the organism's position in a network and that role refers to the actual outputs from and inputs to that organism.

The organisms with high centrality are in a favourable position for controlling - to varying degrees - the amount of information passing through the system and hence also the roles of the other organisms.

It seems possible to state that in a communication system "status" and "role" are conceptually separable with "control" as an intervening element. Thus positions of high status or centrality afford a high degree of control viz-a-viz the whole system and this means the control of roles and hence, in a communication system, the control both of the quantity of signals and the quality of ordering them.

At this point we come to an examination of the cultural system of a human communication system.

## C THE CULTURAL SYSTEM

With regard to the cultural system of a human communication system there are two primary and interrelated concepts which we consider here. Firstly, we can view the cultural system as a system of norms. Selections from the cultural system by an organism will, at least in the semantic sense, be determining for that organism. Not in the full sense of determinism, for it is possible for the organism to reject as well as select; but once selected, norms become determining. Secondly, we can regard the cultural system as a series of alternative possible patterns for ordering signals, both incoming and outgoing. The normative aspect of culture and the "ordering" aspect of culture are, we suggest, reciprocal in that a given order can become normative and a norm implies a given order.

It was assumed above that the cultural system could be either external or internal to the organism but that it would be taken to be external in the present context. This assumption holds.

In Figure VII we see that the organism derives from the cultural system reference signals which set the goals and the standardsfor the whole system. Obviously, if this is to work at all, the organism's structure of expectations must be able to accommodate these signals and the organism must be capable of acting on the received signals. This is assumed. Our primary consideration here is with the ordering of signals.

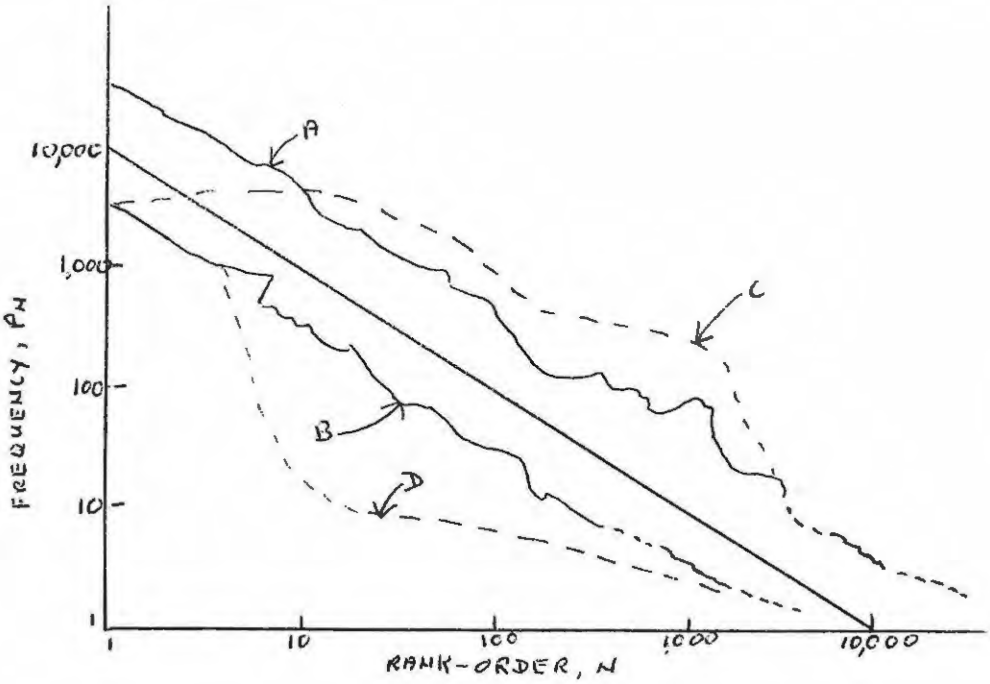
We start off by using a term from linguistics : SYNTACTICS. Loundsbury refers to syntactics as being concerned with the relations of signs to signs with a system of signs.[54] This raises a question which is important to us and which is a point of controversy in the field of linguistics - the problem of the probability with which certain signals follow certain other signals in a sequence.

The view that syntactic structure can be derived from the frequency of signals in sequences would lead us to the statistical study of language and to probability theory, the concepts of ergodic processes, markov chains and to the mathematics of formal neural networks.

A great deal of statistical analysis of spoken and written languages has been carried out in recent years. The classical exponent of the statistical study of language is G.K. Zipf. When designing his code, Samuel Morse gave the shortest symbol, dot, to the most frequent English letter, e, and the longest, dot, dot, dot, space, dot, to the least frequent, z, with a graded scale of length between. In so doing he showed a recognition of the economy of effort; that is, he minimized the average number of dot, space, or dash symbols involved. It has been found that languages envolve similar structure under the natural stress of human economizing; the most frequently used words are the shortest.[55]

Figure XXVI shows curve A, the result of a statistical word count made upon James Joyce's "Ulysees", the volume contains about a quarter of a million word TOKENS with a vocabulary of nearly 30,000 word TYPES.

This curve A results from plotting the frequencies of the various word types against their rank order.




<u>FIGURE XXVI</u>[55] THE RANK-FREQUENCY DISTRIBUTION OF WORDS : A, James Joyce's "Ulysees;" B, American newspaper English; C and D, hypothetical (after Zipf). The co-ordinate scales have been made logarithmic).

Such a linear law is derived from empirical data; if the source of data be changed markedly, it may be felt that the change would be reflected in the form of law. But Zipf takes some different data, corresponding to samples of American newspapers and plots them as in curve B. Considering the divergent natures of these sources of language, the two curves A and B are surprisingly similar. Zipf reinforces his evidence for the existence of a definite "law" by amassing similar data from widely different languages and from tests covering a thousand years of history.[55]

Shannon has illustrated the idea of building up a written "message" as a STOCHASTIC process, that is, as a series of signs (letters or words), each being chosen entirely on a probability basis, depending upon the one, two, three or more signs immediately preceding. Stochastic series in which only digram structure is considered, that is, in which each sign is probabilistically related to one of its neighbours, are called Markoff chains (named after A.A. Markoff). The gathering of monogram and digram statistical data involves an immense amount of labour and with trigram, quadrigram, and so forth, this becomes increasingly prohibitive.[56]

Cherry writes that the relative frequencies p i of the various signs may be estimated by an observer if he watches the source for a long time; however, in practical cases, the possibility of making such an assessment with any pretense to accuracy depends on the source being STATISTICALLY STATIONARY. This means that if the observer watches for a very long time, the relative frequency estimates he makes will not depend upon the actual moment of starting - the statistical parameters of a stationary source are invariant under a shift in the time origin. This assumption of stationariness is normally required in statistical communication theory, and is one of its present limitations. Many practical communication sources are, in fact, far from being stationary. If the source possesses learning ability, it will change its behaviour with the passage of time. In most fields of real HUMAN COMMUNICATION, the assumption of stationary sign behaviour cannot be made.[57]

An ERGODIC source is a statistically STATIONARY SOURCE which has statistical influences extending over finite sequences only.[58]

As far as the model being constructed in the present work is concerned we make the assumption that the information sources serving the system are ergodic. This assumption need only hold in the short-term, however. It would seem that the assumption that the information sources are ergodic is necessary in terms of semantic requirements. It means that signals can only refer to one of a definite and known series of items. The assumption of ergodic sources is also necessary for the definition of a state of short-term equilibrium in which cybernetic adjustment to changes are unnecessary. When the system is in a state of equilibrium the expectations of the constituent organisms are accurately attuned to the signals they will actually receive. In this event the whole series of events in the system is stochastic such that when a few of the events occur the remaining events become increasingly certain.

In the long-term the assumption of ergodic sources cannot hold, but neither can semantic conditions be perfectly satisfied, except in states of equilibrium, when there are no changes. In the long-term we can see the system moving toward equilibrium through a series of cybernetic trials and by a process of learning. A state of equilibrium is, however, only stable in the short-term. In the long-term it is potentially unstable in so far as changes will upset it.

The most important conception we can derive from the statistical theory of determining the probabilities of signals in sequences is that of a fully structured communication system in which every event occuring in every part of the system can be predicted with certainty.

We know that in the English language the probability of the letter "u" following "q" is unity. This means that the letter "u" is redundant. It also means that the organism can expect with certainty the sequence "qu". It should be evident that if very long sequences of signals could be expected on the same basis of probability and if they occurred, then the very long sequence would also be redundant. We suggest that in certain empirical cases long sequences do become redundant - the script of a play to the actors who have mastered it - the score of a piece to the musician who is thoroughly familiar with it.

