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A Behavioristic Approach to the Design of a Digital Model of Human Communication

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The purpose of this study was to determine whether individual communication behavior can be simulated by a digital model. There were two underlying questions related to this proposition. First, is conditioned behavior serial in nature? Secondly, can conditioned behavior be explained as a function of the relative values of the thresholds and the strengths of the stimulus and the response? The support of the proposition was contingent upon affirmative answers to the questions.

Communication behavior was defined as written or vocal speech

by one individual resulting in either the elicitation or the establishment of an S-R mechanism by another individual. The model consisted of certain variables related to the stimulus and the response. The stimulus and the response were the primary variables of the model. There were several secondary variables associated with each primary variable. The components and the relationship among the components of the model were illustrated through the use of computer programming flowchart symbols.

An experiment was undertaken where the model was checked against human behavior. The experiment consisted of establishing an S-R mechanism in one subject's repertoire of behavior. The stimulus events were puretone presentations from a diagnostic audiometer. The response events consisted of lateral movements of the subject's head to the left. The reinforcers were tokens which were turned in for toys and edibles. An experimental booth was used to record the stimulus events, the response events, and the reinforcement. The data were counted, tabulated, and graphed.

The following is a summary of the results of the experiment with regard to the questions and the proposition. First, it seemed that conditioned behavior was serialiin nature. In the beginning of the experiment the subject faced the right, but after differentially reinforcing successive approximations, the subject turned to the front. Eventually, he began turning his head to the left which lead to the desired correct response. This appeared to be a step-by-step process.

A portion of the second question seemed to be true. The concept of stimulus threshold and the concepts concerned with the response variable seemed to be valid. The acceptance of a stimulus threshold was based on the hearing examination of the subject. The secondary variables related to the response were based on established principles of conditioning. The concept of a response threshold was not tested in the experiment. The other secondary variables concerned with the stimulus seemed to be a detriment to the learning that followed. These variables were eliminated from the model. An alternative of giving the stimulus a value was suggested. With the acceptance of the alternative the second question was affirmed.

Since the study concerned a simple stimulus and a simple response, it was determined that at an elementary level communication behavior can be simulated by a digital model.

A BEHAVIORISTIC APPROACH TO THE DESIGN OF A DIGITAL MODEL OF HUMAN COMMUNICATION

by

GEORGE EUGENE WHITLEY

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It seems only appropriate that this thesis begin with an expression of my gratitude for the time and assistance given by my chairman, Dr. Larry A. Steward, and another committee member, Dr. James F. Maurer.

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CHAPTER I

INTRODUCTION

I. GENESIS OF THE PROBLEM

Interest in creating a computer model of communication began with the reading of Computer Models of Personality by John C. Loehlin of the University of Texas. The book was concerned with current efforts at constructing models of personality in computers. Although the study of personality has been usually incorporated under the discipline of psychology, much of the theory found under psychology has been related to the study of communication. Thus, these models of personality provided the initial impetus for this thesis.

While enrolled in several courses dealing with the study of communication, one realization of significance was that in many fields of study scholars have developed theories of communication or, at least, have made contributions to the study of communication. This has been true of Psychology, Sociology, Speech, Anthropology, and Mathematics. Having encountered each of the above areas during graduate and undergraduate studies, the greatest number of courses were in Speech, Psychology, and Mathematics. In the latter area computer programming was of considerable interest.

Course work in the areas of Speech and Psychology led to the awareness of the complexity of behavior. Reducing the study to the communication behavior of a single individual did not markedly reduce this complexity. B. F. Skinner (1965) summarized this point appropriately.

> Behavior is a difficult subject matter, not because it is inaccessible, but because it is extremely complex. Since it is a process, rather than a thing, it cannot be held still for observation. It is changing, fluid, and evanescent, and for this reason it makes great technical demands upon the ingenuity and energy of the scientist. But there is nothing essentially insoluble about the problems which arise from this fact (pp. 19-20).

Thus, after reading the treatise by John C. Loehlin (1968) and having such a background and interest and, in spite of the complexity of the problem, there was considerable wonderment over the possibility of developing a computer model of communication. Such an opportunity came when taking a graduate class with an assignment to develop a communication model. Almost immediately, an attempt was made to create a communication model of individual human behavior that could be programmed in a computer.

II. PURPOSE OF THE STUDY

This thesis was inspired by the model developed for a class assignment. It was realized that the model of communication behavior had little validity and utility until it could be tested. Therefore, it was the purpose of the study to determine whether individual human communication behavior could be simulated by a digital model. An experiment was undertaken where the model was checked against actual human behavior. After the model had been evaluated in light of the results of the experiment, answers to the following questions were proposed.