It has been offered above that role is a general concept and that a linguistic unit such as a paragraph is a special case of a role. Similarly a phoneme could be seen as a special instance of a unit act.

Now if the probabilities of linguistic sequences can be measured stochastically, it follows that the stochastic probability of sequences of any type of unit act in roles should be also capable of measurement. This means that the probabilities of any series of inputs or outputs through any of the system channels should be capable of being determined. It means also that any sequence of "Ve's" is redundant if it is fully expected by an organism.

With regard to the social system the same reasoning can be applied. A network of organisms which is completely probable is - implying that each of the constituent organisms can expect exactly which of the others he will communicate with - also redundant.

It is worth noting the distinction that Basil Bernstein makes between what he calls "elaborated" and "restricted" codes. He writes.

> Different social structures may generate different speech systems or linguistic codes. The latter entail for the individual specific principles of choice which regulate the selections he makes from the totality of options represented by a given language. The principles of choice originally elicit , progressively strengthen, and finally stabilize the planning procedures an individual uses in the preparation of his speech and guide his orientation to the speech of others .........[59]

> ....... If it is difficult to predict the syntactic options or alternatives a speaker uses to organize his meanings over a representative range of speech, this system will be called on elaborated code. In the case of an elaborated code, the speaker will select from a wide range of syntactic alternatives and so it will not be easy to make an accurate assessment of the organizing elements he uses at any one time.[59]

> However, with a restricted code, the range of alternatives, syntactic alternatives, is considerably reduced and so it is much more likely that prediction is possible. In the case of a restricted code, the vocabulary will be drawn from a narrow range but because the vocabulary is drawn from a narrow range, this in itself is no indication that the code is a restricted one.[59]

Bernstein makes the distinction between the verbal component of the message and the extraverbal components. In the first variant of the ideal case of a restricted code, the messages transmitted through all channels (verbal and extraverbal) approach maximal redundancy from the perspective of both transmitter and receiver. This variant will occur where the organization and selection of all signals is bound by rigid and extensive prescriptions. The social relations will be of an ascribed form, located usually, but not always, in religious, legal, and military social structures. The status relations are such that the area of discretion available to the incumbents is severely reduced, with the consequence that few options exist through which the incumbents may signal their discrete intent.[59]

The second variant of the ideal case of a restricted code is one where there is considerably less redundancy in the messages carried through the extraverbal channels, while the verbal channel carries messages approaching maximal redundancy.[59]

The third variant refers to an order of communication where the verbal component approaches maximal redundancy, but where the extraverbal channels permit messages of a relatively much lower order of prediction. If this is the case then it is very likely that the extraverbal channels will become objects of special perceptual activity, as both transmitter and receiver will signal their discrete experience through the agency of such channels.[59]

An elaborated code was defined in terms of the difficulty of predicting the syntactic alternatives taken up to organize meaning across a representative range of speech. This difficulty arises because an extensive range of syntactic alternatives is available within this code and therefore the probability of which alternatives will at any time be taken up is low. This code, through its planning procedures, allows the speaker to elaborate verbally and to make explicit his discrete intent.[54]

Bernstein writes that the form of social relation which generates an elaborated code is such that a range of discretion must inhere in the role if it is to be produced at all. Further, the speaker's social history must have included practice and training for the role. These role relations receive less support from shared expectations. The range of discretion which must necessarily inhere in the role involves the speaker in a measure of social isolation. Control in the role is mediated through a restricted self-editing process as far as the verbal messages are concerned.[57]

The preparation and delivery of relatively explicit meaning is the major purpose of an elaborated code. This affects the manner of delivery. The speech of a restricted code would be delivered in a fast, fluent, relatively unpaused style with reduced articulatory clues. The speech controlled by an elaborated code will be punctuated by relatively frequent pauses and longer hesitations. A specific monitoring, or self-editing, system initially generates the code. The time dimension underlying the planning process producing an elaborated code tends to be longer than the time dimension underlying the planning process producing a restricted code.[59]

Basil Bernstein is instructive in suggesting ways in which sequences of signals can be ordered. What is particularly interesting is that when more than one channel is used at a time, the signals passing through some may be highly redundant (structured) while that passing though the others may permit a higher range of choice and hence value in information.

Before moving on to the following chapter, we would like to dwell a little longer on the distinction between syntactic and semantic.

As conceived here "semantics" coincides with coding in a link envolving one transition. Thus if A gives x, and B gives y then A → x and B → y is both the code and the semantic relationship. We have referred to individual objects x and y and individual signals A and B. However if the object world is seen as constituted by the following arrangement of objects x: y: z: then the signals which represent this arrangement A: B: C cannot be randomly ordered but must be structured in the order A: B: C. If there is only one transitional state then A:B:C can be seen either as the code or as the semantic equivalent of x:y:z. Syntactics, however refers to the internal relationships among the signals A, B and C and the manner in which they are sequentially arranged. Obviously this provides a control over the purely semantic component and hence "syntactics" is well placed in the cultural system when it is seen to be normative. Now - and this is of prime importance - additional signals may be inserted in a sequence which only serve to control the order and have no semantic meaning whatsoever, although they may modify the signals which do. Thus S (A:B:C) might make the semantic transition specific to a particular (x:y:z) whereas G(A:B:C) might make the semantic transition general to any (x:y:z). S,G,A,B, and C are all signals. Of these signals A,B and C are semantic and S and G syntactic. Further, the particular order S(A: B: C) is syntactic. Thus it can be seen that the syntactic component of messages supplies the system with additional (non-semantic) information in order that it can handle the purely semantic signals proficiently. As far as semantics is concerned, however, the extra syntactic signals are redundant.

Noam Chomsky writes that the syntactic component must provide for each sentence a semantically interpretable DEEP STRUCTURE and a phonetically interpretable SURFACE STRUCTURE, and, in the event that these are distinct, a statement of the relation between these structures.[60]

# CHAPTER 4

## T h e M o d e l

The model presented in this chapter is a purely formal one. The elements in this formal model are the same as those which went into building the model presented in the previous chapter, but the purposes which the two models serve are different. In the last chapter the aim was to find a common framework for integrating a large amount of material from different fields but relevant to human communication. It was hoped that the generality and wide applicability of the model might be indicated and thereby substantiated.

In the present Chapter the model serves our hypothesis in the sense of providing a system in terms of which the hypothesis can work.

The model presented here will be a perfect model. That is, it is unlikely to be found in reality. However, if it is to be at all useful, then it should provide a set of interrelated terms which can be used in testing to what extent empirical situations deviate from it.

The model is perfect in another sense as well. That is, it purports to satisfy entirely the semantic conditions for perfect communication.as stated in the hypothesis.

A primary postulate which can be derived from the model is that semantic conditions will be satisfied only under conditions of maximum redundancy. Hence the model will be drawn under the assumption that these conditions prevail. It follows that semantic conditions cannot be satisfied in a situation which is the opposite of maximum redundancy - i.e. maximum entropy. It will be shown, once the case of maximum redundancy has been stated, why this is so. This will entail reversing the model.

In so far as the model will be formal and perfect all the working parts of it must be explicitly described. In empirical situations and to some extent in the model presented in the previous chapter, many of the "rules" of operation are implicit. In this chapter these must be made explicit.

The model purports to be consistent with the action frame of reference. It can be said to be a "special" theory which is on a lower level of generalization than the categories within the action frame of reference.

The action frame of reference puts forward the ends-means schemata as a generalization. The model developed here is specialized in that it is interested in only one end and only one set of means. That is why it is a special theory. If it were general within the action frame of reference, it should serve as a theory for any end around which an action system can be organized. This is manifestly not the case.

The end of the system in the case of our model is the identification by organisms in a social system of objects in an object world in terms of the criteria of a cultural system. For the attainment of this end, the system will use certain means. The means will be said to be efficient if (a) the end is achieved and (b) the system is not disrupted.

## THE CULTURAL SYSTEM

A.1 The cultural system is assumed to be physically external to the other systems. This is not a necessary assumption for it could equally be seen to exist within the organism. The assumption is made for convenience.

A.2 The cultural system has control over the whole system in the sense of providing a normative definition of all its operations.

A.3 The cultural system defines the boundary of the whole system. That is, it states which organisms may be part of the system and their relationships to one another. It further defines the object world and the objects to be identified within it.