1. Is conditioned behavior serial in nature?

2. Can conditioned behavior be explained as a function of the relative values of the thresholds and strengths of the stimulus and the response?[1]

In the experiment certain of the components and their relationship among the components of the model were isolated in an experimental setting. Once the data had been derived and examined, the model was evaluated. Some components of the model were eliminated and others remained unchanged, while one element was modified. Based on the evaluation of the model, answers to the above questions were proposed. Once the answers to the questions were determined, the proposition was discussed.

In formulating the scope of the thesis and gathering background information, the model has gone through several changes and modifications from the time when it was initiated. What had not been altered, however, was the intention to discover whether individual human communication behavior could be simulated by a digital model.

[1]For an explanation of the terms and concepts in the proposition and the questions, see pp. 7-41.

CHAPTER II

MODELING IN GENERAL

The use of models is not a new technique to the theorists in the physical sciences. On the other hand, it is relatively new to the social science field. Therefore, a meaningful understanding of the use of models necessitates locating modeling within the framework of theory and science. This chapter includes the following: 1) an overview of modeling, 2) simulation--an operating model, and 3) the role of computers in simulations.

I. AN OVERVIEW OF MODELING

The concern of science is reality. A group of propositions about certain aspects of reality make up a theory. Of importance to the theorist is the description of the components of the reality and the relationship among those components. J. R. Raser (1969) indicates that in the physical sciences when a theory is tested and determined to describe correctly the reality with which it is concerned, then the theory is no longer called a theory but a law. Furthermore, if this takes place in the social sciences, it is suggested that the theory is not discussed in such an absolute way but in terms of probability. Whether a theory becomes a law or is discussed in terms of probability is beyond the scope of the thesis. However, it can be stated that if a theory is tested in a discipline and found to describe correctly the reality with which it is concerned, then the theory can be viewed as a valid one. It can also be said that the scientist in any discipline is concerned with reality and theory is an attempt of expressing reality.

There are many ways of expressing theories. They can be in the form of verbal statements, in the form of symbols, or in mathematical formulae. These are often called models and models are a way of expressing theories. The elements and structure of the model may be either symbolic and/or physical representations of what is being modelled. Investigations that concern the elements or the structure of a model provide information about the elements or the structure of the theory. If a model is valid, and similar studies are undertaken, one of the model of a theory and the other of the theory itself, then these investigations should give the same conclusions. A scale model of a supersonic airplane studied in a wind tunnel can provide important and sound data about the actual full-scale airplane. The model furnishes a way of investigating the real thing. Since theories denote reality and models can be symbolic or physical representations of reality, then models express theory.

In model building, the elements and the relationships among the elements must be specified, as in constructing a theory. Processes of abstraction, identification, and specification are usually required by the theorist and the modeler.

> In constructing the model, as in constructing the theory that it expresses, it is necessary first to identify the components of the system and then to specify the relationships among them.... With most theories, a process of abstraction is necessary. That is, one postulates that certain aspects of the system are relevant to the problem at hand and that certain aspects of the system are not. Only those aspects

> that are judged important are included in the model. Through this process of identification and specification, redundant and distracting details are eliminated... (Raser, 1969, p. 7).

The choice to include some components and to ignore others and to carefully indicate the relationship among the components determines the quality of the model. If a wise selection is made, then the model is a good one.

An example of both a model and the role that mathematical models play in science is illustrated by the work of Coombs, Raiffa, and Thrall (1954) (Figure 1).

> With some segment of the real world as his starting point, the scientist, by means of a process we shall call abstraction (A) maps his object system into one of the mathematical systems or models. By mathematical argument (M) certain mathematical conclusions are arrived at as necessary (logical) consequences of the postulates of the system. The mathematical conclusions are then converted into physical conclusions by a process we shall call interpretations (I) (p. 20).