A.4 The cultural system provides the criteria for efficiency. That is, it prescribes upper and lower limits to the amount of time and energy that can be spent in identifying the given objects without disruption to the system.

A.5 When energy or energy over time is to be transmitted through the system, the cultural system defines what amounts of energy are to be present to constitute a signal and how these signals are to be ordered in sequences.

A.6 The particular order of the sequence is the syntactic structure. The cultural system specifies all the syntactic structures of the communication system. The syntactic component of a sequence of signals is analytically separable from the semantic component and, as far as the attainment of the end is concerned, acts as a means. Thus certain additional signals may be inserted in a sequence which instruct the system to order in a particular way. These additional signals are in themselves superfluous semantically, but the order which they bring about has a bearing on the objects identified.

A.7' Since the cultural system specifies the objects to be identified, the time and energy spent in identifying them, and the sequences of signals which can be transmitted through the system as a means of identifying them, it can specify also the total amount of information which must pass through the system. This can be stated in bits (binary digits) and can be calculated in the following manner, according to information theory.

Let us suppose that the object world consists of eight objects, lettered A to H. We divide the object world in half and ask : "Does the relevant object come before E?" The answer will enable us to immediately eliminate half the letters. Suppose the answer is "yes", then we repeat the process by dividing the remaining letters into two equal groups, and ask "Does it come before C?" Perhaps the answer now will be "no". Our third question "Does it come before D?" is the final one. This technique is represented by the following table.

TABLE VII

| QUESTION | DIVISION | ANSWER |
|---|---|---|
| 1. BEFORE E? | ABCD - EFGH | YES |
| 2. BEFORE C? | AB - CD | NO |
| 3. BEFORE D? | C - D | NO |

It can be seen that if the size of the object world is doubled, only one further question is required.

It seems reasonable to base the unit of difficulty upon the number of YES-NO answers required when an optimal strategy is employed. This is the basis of the standard unit of selective information. The statement "It is D" in the context of an object world of sixteen equiprobable objects is said to contain four units of information. In a context of only eight letters, the same statement contains three units.

Since the amount of information is so closely related to the size of the object world, we can apply our measure to the object world itself. Thus the object world A to P contains four potential questions before any one object can be identified. The amount of information associated with it is therefore said to be four bits per object. In this sense the amount of information is called "uncertainty" or "entropy" and is denoted by the letter H.

In order to distinguish between information in a sequence of signals and the entropy of the object world, we name the former I. Thus the amount of information in any solution of the object worlds A to H and N to P may be written

I (A to H) = 3 bits   H (H to H) = 3 bits per object
I (A to P) = 4 bits   H (A to P) = 4 bits per object

It is useful to establish a formula relating the size of the object world to the amount of uncertainty associated with it. If the object world has only one member, then there are no questions to be asked; uncertainty is therefore zero. If there are two objects, we need one question to decide between them. We have already seen that as the size of the object world doubles, the number of questions increases by one. This can be summarized in the form of a table.

TABLE VIII

| SIZE OF OBJECT WORLD (N) | NO. OF QUESTIONS (H) |
|---|---|
| 1 | 0 |
| 2 | 1 |
| 4 | 2 |
| 8 | 3 |
| 16 | 4 |

From this table it is obvious that we may express the relation between n and H in the form

$$n = 2^{H}$$

The required equation for H is

$$H = \log_2 n$$

In the example given all the objects in the object world are equally probable. If the objects are not all equally probable then the balance in terms of probabilities may be greatly different from a balance in terms of the number of objects. An example might clarify this point.

The object world consists of objects A to D. They are likely to occur in the proportion 4 : 2: 1: 1, that is

PA = .5
PB = .25
PC = ..125
PD = .125

If we use the strategy of having an equal number of different objects on each side of our "pivot", our first question would be

| QUESTION | DIVISION | ANSWER |
|---|---|---|
| 1 BEFORE C? | AB - CD | YES |

Then, in terms of probabilities, the choice would be between (.5 + .25) and (.125 + .125) which fails to give a balance. In order to arrange to achieve the required balance of probabilities, we must first present an object world in which each object occurs in proportion to its probability. In terms of the example, this list is in the form

AAAABBCD

In this case our first question is

| QUESTION | DIVISION | ANSWER |
|---|---|---|
| 1 BEFORE B? | AAAA - BBCD | YES |

SOLUTION : A.

Our first question has led immediately to the solution. On the other hand, had the correct solution been either C or D, we should have required three questions to identify it, whereas our former method would enable us to identify any of the four objects in two questions. The advantage of balancing probabilities is only apparent when we realize that we are interested in keeping as low as possible the AVERAGE number of questions. Let us do some simple arithmetic to compare the two techniques.

If we balance the number of different objects on each side of the pivot, we shall require, in each case, two questions to give us the solution. Obviously we shall use an average of two questions per solution.

If, on the other hand, we balance the probabilities, the number of questions will vary, according to the object selected. It will be seen that for AAAABBCD the number of questions is

TABLE IX

| SOLUTION | NO OF QUESTIONS | WEIGHING FACTOR |
|---|---|---|
| A | 1 | ½ |
| B | 2 | ¼ |
| C | 3 | ⅛ |
| D | 3 | ⅛ |

The average number of questions is evaluated by computing the weighted mean of these numbers.

i.e. MEAN $= (\tfrac{1}{2} \text{ of } 1) + (\tfrac{1}{4} \text{ of } 2) + (\tfrac{1}{8} \text{ of } 3) + (\tfrac{1}{8} \text{ of } 3)$

$= \tfrac{1}{2} + \tfrac{1}{2} + \tfrac{3}{8} + \tfrac{3}{8}$

$= 1\tfrac{3}{4}$

Our saving then, is an average of ¼ of a question in two, or 12½ per cent. In other situations the saving can be much more dramatic.

Our definition of uncertainty can be amended as we have shown that the equation

$$H = \log_2 N$$

is valid only when all the possible solutions are equiprobable.

We can derive the formula for H as calculated in our last example by examining the method used to compute it. We first found the number of questions asked for each possible solution, and then found the weighted mean of these numbers of questions. Inspections of table IX will show that columns 2 and 3 are not independent. The number of questions is equal in the logarithm of the weighting factor multiplied by minus one.

Each weighting factor is equal to the probability of the corresponding outcome. So we represent the weighting factor of the i th outcome as p i. It follows that for "Number of Questions" we can write $- \log_2 p_i$.

H was evaluated by multiplying together the corresponding figures in columns two and three, and summating these products, i.e.

$$H = \sum_{i=A}^{n} \left[ (-\log_2 p_i) \times p_i \right]$$

This formula is usually written in the more convenient form

$$H = -\sum p_i \log_2 p_i$$

We can now show how our two formulae for H are related. The first formula was a special case of this more general one. When all the solutions are equiprobable, we can write,

$$p_A = p_B = \ldots\ p_i = \frac{1}{n}$$

So we can substitute $\frac{1}{n}$ for Pi in the equation above and obtain

$$H = -\sum \left( \frac{1}{n} \log_2 \frac{1}{n} \right)$$

All the terms to be summated are equal, and there are n of them, so

$$H = nx - \left(\frac{1}{n} \log_2 \frac{1}{n}\right)$$

$$= - \log_2 \frac{1}{n}$$

$$= \log_2 n$$

It still remains to define I, the amount of information in a particular solution, when these solutions have non-identical A PRIORI probability. It is, quite simply, the number of questions required to obtain any particular solution, i.e.

$$I_i = - \log_2 p_i$$

Thus using our four-object object world,

$$IA = 1,\ IB = 2,\ IC = 3,\ ID = 3$$

The "bit" was referred to above. In order to explain this term more fully, let us go back to the first example in A.7 which was the object world of objects A to H (TABLE VII). These were divided successively into halves, each division being associated with a yes or no answer. If we take a list of answers, we can employ it as an alternative way of expressing one particular object. In the example, the answers YES-NO-NO gave the solution D. The answers YES-YES-YES would have given A, NO-YES-NO, F. It will be seen that any combination of three YES's or NO's gives a unique solution: we must, of course, take account of the sequence as the result stated merely as "two yes's and a no" could be one of several things. Since we can have either Y or N in each of three positions the total number of possible permatations is 2 x 2 x 2 which equals eight. The answer tabulations, and their corresponding objects are tabulated in full below.