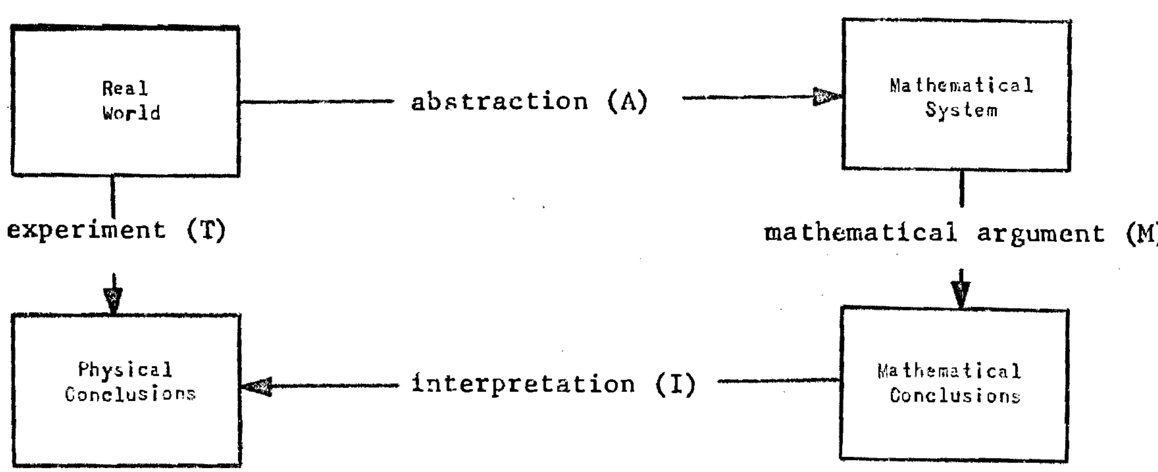


Figure 1. The Coombs, Raiffa, and Thrall model illustrating the role mathematical models play in science.

The elements of this model are specified by the boxes and terms placed within the connecting lines. The lines show the relationship among the elements. If what is included is wisely selected, then it is a good model.

Many models are being used in the physical sciences. This is probably the first area where models, both symbolic and physical, received wide application. The construction and utilization of models is becoming more popular. Communication theorists are using this technique. There is the Shannon and Weaver Model (1965), the model proposed by G. A. Miller (1956), the Westley and MacLean Model (1951), and the SMCR Model by Berlo (1963) (see Appendix A).

The use of models is being attempted by scholars in many areas of science. They are gaining in popularity, especially in the social sciences. Theories sometimes can be expressed advantageously in a model. The process of formulating models is no different from that of formulating theories. Both are concerned with reality.

II. SIMULATION--AN OPERATING MODEL

Just as theories are special ways of describing reality and models are specific methods of expressing theory, so are simulations special kinds of models. According to common usage, almost all model building could be called simulation. Due to popular usage, however, simulation might refer to imitation, something that is false, phony, or a copy. It can be used when one thing is like another and there are even references to deception.

Two additional terms are often used as synonyms of simulation. First, a term used by mathematicians and simulators is "analogue." An analogue is referred to as "something that is analogous to something else, or something <u>similar in function</u> but different in structure and origin" (Raser, 1969, p. 13). Secondly, replication is often used in place of simulation. F. Crosson and K. Sayre (1963) state that a definition of replication should "be broad enough to accommodate reproductions, facsimiles, test models, duplications, and dummies" (p. 5). This includes items that are used by children for enjoyment, such as dolls, toy animals and trains. Research instruments, referred to as mock-ups or scale-models come under this heading. Replication takes into account war games.

> The common characteristic of these examples is that each reproduces at least some of the physical characteristics of the original object or process which is replicated... Both war games and actual combat involve the employment of soldiers and battle equipment, and the mock-up spaceship capsule is adequate for its purposes only insofar as its controls look, feel, and act like their counterparts in an actual space vehicle (Crosson and Sayre, 1963, p. 5).

Photographs and paintings of objects are not considered replications, because the real object is usually three-dimensional. None of the aforementioned terms are to be confused with the meaning of simulation used throughout this thesis.

The social scientist uses the term in a much narrower sense. A specific meaning is necessary due to the utilization of simulation as a device in the study of human systems. The human systems for the social or behavioral scientist are psychological and social processes. Richard E. Dawson (1962) defines the term in the following way:

> Simulation, as a social science research technique, refers to the construction and manipulation of an operating model, that model being a physical or symbolic representation of all or some aspects of a social or psychological process. Simulation for the social scientist, is the building of an operating model of an individual or group process and

> experimenting on this...simulation by manipulating its variables and their relationships (pp. 2-3).

It is important to realize that simulation is an operating model and it displays processes over time. To a large degree then "...simulation can be thought of as a dynamic model. Simulators, therefore, must try not only to build a model of system structure, but also to incorporate system processes" (Raser, 1960, p. 10).

In order to simulate structure and process of a referent system, the processes in simulation are abstraction, simplification, and substitution (Raser, 1960). As indicated in the section under modelling, abstraction is important for selecting the components and the relationships among the components of a system. A simple model which is less expensive and easier to manipulate is sometimes more preferable. Another crucial process in simulation is substitution. It is important to consider the degree to which the components in the simulation correctly represent their counterparts.

The purpose of the preceding paragraphs was to clarify what simulation is, what is the difference between a model and a simulation, and the processes involved in simulation, as well as the terms that are frequently interchanged with the term simulation. In the following paragraphs the rôle of simulation will be discussed.

The role of simulation as pointed out in the definition by Richard E. Dawson is basically that of an investigative method or research technique. This technique allows the social scientist to study and learn about the behavior of individual and group processes. While the research method is as yet not a standard tool, it is becoming a more popular instrument in the investigations of the behavioral and social scientist. The fact that simulation may become a common tool in research is due to the following developments:

> ...dramatic advances in machine computational and analogizing capabilities; greater emphasis on rationalizing division-making procedures; increased recognition that understanding social phenomena requires examining complex systems of interaction rather than isolated entities; a growing tendency to approach problems from the perspective of several disciplines simultaneously; and the increased popularity of a philosophy of the social sciences that insists on multivariate analysis, rigorous specification of assumptions and relationships, and theories that are temporally dynamic rather than static (Raser, 1969, p. ix).

Having the potential to examine many variables over a period of time is a great asset to the social scientist. The criteria used to evaluate the use of simulation are reproducibility, visibility, and economy.

One of the most important advantages of this technique is that it allows the experimenter to reproduce processes that exist in nature. Researchers can repeatedly observe events that they could not have otherwise done in real-life situations. An investigator can reproduce a situation many times that might never occur again in nature. The simulator can investigate the variables and their relationship with regard to real-life outcomes. He can perform a large variety of manipulations of the variables, the assumptions and the relationships among the elements of the system. In short the experimenter can reproduce, but he also has a great deal of control over many situations. Because of the moral and physical factors when experimenting with real people and real social systems, this is an advantage of simulation.

There are two ways that a simulation may increase the visibility of a system being investigated. First, a phenomenon might be physically more accessible by using the simulation approach. If it is more accessible, then the phenomena are much easier to observe. Secondly, a simulation could increase the visibility of a system by simply clarifying it. To model or simulate requires clarifying the assumptions, the variables and the relationship of the variables of a system, which can help to improve many of the theories in psychology and sociology that are general and vague with little predictive power.

The economy of simulation can be either an advantage or a disadvantage. Due to the equipment and the number of trained participants, simulation is frequently quite expensive. But, on the other hand, it can be less expensive when attempting to gain information about the real situation. Some experiments that can be simulated can eliminate costly mistakes caused by waste or disaster. In the long run all the advantages must be weighed against the results that might be gained from using other research techniques, whether it is concerning economy, visibility, or reproducibility.

One of the criticisms of social science has been that it is too simplistic. In many cases research consisted of isolating one variable and attempting to hold all others constant. This never occurs in reality. It was necessary to ignore the dynamic nature of human affairs where a change in one variable produces changes in other variables. The ultimate purpose of research in Social Science "is the formulation of theories that explain and predict behavior" (Dawson, 1962, p. 5). Similarly, research is concerned with exploring theories and testing of hypotheses. Simulation can be viewed as a technique of research.

As in the case of model building, adequate reproduction of the real system is the concern of all simulations. In carrying out research in a simulated environment the investigator will not successfully determine the behavior of the real system, unless the necessary characteristics of the real system are validly modelled (Dawson, 1962). A thorough knowledge of the real system is required by the researcher, as well as having reliable means of reproducing the model in the simulated environment. This problem is not a simple one to overcome.

In spite of this, however, simulation is a useful tool for exploring theories and testing hypotheses. Simulations are specific kinds of models, models are means of expressing theory, and theories are ways of describing reality. For the scientist the capability of studying processes over a period of time in an operating model is preferable for the advancement of science. It would seem that an ideal study for a social scientist would be to explore individual or group behavior in an operating model.

III. THE ROLE OF COMPUTERS IN SIMULATION

Simulation is often used in conjunction with computers. A computer offers the simulator the opportunity to study a number of variables and their relationships over a period of time. This interesting use of building and operating models of complex systems in the medium of the computer is taking place in a number of fields. One of the most difficult endeavors is that being made by psychologists and others to model human behavior. Some attempts have been concentrating on rather narrow aspects of the human system, while other researchers are concerned with behavior in general.

In spite of the difficulty of computer models of human behavior, computers, for the most part, have attracted wide interest in scientific research. Scientists have become interested in computers as theoretical tools. "A computer model of a system is a concrete embodiment of a theory about the operation of that system, and running it as a computer is a way of determining what the theory predicts under specified sets of conditions" (Loehlin, 1968, p. 5). In many cases theories are complicated and a computer model is a practical means of coming up with sound predictions, as well as testing changes in assumptions underlying a theory. Due to the development of the computer as a research tool, some scientists are turning to this method with renewed practical and theoretical interest. This interest is occurring in the social sciences, also. However, it is necessary to clarify some features of the computer before any utilization of this approach.