TABLE X

| OBJECT | ANSWERS |
|---|---|
| A | YYY |
| B | YYN |
| C | YNY |
| D | YNN |
| E | NYY |
| F | NYN |
| G | NNY |
| H | NNN |

The number of successive choices, which we have called "units of selective information" is the same as the number of binary digits. Thus I is in bits (a contraction of the term "binary digit") and H in bits/letter.

SOME CHARACTERISTICS OF H

1. A value of $H = - \Sigma p_i \log_2 p_i$ can be found for any corresponding values of pi.

2. If all possible outcomes are equiprobable, then the value of H increases as the size of the ensemble increases.

3. The unit of uncertainty is additive. This can be demonstrated taking, for example, an ensemble of three objects, A,B, and C with associated probabilities of 0.40, 0.18, and 0.42. We can represent a method of identifying any one of these three members with a tree diagram containing two choice points.

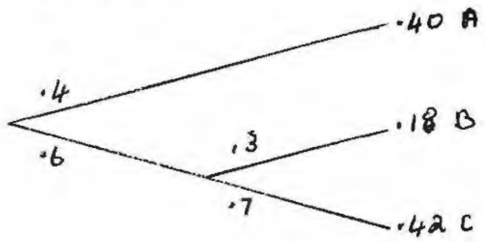



FIGURE XXVII

"TREE" DIAGRAM

At the first choice point (always encountered) the probabilities are 0.4 and 0.6. In addition we encounter 60 per cent of the time the second choice point at which the probabilities are 0.3 and 0.7. The law of additivity states that if a choice is broken down in this way into successive choices, then the uncertainty associated with the whole ensemble is the weighted sum of the uncertainties of its parts. In the example we have

$$H\ (.40,\ .18,\ .42) = H\ (.40, .60) + .6H\ (.3, .7)$$

The three properties of H we have listed so far are sufficient for the derivation of the formula.

$$H = -K \sum pi \log pi$$

Shannon (1948) offers as his second theorem that the only H satisfying the three conditions is the one given above. K is a positive constant. By making it unity and by taking logerithms to the base 2, we thereby determine the size of the unit of uncertainty, and arrive at a measure which corresponds to that derived earlier from considerations of successive halving of probabilities.

4. For an object world of a given size, H is a maximum when all the possible outcomes are equilikely. It was shown above that the uncertainty of a four-object object world decreased from 2 bits per object to $1\frac{3}{4}$ bits per object when the relative frequencies were unequal.

5. The minimum value of H is 0. This occurs when there is only one possible outcome. Since the result is known, uncertainty vanishes.

We may now proceed to define two further concepts. The ratio of the actual uncertainty of a source to the maximum uncertainty, given n, is called the Relative Uncertainty. In the case of the four-object object world considered above,

$$\text{Relative Uncertainty} = \frac{\text{Actual Uncertainty}}{\text{Maximum Uncertainty (given } n = 4\text{)}}$$

$$= \frac{-\Sigma pi \log pi}{\log n}$$

$$= \frac{1^{3}/_{4}}{2} \text{ or } \frac{7}{8} \text{ or } 87.5 \text{ per cent}$$

The difference between the maximum uncertainty and the actual uncertainty, expressed as a fraction of the maximum uncertainty, is termed "redundancy".

$$\text{i.e. Redundancy} = \frac{\text{Maximum Uncertainty} - \text{Actual Uncertainty}}{\text{Maximum Uncertainty}}$$

$$= 1 - \text{Relative Uncertainty}$$

We may say that in those cases where actual uncertainty is at a maximum redundancy is simply the reciprocal of uncertainty.

A.8 For semantic conditions to be satisfied either there is only one object in the object world in which case uncertainty will be zero and any signals transmitted through the system will be over 100% redundant or alternatively there is more than one object in the object world in which case there will be uncertainty and in which case signals transmitted through the system will carry just sufficient information to reduce the uncertainty. In either event the system is characterized by redundancy.

A.9 Since the cultural system controls the whole communication system, it specifies not only the uncertainty associated with the object world and the amounts of information required for identifying objects within it, but also takes into account the uncertainty of the information sources, transmitters, receivers and destinations in each of the subsystems linking the cultural system to the object world.

A.10 Since the cultural system can specify the amount of information which can identify the objects in the object world it can lay down the number of signals which must pass through the system channels of which that amount of information will be the measure.

If more than the correct number of signals is transmitted it means that the system is operating at over 100% redundancy which is uneconomical as far as semantic conditions are concerned. If fewer than the correct number of signals is transmitted then not all the necessary selections can be made and it is possible that the object in question may not be identified. That is, the uncertainty cannot be sufficiently reduced for semantic conditions to be satisfied.

A.11 The cultural system takes into account the total amount of energy available to each of the system parts. Since signals are a form of energy, the cultural system, by virtue of specifying the correct number of signals, also prescribes in what quantities the system shall expend its energy. It follows that the system goal cannot be attained within a given time if there is not sufficient energy available to the system. It also follows that energy is wasted if the codes used are not the most efficient. The most efficient code is that which enables objects to be identified with the lowest average number of bits. Above this lowest average number the signals are more than 100% redundant.

A.12 Signals are energy spent over time. The cultural system specifies what time the system can be allowed for all its signalling processes. With energy constant, too much time will entail delays not expected by the system hence preventing the satisfaction of semantic conditions which require no uncertainty. If too little time is spent not all the energy necessary for the required signals can be spent, if the channel capacity of the system is limited.

A. 13[2] As mentioned above, the cultural system specifies in what manner signals are to be syntactically ordered into sequences. We saw (A.7) how the laws of probability influenced the identification of an object in the object world. The laws of probability also underly the structuring of signals in sequences.

A system which produces a sequence of discrete signals according to certain probabilities is called a"stochastic process". If these probabilities depend upon previous events in the series, the process is called a Markoff one. An "ergodic Process" is a Markoff process in which no appreciable inter-signal influence extends over more than a finite number of signals. That is to say, any reasonably large sample is representative of the whole sequence. This is calculable. Ordinary language serves as an example.

To attack the problem directly in the case of printed English, it would be necessary to construct a square matrix with twenty-seven cells in each of twenty-seven rows. Rows and columns would then be labelled with the twenty-six letters of the alphabet and a space. (We ignore punctuation marks). Each column would represent the 'present' letter, and each row the previous letter. From larger samples of printed English, we might then keep a frequency count in each of 729 cells of the matrix showing the number of times that each of the twenty-seven characters was preceded by each of the others.

We resort to a four letter alphabet for an example of manageable size. Let us suppose that the following is a sample of text in this alphabet.

BACAABADACBADAABACAD -

ABAACBABBADACBADAABA

It will be noted that the probabilities of A,B,C and D are respectively $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{8}$.

We may now construct a matrix in order to count transition frequencies.

In Table XI we enter in each cell the number of times that each letter is followed by each other letter; thus A is followed by A four times, A is followed by B five times, and so on.

It will be noticed that the row and column totals are almost identical with the frequencies of occurence of each letter. The reason that complete identity is not achieved is simply that no letter precedes the B which begins the sequence, and nothing follows the final A, so we are one count short in each case.

From the frequency matrix, we can compute a probability matrix simply by expressing each frequency count as a proportion of the corresponding row total. These are conditional probabilities and shall be represented in the form Px(Y), which is read 'the probability of y, given x'.

TABLE XI

| | | Y | | | | ROW TOTAL |
|---|---|---|---|---|---|---|
| | | A | B | C | D | |
| X | A | 4/19 | 5/19 | 5/19 | 5/19 | 1 |
| | B | 9/10 | 1/10 | 0 | 0 | 1 |
| | C | 2/5 | 3/5 | 0 | 0 | 1 |
| | D | 1 | 0 | 0 | 0 | 1 |

In this case the row totals are each 1. This merely expressed that for each letter, either A,B,C or D will follow; there are no gaps in the text.

It should be noted that since we are computing probabilities from empirical frequencies, we make the assumption that our sample is truly representative of the whole text.

The calculation of amounts of information and redundancy is now quite straightforward. We consider first the case when the last letter in the series was A. There are four possibilities for the following letter, and the average amount of information we gain when this is identified is given by

$$-\sum_{Y=A}^{D} P_A(Y) \log P_A(Y)$$

$$\text{i.e. } \left(-\tfrac{4}{19} \log \tfrac{4}{19}\right) + \left(-\tfrac{5}{19} \log \tfrac{5}{19}\right) + \left(\tfrac{5}{19} \log \tfrac{5}{19}\right) + \left(-\tfrac{5}{19} \log \tfrac{5}{19}\right)$$

In a similar way we can establish the average amounts of information gained in identifying the letters following B,C, and D. Since we are interested in the average overall information given, we require the weighted mean of the four separate values. The weighting factors are, of course, PA, PB , PC, PD. The results of our calculation are set out in the table below.

TABLE XII

| X | $-\Sigma P_X(Y) \log P_X(Y)$ | P(x) | PRODUCT |
|---|---|---|---|
| A | 1.995 | ·5 | 0.997 |
| B | 0.469 | ·25 | 0.117 |
| C | 0.971 | ·125 | 0.121 |
| D | 0.000 | ·125 | 0.000 |

The average amount of information taking into account these sequential dependencies is given by the sum of the final column in the table, and may be represented.

$$H_X(Y) = \sum_{X=A}^{D} \left\{ -\sum_{Y=A}^{D} P_X(Y) \log P_X(Y) \times P(X) \right\}$$

This expression is usually written in the slightly shorter form,

$$H_X(Y) = -\sum^{Y}\sum^{Y} P(X)\, P_X(Y) \log P_X(Y)$$

In our example the value of Hx (Y) is 1.235 bits/letter. When, therefore, we take account of sequential dependencies of pairs of letters (or 'digrams '), the uncertainty decreases by the amount

$$H\ (\text{digrams}) = H\ (Y) - Hx\ (Y)$$

$$= 1.75 - 1.235 \text{ bits/letter.}$$

$$= 0.415 \text{ bits/letter.}$$

The redundancy, due partly to unbalanced frequencies and partly to digram structure, is then,

$$\frac{1.235}{2} \times 100 \text{ per cent.}$$

$$= 61.75 \text{ per cent.}$$

We could now proceed to investigate the trigram structure by finding the probability of each letter following all the pairs AA, AB, AC ...... DD, and determine an uncertainty which could be denoted Hxy (Z). Such calculations, using bigger and bigger pieces of text, could proceed until the value of H vanished. This must inevitably happen with an ergodic process which is defined as one in which inter-symbol influence extends only over a finite number of syllables.

In the case of printed English inter-letter influence is shown to be small beyond a range of about 15 letters, and the total redundancy is estimated to be of the order of 60 per cent.

It would follow that if, in our communication model, all the operations over a definite period involving signals being transmitted through channels could be predicted (i.e. if the probability of each signals and the n-gram structure of the sequence were known in advance) then the rules of syntax would be completely specified and the sequences of signals would be 100 per cent redundant. This implies that there is no freedom of choice in the selection of which signal is to follow which other signals in the sequence.

If redundancy is lower than 100 per cent and there is freedom of choice this means that the rules of syntax are not completely determining or allow substituion which is made on a basis other than that of probability. This implies, however that the system is not fully informed of what to expect and under these conditions semantic requirements cannot be satisfied.

A.14 The distinction was made (A.7) between information and uncertainty. The former was related to the number of selections (binary) which must be made in order to identify an object in an object world and the latter to the number of objects in an object world and their probabilities.

While "information" and "uncertainty" are related they apply, in the model to different things. Information is a measure of signals, or an ordered sequence of signals and is hence a dynamic concept, for signals move in the channels connecting the system parts. Uncertainty is a measure of the stationary or constant parts of the system - the object world, cognitive maps or sign systems stored in organic memory, the composition of transmitters and receivers.

Redundancy applies to both information and uncertainty. In the case of the former redundancy refers to the extent to which it is expected that certain signals will follow certain other signals in a sequence. In the case of the latter redundancy refers to the "prior knowledge" in any part of the system of the state existing in another part. Hence it refers to the correspondence between the systems of categories in different parts of the system. The specific measure of redundancy is given by the number of items in a category system and the probability of the occurence of each.

A.15[3] The cultural system must take into account the capacities of the channels linking the system parts.

The capacity of a channel is not an absolute. It is relative to the uncertainty of the systems which it connects.

Suppose we have a channel which can transmit a number C of off-or-on pulses per second. Such a channel can transmit C binary digits per second. Each binary digit is capable of transmitting one bit of information. If the uncertainty of a message source (H), measured in bits per second, is less than C, than, by encoding with a suitable code, the signals from the source can be transmitted over the channel.

Shannon gives the fundamental theorem for the noiseless channel. He states it as follows :

> Let a source have entropy H (bits per symbol) and a channel have a capacity (to transmit) C bits per second. Thus it is possible to encode the output of the source in such a way as to transmit at the average rate $(C/H - \varepsilon)$ symbols per second over the channel, where $\varepsilon$ is arbitrarily small. It is not possible to transmit at an average rate greater than C/H.

This means that any discrete channel has some particular unique channel capacity C. Any ergodic message source has some particular entropy H. If H is less than or equal to C, we can transmit the messages generated by the source over the channel. If H is greater than C, we cannot.

It would stand to reason that in a situation in which the object world had only one object within it would be possible to have a system with zero channel capacity.

In actual fact the capacity of the channels in a human communication system is likely to be greater than zero bits per unit time. This means that they are adequate for conveying all the information required for satisfying semantic conditions provided that the object world and other information sources do not exceed a tolerable amount of uncertainty.

A.16 Since the cultural system accounts for channel capacity it can also give the particular network of organisms which will best serve optimum capacity requirements. This means that redundancy can be built into the social system. Since a given arrangement of organisms might best serve the attainment of the system end, the freedom of choice of organisms to select other organisms with which to communicate might be curtailed. Each organism can then expect, on the basis of full probability to receive signals from certain other organisms at specified times and will itself transmit the required signals at the correct times.

A.17[4] With regard to any subsystem within the total communication system we can consider two sources of uncertainty : that at the information source and that at the destination. We can denote the uncertainty of the source H (in) and that of the destination H (out). These two uncertainties are perfectly related in the ideal case, but if errors occur, the relation is less then perfect. The situation may be represented by a pair of circles, the overlap between which represents transmission from source to destination, and the remaining parts of which represent the uncertainty of the source when the output is known, and vice virsa.

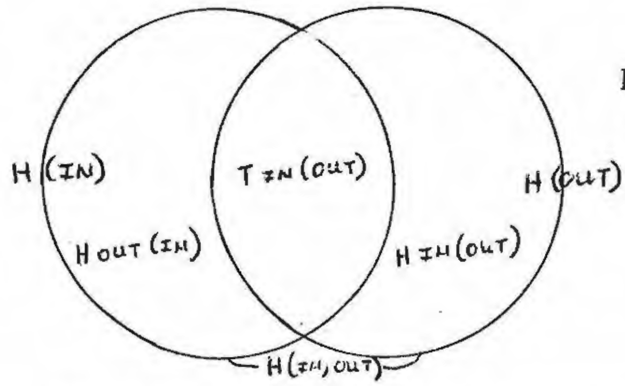



FIGURE XXVIII : <u>THE RELATION BETWEEN THE INFORMATION FUNCTIONS</u>.

Three areas are produced by the overlapping circles in Figure XXVIII These are.

H out (in). The information which is in the input but not the output, and is therefore lost. This is called "equivocation"

T (in, out) The information which is common to both input and output. This is called transmission.

H in (out) The information which is in the output but not in the input, and must therefore be generated in the system itself. This is called "ambiguity" or "noise".

The sum of these three parts provides the fourth derived information function formed from the two primary functions H (in) and H (out).

H (in, out) The total amount of information in the system. It may be regarded as the average uncertainty of all the possible states within the system.

From the geometry of the diagram it is possible to express the relationships between the various functions in numerous ways. We take some examples.

1. H (in) = H out (in) + T (in; out).

   i.e. The input uncertainty is portioned in two parts; that which is transmitted and that which is lost

2. H out (in) = H (in) - T (in; out)
   i.e. equivocation is the difference between input uncertainty and transmission.

3. H (out) = H in (out) + T (in; out)
   i.e. The output is the sum of the transmitted information and the system noise.

4. H (in, out) = H (in) + H in (out)
   i.e. The total information in the system is the sum of the input and the noise.

5. H (in, out) = H (out) - H out (in)
   i.e. The total information in the system is either in the output or is lost.

When the system as a whole is in a state of redundancy the cultural system can specify the total amount of information in the communication system or any of its subsystems if noise and equivocation can be predicted in advance.