First, it must be clearly understood that the computer is strictly a medium. The computer is not the model, but rather the model is programmed in the computer. Simple logical and arithmetical operations are the elementary units of this medium. The computer provides an environment wherein different relationships can be established between these units. Once the basic units have been formulated, various plans of operating the model can be used. Just as a canvas is a medium for the artist, the computer can also be used as a medium by the researcher. The particular medium selected to demonstrate and describe a model of a theory will have an effect on the model itself. The medium of a computer is no exception.

Secondly, the simulation of human behavior is a complex and a difficult problem when attempting to use a computer as the medium. If a researcher can legitimately assume that human behavior is of a step-by-step nature, then the use of a computer might be a practical approach. This assumption will be made for the model in this thesis. It is assumed that an individual exhibits human behavior in a serial process. A person can breathe, talk, and drive a car at the same time, but his attention can not be given to all of these processes at a particular moment. Individuals write one word after another and speak one word at a time. When it comes to complex tasks, most of them can be broken down into a single serial sequence. Generally, "as far as action is concerned, a serial representation in a computer is a fairly natural arrangement" (Loehlin, 1968, p. 141). An operating model of human behavior, programmed in a computer, should be assumed to be serial in nature.

However, the computer should not be used for every conceivable model. Some models are easy to program into a computer and would be useful for the investigator. Others are difficult to represent effectively in a computer and would provide no advantage to the researcher. The computer is not a cure-all for the scientist. As in the case of simulation in general, the criteria used to evaluate the use of a computer for simulation are reproducibility, visibility, and economy. The decision to use the computer for simulation must in final analysis be evaluated against the other methods available to the researcher.

In conclusion, simulation has its advantages and computers offer an excellent medium to study these operating models. These models consisting of components and relationships among the components can be investigated with regard to time. Simulation is a research tool where dynamic human processes can be examined. If the medium of a computer is utilized, the process should be step-by-step in nature. Simulation can be a good tool and its understanding to contemporary research is essential for today's scholar.

CHAPTER III

CONDITIONING: A SPECIFIC MODEL

The theory of conditioning can be considered as a predictive model. This theory is located within the scope of Learning Theory. Its development is due in part to the work of Pavlov and Skinner. The purpose of this chapter is to present the concepts and principles necessary for an understanding of conditioning. It includes (1) a general summary of the basic concepts of conditioning, and (2) concepts of conditioning related to the study of communicative behavior.

I. A SUMMARY OF THE BASIC CONCEPTS OF CONDITIONING

There are many different ways of describing man. The categories a scientist uses spring from different attitudes, values, and interests. Each source depends on the point of view taken with regard to the assumptions made about the human organism. J. R. Raser (1969), in _Simulations and Society_, points out several views of man. The concept of man which is probably the oldest and simplest indicates that man is the product of an omniscient and omnipotent God. The view of man as a reasoning animal expressed by Thomas Acquinas and included in the term _homo sapiens_ is essentially the anthropological concept. The belief where human behavior is to a large extent the result of unconscious forces operating at the emotional level is called the Freudian or the psychological. Finally, the behavioristic view, of current popularity, stipulates "that human behavior is the mechanistically determined result of a complex biogenetic, socio-economic matrix"

(Raser, 1969, p. vii). Basically, the forces that cause human behavior emerge out of a complex scheme of social and economic factors. This latter view of man is important to this study and is a basic assumption for the development and understanding of the model to be explained in Chapter IV.

To go a step further, behaviorism and learning need be defined prior to a thorough comprehension of conditioning. Both of these terms have wide usage with a variety of meanings depending on the purposes involved. Consequently, behaviorism is defined as the study of observable individual or group behavior excluding references to inner states of the individual or group under study. Generally, the behaviorist does not deny the existence of inner states of the human organism, but "believes them not to be relevant in the analysis of behavior" (Skinner, 1965, p. 45). Since the model is not concerned with inner states of the human organism, it can be referred to as a behavioristic model.

To continue, many of the definitions of learning are concerned with "a change in performance" (J. A. McGeoth, 1952, p. 4). Two sources are used to come up with a suitable definition of learning. According to A. W. Staats and C. K. Staats (1963) "learning is a relatively permanent change in behavior which occurs as a result of practice" (p. 21). Similarly, learning is defined by J. A. McGeoth (1952) as "a change in performance which occurs under conditions of practice" (p. 5). Determining what the important conditions are and being able to clarify that not all changes of behavior are learned is a problem for the researcher. The definition to be used for the purpose of this study is that learning is a change in behavior under conditions of practice. The specific conditions of practice will be clarified in the following consideration of the concepts related to conditioning. Before proceeding with an explanation of conditioning, it is necessary to develop an understanding of a stimulus and a response.