A.18 In a human communication system noise might arise from a number of sources. Energy might be expended through the system for the attainment of ends other than the identification of objects in an object world. When a part of the communication system is used for alternative ends, noise is likely to arise. Noise may enter the system from "outside" and may take the form of anything from traffic noise to mist. The noise might be present within a subsystem as, for example, when an organism's nervous system is in an unsettled state.

When the uncertainties of source and message are below the capacity of a channel the system is able to operate under a certain degree of noise.

The reasoning is as follows. Let us assume that the system source is uncertain and that three binary digits can reduce this uncertainty. Under these conditions a channel capacity of three binary digits per unit time will be operating under maximum capacity. If, however the source is fully redundant then no binary digits are required. The remaining part of the channel can be taken up by noise. This means that those conditions which satisfy semantic criteria also tolerate a certain degree of noise when $H < C$. The same channel can operate under conditions of higher uncertainty when there is no noise.

It may be thought that if we allow noise to enter the system when redundant conditions obtain in the source and the message then the uncertainty at the destination will be greater than semantic criteria will tolerate because noise has added non-essential or ambiguous components to the message. This will be the case and accordingly we are led to the assumption that the noise is of a type which can be predicted with certainty by the system. If this assumption holds it means that the destination can separate the noise signals from the message signals sent by the transmitter because it can predict in advance the noise signals which will be received.

Predicted noise can be tolerated by the system and can be overcome by making the message more redundant if the added redundancy together with the normal message and the noise do not exceed channel capacity.

Noise will also not be a problem if the signals which it introduces are of a different type from those which constitute the message and the system only responds to the latter type of signal.

Noise which will prevent the attainment of the system end in a way which satisfies semantic conditions is that which cannot be predicted by the system and which cannot be distinguished from the other components of the message. This type of noise cannot be taken into account culturally and will be a genuine hazard to the system.

Equivocation can also be tolerated provided that it is expected at the destination so that the difference between what is recieved and what should be received can be made good by the knowledge that a certain amount of equivocation has taken place.

A. 19 The cultural system, then, specifies the end of the whole communication system and states how this end is to be achieved given the component parts of the system, the amount of energy available to these parts, the capacity of the channels, the time period over which the system can operate and the amount of disturbance, in the form of noise and equivocation, that the system can tolerate.

The cultural system specifications act as a set of instructions for the system which is perfect on the assumption that no change takes place in the system (additions to or subtractions from the object world; destruction of system parts) and no unpredicted disturbance affects the system from without or within.

The cultural system is itself fully redundant to the rest of the system since it is assumed that a sufficient amount of learning has taken place in the constituent organisms such that they can expect, on the basis of full probability, just what instructions will be received and such thatonce the instructions are received they know exactly in what manner to handle them.

Since the cultural system is assumed to be physically exterior to the rest of the system, time and energy must be expended for the instructions to pass from it to the receiving organisms. Hence part of the cultural system specifications will relate to the cultural system itself and will state in what manner it relates to the other parts of the system. Hence the instructions themselves must be ordered in a sufficiently redundant fashion in order to integrate with the workings of the whole system.

A.20 The whole system will continue to operate in time until changes occur in any of its parts, including the object world. When a change occurs, uncertainty is introduced into the system and semantic conditions cannot be satisfied until new learning takes place. Thus, in the short-term, one of the conditions for semantically perfect communication is that the system is a stationary one.

Semantic conditions accordingly also require that no information passes through the system other than that which is required to reduce the uncertainty of the (existing) ergodic sources.

The extreme case of the semantically perfect system is that in which only one outcome is possible from any of the sources or at any of the destinations. In this case semantic conditions will be satisfied when the system operates over no time at all and with no energy at all. This is also the most efficient and least costly type of system. If any signals do pass through the system they will be over 100 per cent redundant.

## THE SOCIAL SYSTEM

B.1 The "social system" as a general sociological concept is a wider entity than that described here. Our description is limited to those component parts of it which are necessary for inclusion in a communication system with a specific end.

B.2 The social system is entirely consistant with the cultural system described above. Any change in the given social system means that the cultural system is no longer perfectly suited. The social system might, of course, readjust itself so as to once again meet the requirements of the cultural system.

B.3 The social system comprises those relationships among organisms which are significant for the transmission of signals. Thus the channels possible among the organisms must be organized in a way which will make possible the transmission of those signals which are necessary for the attainment of the system end.

B.4 With n number of organisms in the social system any one channel may be used as a connecting device to varying extents. The range of employment of any one channel might be said to range from O, when the channel is not employed at all to $N^2$ when the channel serves as a two-way link between each organism and every other organism and as a feedback device to each of the organisms. Variations within this range are possible as when, for example a channel serves as a one-way link from one organism to all the others or when only certain pairs of organisms out of the total number are linked by a given channel.

Let us assume that the only channels in a human communication system are :

1) Vocal-acoustic

2) Kinesic-visual

3) Direct-manipulative-tactile.

Let us further assume that each organism can be employed on all these types of channel at the same time. We have already seen that the total range of employment of any one type of channel is 0 - $N^2$ . For all three channels the range would then be 0 to $3N^2$.

$3N^2$ would also characterize the total amount of channel choice available in the social system. If the situation is indeterminate then the exact number of channels used at any time would be arrived at randomly; however within the limits of 0 to $3N^2$.

The capacity of channels in the social system would be calculated by determining the capacity of each type (absolute capacity), multiplying that capacity by $N^2$ and adding together the three results.

For the attainment of the system end only a limited amount of information must pass through the social system. The social system is, in this instance, purely a channel, or system of channels. The amount which must pass through is just that which will reduce the uncertainty of identifying objects in the object world. This amount will be set by the cultural system.

From the point of view of identifying objects in the object world it is indifferent which channels are actually utilized. It might be presumed, however, that if the criterion of minimising time and energy is to apply then that channel will be utilized in which codes can be used which require the least expenditure of time and energy.

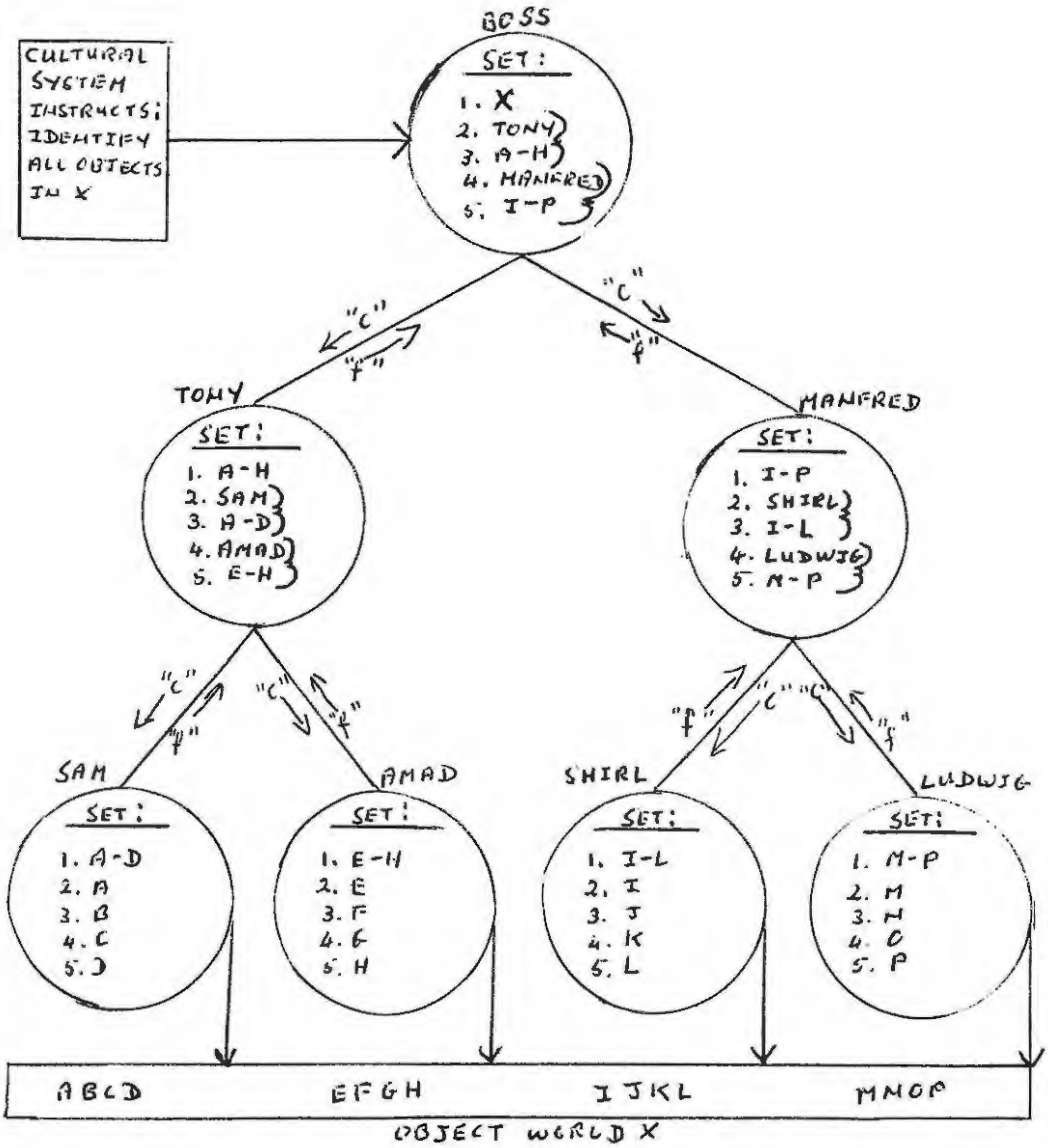
If it is assumed that, say the vocal-acoustic is, in a given situation, the channel which can transmit the most information with a stipulated amount of time and energy then that will be the first choice. If, however, the uncertainty of the cultural system or object world is greater than the absolute maximum of this channel, then alternative channels will have to be utilized.