Definitions of stimulus vary from simple physiological concepts to more complex concepts applying to higher order processes, to learning, and to social processes (Green, 1963). As the theorist moves from the simple to the complex, the difficulty in selecting an appropriate definition becomes more difficult. A. W. Staats and C. K. Staats (1963) refer to stimulus as "an environmental event" (p. 21). While D. Berlo (1963) indicates that a stimulus is "any event that can be sensed by an individual" (p. 24). Both of these definitions are excellent for the purposes here. It is important to consider whether an organism can sense an event and whether the event is environmental and capable of producing a sensation in the receptors of an organism. Admittedly, there are numerous environmental events in most organism's surroundings. But just as important, there are relatively few of these events that any one organism is capable of sensing. The definition selected for this study is a combination of the two presented above: a stimulus is an environmental event which an individual is capable of sensing.

E. J. Green (1963) adds that a stimulus can be in one of two states: "a potential stimulus or an effective stimulus" (p. 28). Essentially, a potential stimulus is the stimulus which has the potential of producing a sensation in an organism, whereas an effective stimulus is a stimulus that the organism has sensed. The difference in these two states is whether an organism has sensed the stimulus or not.

As a researcher scans the literature and encounters the word, "stimulus," nearby the word "response" is likely to be found. The word response "is borrowed from the field of reflex action and implies an act which, so to speak, answers a prior event--the stimulus" (Skinner, 1965, p. 47). This is not a necessary condition, since it is not always possible to identify a prior stimulus.

D. Berlo (1963) indicates that "an action taken as a result of a stimulus is a response" and then he adds further that there can be an "overt response and/or a covert response" (p. 75). A. W. Staats and C. K. Staats (1963) define a response as simply "a behavioral event" (p. 20). Thus, the definition used in this study is that a response is a behavioral event which is observable and measurable elicited as a result of a stimulus.

E. J. Green (1963) proposes that "any definition of a response is artificial," because the observer imposes the definition upon behavior (p. 23). The response is defined by the physical environment and the definition is then sharpened by the experimenter.

> ...each instance of behavior is unique in that the precise physical coordinates existing at one time have changed before the next instance takes place. Behavior is time ordered; even if there were no other differences between two response instances. They would of necessity differ because they had taken place at different times... One variable that controls behavior is behavior itself. The organism that has made a response a second time differs from the organism that made the response for the first time because the physical

> consequences of action alter the probabilities of further action by that organism. It may be that the behavior change is irreversible, if for no other reason than that the changes in the environment in which behavior takes place are irreversible (Green, 1963, p. 23).

The solution to the problem of the definition of a response is found in the concept response class or class of responses. Once a response has occurred, it cannot be controlled or predicted, only the prediction of future responses which are similar is the concern of a predictive science. Therefore, of greatest interest is not the response but a class of responses.

This class of responses can be described by the word "operant." The reason this term was introduced is for the purpose of distinguishing between reflexes and responses which operate on the environment. B. F. Skinner (1965) explains that operant "emphasizes the fact that the behavior operates upon the environment to generate consequences. The consequences define the properties with respect to which responses are called similar" (p. 47). E. J. Green (1963) points out that

> Groups of response instances share common properties, such as their common existence as a function of some independent variable. Stated another way, the environment, in interaction with the organism exhibits certain consistencies to which an adaptive organism can respond... A response class (an operant) is defined as composed of those behaviors which are controlled by a common environmental operation upon the organism (p. 24).

In many cases the environmental operations are the contingencies of reinforcement which define the behavior. While a response refers to an instance of behavior and response class refers to instances of behavior, operant is concerned with a kind of behavior. Operant is used as a noun and an adjective.

It should seem obvious that an organism may exhibit a large variety of responses in his behavior over a period of time in relation to certain conditions. For example, when an individual is presented with a pad of paper, he may write on it, draw pictures, set it aside, and so on. This potential behavior of an organism is called a repertoire. And a repertoire is made up of a collection of operants (Skinner, 1957).

If in the above example the individual is an artist, then it can be said that the drawing of something is likely to occur. Generally, some responses of a repertoire of behavior are more likely to occur than others. That is, there is a greater probability that under certain conditions one response may occur over another response. This probability of emission of a kind of response is called the response strength or the response class strength (Skinner, 1957).

When considering the study of a class of responses, the researcher must begin with basic assumptions about behavior in general. The behavioristic assumption, associated with this thesis, indicates that the influential forces which cause human behavior are basically due to social and economic factors of one's environment. Learning is also significant for the study of any change in behavior. An environmental event which an individual is capable of sensing (a stimulus) can cause or elicit a behavioral event which is observable and measurable (a response). Since behavior is time ordered, a study must be concerned with the response class which is part of an individual organism's repertoire of behavior. With these concepts, it is now appropriate to discuss conditioning.

There are a number of reasons for the popularity of conditioning methods. J. A. McGeoth points up two of these reasons.

> ...conditioning techniques permit the relatively precise determination of various relationships which we can assume to be fundamentally true of the learning process...and we find that the results of conditioning research have been a fruitful source for theoretical concepts used in the explanation of more complex forms of learning (1952, p. 63).

Thus, the area of conditioning consists of concrete techniques and a productive theoretical source for the study of learning.

Conditioning consists of two types: respondent conditioning and operant conditioning. First, respondent conditioning is often referred to as classical conditioning. Pavlov's work with learning in dogs in 1927 is usually associated with this kind of conditioning. Generally, his work involved pairing a stimulus that evoked the reflex of salivation with one that did not. Pavlov used meat powder to elicit the natural response of salivation and a tone was used as the neutral stimulus. These two stimuli were paired together in time, so that eventually the tone elicited the salivary response. This procedure has come to be called respondent or classical conditioning.

It is described by A. W. Staats and C. K. Staats (1963) as follows: "If a stimulus, originally neutral with respect to a particular response is paired a number of times with a stimulus eliciting that response, the previously neutral stimulus itself will come to elicit the response" (p. 36) (Figure 2).

$$S \rightarrow R$$

Figure 2. The paradigm used to illustrate the general technique of classical conditioning.

J. A. McGeoth (1952) describes the essential features of respondent conditioning in the following manner:

> (a) an originally neutral stimulus called a <u>conditioned stimulus</u>, (b) a stimulus which has the characteristic of evoking one of the natural reflex responses of the learner termed an <u>unconditioned stimulus</u>, (c) the reflex response to this unconditioned stimulus known as an <u>unconditioned response</u>, (d) the pairing together in time of the conditioned and unconditioned stimuli, and (e) the eventual occurrence of a response which closely resembles the unconditioned response, but made in response to the conditioned stimulus, known as a <u>conditioned response</u> (p. 64).

The paradigm used to schematize the work of Pavlov is illustrated below.

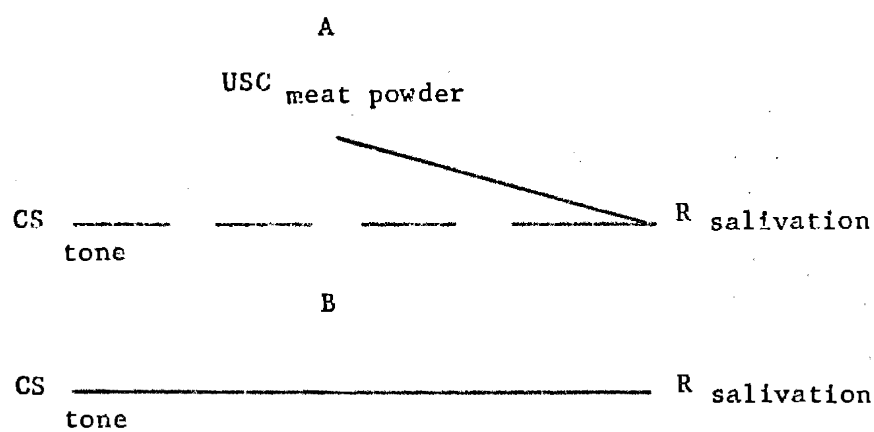


Figure 3. The paradigm illustrates the work of Pavlov where A shows the neutral stimulus and the unconditioned stimulus being paired to elicit the response while B shows the conditioned stimulus eliciting the response.

In A the meat powder which elicits the salivation response is paired a number of times with the tone. As a result of A occurring, the tone will eventually elicit the salivation response.

The unconditioned stimulus, abbreviated UCS, is the meat powder. The CS or the conditioned stimulus is the tone. While the unconditioned response is the salivary response of the dog as a result of the UCS, the CS elicits the conditioned response, a part of the class of responses of salivating by the dog. Classical conditioning has been used to explain and demonstrate certain reflex behavior in humans, as well as lower organisms.

Not all behavior is conditionable when using the respondent conditioning technique, simply because some reflex responses are more easily conditioned than others. The types of responses that can be learned by this method are limited by the reflex repertoire of the learner (McGeoth, 1952).

The second type of conditioning is called operant conditioning or instrumental conditioning. Generally, the principle of instrumental conditioning can be stated "that the consequences which follow a particular behavior affect the future occurrence of that behavior" (Staats and Staats, 1963, p. 41). The behavior under such conditioning can weaken (cause the behavior to become less frequent) or strengthen (cause the behavior to become more frequent) depending on what consequences follow the behavior.