It can also be said that if a high degree of noise exists in one of the channels, then, if the noise plus uncertainty are greater than channel capacity then other channels might be used even though these are not noise free.

It follows that if the channels in the social system have a total capacity which is greater than that required by the end in question than they can be utilized for other purposes as well.

ORGANIZATION OF "SETS" AMONG MEMBERS
OF A HIERARCHICAL SOCIAL SYSTEM

FIGURE XXIX



B.5 The particular arrangement of organisms in the social system will come about as a result of the learning which has taken place in each. With regard to the specific object world in question each organism has a set (cognitive ap, conceptual scheme, system of categories etc).

If the sets of all the organisms are identical then it is indifferent as to which of them are placed in any particular position.

In the social system semantic conditions will be satisfied if each of the organisms has a set which is identical with the sets of the others. When there are discrepancies semantic condtions are not automatically satisfied. In this case the particular arrangement of organisms in a network is no longer indifferent to which organism is placed in which position.

By way of example let us assume the following case : There are seven organisms in the social system whose sets are each characterized by five items . (See Figure XXIX).

The seven organisms are called, respectively, Boss, Tony, Manfred, Sam, Amad, Shirl and Ludwig.

As is seen, no two organisms have the same set yet the way they are organized is ideal for identifying the objects A to P in the object world "X".

It is clear from Figure XXIX that the system of linkages in the social system is the only one possible in view of the end of the system. Manfred could not take the place of Boss because firstly, Manfred's set does not contain "X" which is the instruction received from the cultural system and secondly Manfred would have no means of identifying objects A-H. Similarly, Boss could not by-pass Tony, for only Tony's set refers to Sam and Amad who alone have access to the discrete objects in the group A-H.

Presumably, with learning, Amad's set could be expanded to include the items in Sam's, Shirl's and Ludwig's sets as well. In that case Boss could communicate directly with Amad and Tony, Manfred, Sam, Shirl and Ludwig would become superfluous. Learning, however, takes time. If the unit allowed in the cultural specifications for the identification of objects is less than the time required for learning then the particular arrangement of organisms in figure 29 is the only one which can immediately satisfy semantic conditions. In such a time - limited system, Boss expects answers to reduce his uncertainty within a specified time. If answers arrive after that amount of time then semantic conditions are not satisfied.

We assume that the system operates on a short-term basis in which no time is allowed for cybernetic learning and adjustment. Accordingly, unless organisms are interchangeable by virtue of having identical sets, a PARTICULAR arrangement of organisms in a network will have to exist for the system end to be attained.

Since no change is allowed for, that particular network could be termed redundant, for any signals transmitted or received by its constituent organisms can be predicted on the basis of full probability.

B.6 Although we have assumed that no time is allowed for cybernetic learning and change to take place in the social system we do assume that it operates on principles of cybernetic control. Thus in Figure XXIX the organisms not only form a network but become stratified within this network on the basis of which order signal they can transmit. It is clear that Boss is highest in the stratification system for no control signals are transmitted to him, whereas he transmits control signals downwards. Sam, Amad, Shirl and Ludwig are lowest order organisms for they receive only control signals and transmit only feedback signals.

B.7 Noise or equivocation in the social system can have a number of different sources. Basically noise means the addition of unwanted signals to messages in a channel and equivocation means that certain signals which were transmitted do not arrive at their destination.

Let us regard the whole social system as a complex channel linking the cultural system and the object world. In such a view any organism forming a node in this complex channel can be regarded as a source of noise or equivocation.

Noise can arise if any of the organisms are expending their energy towards some other end than that specified in the cultural system described here. If this is the case signals might arise in the system which compete with those specified in the cultural system. The extreme case of noise or equivocation in this regard would arise if the competing end which any organism attempts to attain is the prevention of the attainment of the end given in the cultural system of the model. In this extreme case any of the following means of introducing noise or equivocation might attain the end which specifies the prevention of the attainment of the end given in the model :

1) A given organism might simply not act on the reference signals given to it - the extreme of equivocation.

2) An organism might transmit the required signals but only after a delay not allowed for by the system - equivocation.

3) An organism might alter the required order in which the signals should appear - a form of syntactic noise.

4) An organism might select the correct set (ensemble, object world etc), but might purposefully make the incorrect selections within it and stilluse the correct code - a form of semantic noise.

5) An organism might purposefully select the incorrect set - a form of semantic noise.

6) An organism, as transmitter, might add additional, unnecessary signals to the message so as to create confusion at the destination as to the set from which they were selected.

Any of the forms of noise might arise not because of competing ends which interfere with the culturally given end but simply because the learning of the consituent organisms is insufficient or is of the wrong type for them to comprise suitable system parts in the social system required for the attainment of the system end.

Deficiencies of this type could arise from so many factors in the social system that a full account cannot be given here. Only a few might be suggested.

1) A given caste or class system might not be suitable for the attainment of the system end because of unduly restricted codes required when members from different castes or classes communicate with each other. The restriction of the code might be for reasons other than semantic.

2) In a given social system taboos might be placed (with concomitant sanctions) on the use of certain signals. Those signals may be necessary for all selections to be made on semantic criteria.

3) A given organism in the social system - essential to the attainment of the culturally stated end because of certain capacities or because of past learning - may be rejected from the network by the other organisms for reasons other than semantic. The rejection of this organism would lead to a form of equivocation.

Alternatively, the organisms in the social system might attempt to establish linkages with a given organism, not because that will facilitate the attainment of the end in question, but because that organism, say, possesses certain qualities which the others desire. This might lead to a form of noise in that additional, non-essential signals might be transmitted through the system's channels.

THE ORGANISM

C.1 As far as the attainment of the end of the communication system is concerned, the cultural system specifies those parts of the constituent organisms which must enter the system, as well as the way these parts must function in the total system. The cultural system takes the organism into account as a system of energy and hence will prescribe what quantities of energy must be expended by the organism and how these quantities are to be ordered over time.

C.2 The cultural system sets limits to the range of choice which the organism may have in making selections or in ordering its energy. This does not meanthat the organism is culturally determined in any broad sense. It merely sets forth the conditions which must hold for the organism if semantic conditions in the total communication system are to be satisfied.

C.3 Any particular order of energy expanded over time is the organism's role. This role is enacted in terms of the organism's set of expectations. If the instructions received by the organism from the cultural system and if any set of signals received by the organism from other organisms in the social system or from the object world are fully in accord with the organism's expectations then the organism's role can occur on the basis of full probability, and must do for semantic conditions to be satisfied.

In a situation in which both inputs to and outputs from the organism are fully probable the organism's role can be said to be 100 per cent redundant and will bear no information for the organism or for (other organisms in) the social system. Uncertainty, however, is reduced to nil and semantic conditions satisfied.

C.4 The central nervous system of the organism is the most important part of it viz-a-viz the communication system as a whole. The central nervous system might be said to comprise : sets of receivers (eyes, ears, skin, nose, tongue); sets of transmitters (vocal system, facial and bodily movements including special motor skills such as writing); a system of channels (chains of neurons linking receivers to the sensory areas of the brain and chains of neurons linking the motor areas of the brain to the transmitters); a system of information storage (given by the chemical composition of neurons in the brain owning to DNA and RNA functions); and a system of control (given by the organization of brain functions).

C.5 The system of control in the organism is satisfied in the model by the schematic diagram given of the organism in Figure VII and its description in the previous chapter.

C.10 It appears that semantic conditions are satisfied for the organism if it is a stationary system for only then will all the messages within it be redundant.

THE OBJECT WORLD

D.1 While, for certain purposes, the object world could be viewed as internal to the organism and equated with its system of categories, it is, in our model, conceived materially, as having its own existance outside the organism.

D.2 The object world enters the human communication system in so far as one or more organismsin that system receive signals from the object world in the form of light waves, sound waves or physical contact.

D.3 That part of the object world which enters the communication system can be a finite or an infinite series of items depending on whether redundant conditions hold in the rest of the system. If the rest of the system operates on a redundant basis then the object world will be a finite entity, if not, then an infinite entity.

D.4 For semantic conditions to be satisfied in the communication system as a whole, the cultural system will specify all the items to be identified in the object world and will act, through its reference signals, as a constraint on selections made by organisms from the object world. The cultural system will specify a finite number of items to be identified and if, within the time and energy limits imposed on the organisms they identify the corresponding finite number in the object world by means of receiving expected signals from the object world, then semantic conditions are satisfied in the system as a whole.

The model of a communication system we have drawn thus for exhibits those properties which are necessary to satisfy semantic conditions. Thus, in general, it purports to contribute towards an understanding of the relationship between words and objects, language and reality, culture and objects and the like. It contends that words, when used by men can only be perfectly certain as a tool for understanding reality when the men themselves have a complete knowledge of all words, all that exists in reality and all the accepted ways of using words to stand for certain aspects of reality.

Only then can men be fully certain of the meaning of what they say and do and what other men say and do. This requires, however, that men don't change, that the world around them does not change, nor their conceptions of it and further that the language they use is constant over time and can be predicted with full probability.

This is not the case however. Men change and learn. The world changes. Their conceptions of the world change and the language they use for describing the world changes. If, in fact, nothing ever changed, there would be no need to communicate. This, strangely enough, would allow for the most efficient communication system - one that required no time or energy.

Change, however, is not entirely without pattern nor is change complete change. If it were, if no one knew what to expect from one moment to the next, we should have the conditions which our model in reverse would describe.

If we reversed the model, semantic conditions could never hold, the cultural system would be in such a chaotic state that it could not rightly be called a system - no order could be discerned within it, the probability of any one man interacting with any one other at any particular time would be indeterminate, the object world would be an infinite entity changing infinitely fast, men would have no cognitive maps but merely a completely disordered and random array of signals activating the neurones in their brains. The "system" so described would be operating under conditions of maximum entropy. It would be thoroughly mixed up. All selections made would be purely random. All events in the system would be entirely uncertain. "Messages" would have no internal probabilities or syntax. Under these conditions maximum information is conveyed through the system for the number of bits required to reduce the uncertainty of any signal is infinitely high.

Empirically a communication system is likely to fall midway between entropy and redundancy. That is, the events in most situations should be predictable with a fair degree of probability.

Man's efforts in communicating might be seen as a never-ending struggle to maintain equilibrium between the two extremes of redundancy and entropy.[5] When the world changes he attempts to reduce his uncertainty in it by making his culture and his language consistant with it and hence redundant with regard to it.

When the world does not change and he operates under conditions approaching redundancy, he will introduce change either into the world or into his language and his thinking about the world in order to increase his uncertainty within it. Neither of the two extremes - redundancy and entropy - are acceptable and in fact neither of the two can be conceived as forming the basis of an empirical system.

# CHAPTER 5

## C o n c l u s i o n

The present study was concerned chiefly with semantics. It attempted to solve the prime semantic problem - the relationship between culture and reality - by demonstrating what links actually hold between the two.

The hypothesis was put forward that in a human communication system semantic conditions for perfect communication are satisfied when expectations involving signals from an object world match perfectly expectations involving signals from a cultural system.

Theoretically it was demonstrated that semantic conditions can only be satisfied perfectly when the communication system operates under conditions of full redundancy. One of the presuppositions of full redundancy is that, looking at the system as a whole, the structure of the object world is identical to that of cultural system or at least parallel to it in the sense that a code could be found to facilitate a one-to-one translation of the one system into the other.

Empirically it is unlikely that redundant conditions apply completely. Hence there will always be some degree of uncertainty as to the meanings of words. Semantic conditions are unlikely to be satisfied in real situations It is hoped that we have demonstrated that attempts of philosophers such as Wittgenstein and Carnap to work out a language or a logic to describe reality in a perfect sense - to arrive at the semantic "solution" - can only be valid in a purely formal sense.

Perhaps the main contribution of this thesis has been a novel approach to the problem of semantics. We have taken the view that the issues in semantics can be better understood when put onto a quantifiable basis. This means that quality can be seen in terms of quantity. A picture is only a good one, semantically, if all the parts are there. In this regard information theory, as developed by telecommunication engineers, was found to be invaluable.

It might be put forward that information theory as used above has created as many problems as it has overcome. This may be so. We suggest however that the problems it has created are primarily technical ones.

Unfortunately we have not been able to resolve all the issues which emerged here in a rigorous manner. The mathematics underlying these issues was too complicated. Nevertheless this thesis may have some importance if the issues raised are indeed significant and if it is thought that the approach taken towards a solution is a valid one and worth pursuing..

It is hoped that we have succeeded in showing that, on a pragmatic level, semantic relationships are highly complex and that if one wishes to look at such a relationship in operational terms it is necessary to use a framework which incorporates sociological, neurological and physical concepts at the very least.

The main success of this work has been in achieving such a framework. It has been demonstrated that a modified version of Parsons' Schemata of four interrelated systems is a powerful tool for organizing into a meaningful whole concepts from telecommunication engineering - particularly what we have called a "Shannon-type system" - from neurology, psychology, cybernetics, linguistics, physiology and physics.

Apart from achieving a common operational framework for the above-mentioned disciplines we have shown in what manner their basic units are co-ordinate. Thus the "role" of sociology, the unit of energy or energy over time of physics, the phoneme of linguistics, and the "bit" of information theory can be reconciled in terms of one another.

While the problem of noise was discussed, the assumption underlying the model of a communication system constructed above, was that it operated under noise free conditions. Noise is a problem which, to be dealt with adequately would have required far more specilized research into deviancy, conflict and disorganization in sociology and the pathological aspects of neurology and physiology, than could be undertaken here.

Although for the most part the thesis was purely theoretical an attempt was made in Chapter III to substantiate the theory by elaborating parts of the model with empirical and quasi-empirical material.

In general the approach taken in this thesis was non-critical. The aim has not been to provide an alternative to previous thinking on communication or in any way to revolutionize the field and thus no debunking was required. Rather integration was sought. We yielded to the temptation of fitting together concepts, units, elements of theories, because they seemed to belong together by virtue of their bearing on a common problem. A new synthesis was the end in view.

Whether or not a new synthesis has been achieved is for the reader to judge. The hope of the writer is that the loopholes and inconsistencies which undoubtedly are present in his work do not overshadow his thinking on a fresh and possibly important conception of the phenomenon of human communication.

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CHAPTER IV

1. The bulk of A.7 is taken from Elwyn Edwards' Information Transmission. We have merely substituted some of our own terms.

2. Here we have again taken from Edwards' book.

3. And again

4. And again

5. See André Martinet : Elements of General Linguistics P.167ff for a discussion which roughly parallels our own. He writes "At each stage of the evolution an equilibrium is established between the needs of communication which demand more and more specific units, each of which appears with less frequency in utterances, and on the other hand, man's inertia, which impels him to make do with a restricted number of units of more general meaning and more frequent use" (P.167).

CHAPTER V

1. It might be thought that on account of the assumptions we have had to make regarding the information sources of our model - i.e. that they were ergodic - we have landed ourselves in the same position as the the philosophers who treat semantics from a purely formal point of view. This is not the case. If we drop the assumptions our model will still stand. Instead, what will happen, is that now, within the model, semantic conditions will not be satisfied and (using a strict definition of semantic conditions) this is likely to be the case in empirical situations as well.

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