The consequences that strengthen behavior are termed rewards. More specifically, however, the consequences of this conditioning method consist of stimuli. These stimuli are called reinforcers and the act of following a behavior with a stimulus is reinforcement (Figure 4).

$$R \longrightarrow S$$

Figure 4. This paradigm illustrates the procedure of instrumental conditioning.

There are different types of reinforcers which depend on what occurs to a given behavior and how the stimuli are presented. First, if a stimulus closely follows certain behavior and it increases the probability of that behavior occurring again in the future, then the stimulus is termed a positive reinforcer (symbolized as S^{r+}) (Figure 5).

$$R \longrightarrow S^{r+}$$

Figure 5. This paradigm illustrates the strengthening of behavior.

If a stimulus increases the probability of behavior occurring again when its removal follows that behavior, it is called a negative reinforcer (symbolized as S^{r-}). Finally, when a stimulus is presented following a behavior and the frequency of the behavior decreases, the stimulus is an aversive stimulus. Aversive stimuli and negative reinforcers can be the same type of stimuli. The difference being only in whether the stimuli are presented or withdrawn (Staats and Staats, 1963) (Figure 6).

$$R \longrightarrow S^{r-}$$

Figure 6. This paradigm illustrates the weakening of behavior by an aversive stimulus or a negative reinforcer.

A feature related to the reinforcement of a response is the time between the occurrence of the response and the presentation of a reinforcer. The term temporal discrimination is used to distinguish between the case where the rate of responding is high when reinforcement occurs and the case where responding is low, when reinforcement never occurs. W. H. Morse (1966) states that "the immediate presentation of a reinforcer has a greater effect in engendering behavior than the delayed presentation, but delayed presentations do strengthen behavior somewhat..." (p. 91). There are studies reported where a delay in reinforcement is used in the laboratory. The findings indicate that the rate of responding is higher when reinforcement is immediate rather than when reinforcement is delayed. For operant conditioning the time between the occurrence of a response and the presentation of a reinforcer influences the rate of responding.

It can be said that the immediacy of the consequences, as well as the consequences that follow behavior are important to operant conditioning. The consequences that follow a behavior are the reinforcing stimuli. In the respondent conditioning situation, the subject receives the conditioned stimulus on every trial regardless of the response made. However, under circumstances of instrumental conditioning, the subject must emit the response before reinforcement is presented. B. F. Skinner (1965) states the distinction in this manner:

> In the Pavlovian experiment...a reinforcer is paired with a stimulus; whereas, in operant behavior it is contingent upon a response... In operant conditioning we 'strengthen' an operant in the sense of making a response more probable or, in actual fact, more frequent. In Pavlovian or respondent conditioning we simply increase the magnitude of the response elicited by the conditioned stimulus and shorten the time which elapses between stimulus and response (p. 48).

Thus, there is a difference between the procedures of respondent conditioning and operant conditioning.

Respondent conditioning has wide generality to many learning situations. E. J. Green (1963) points out that operant conditioning can be applied to the following: "trial and error learning, verbal conditioning, motor learning, problem solving, concept formation and insightful solution to problems" (p. 45). Therefore a large portion of everyday acts by an individual can be explained in terms of instrumental or operant conditioning, as well as classical or respondent conditioning.

Up to this point, a response is considered as a dependent variable under the control of other events. In laboratory environments there are numerous studies "involving fairly discrete S-R relationships" (Staats and Staats, 1963, p. 86). However, in everyday situations a person does not behave in such a discrete fashion, but rather one response leads smoothly to the next. The response itself can control later behavior in an organism. This is referred to as chaining or behavior chaining. D. S. Blough (1966) states that in this type of chaining or behavior chaining "each response is the principal controlling stimulus for the next" (p. 373). There are many types of behavior that are coordinated in response chains. They include driving a car, playing a piano, memorizing a passage of poetry or simply tying a shoelace. Originally in each case the responses were dependent on environmental stimuli for eliciting each response causing these operations to be not easy tasks. Later, however, each response leads to the other being completely independent of the environmental stimuli. It seems that "language behavior, as well as physical skills, depends heavily upon response chains" (Staats and Staats, 1963, p. 95).

The principles of conditioning were largely derived by B. F. Skinner from the work on reflex-arcs by Sherrington and Pavlov. It has been suggested that these latter two scholars would be seriously concerned with the way their concepts have been expanded by some psychologists. In an article by G. A. Miller, E. Galanter, and K. H. Pribram (1968) recent findings about reflex action were summarized.

One finding of importance to the present study that was incorporated into the model concerned the concept of threshold. This concept, while ignored by many, is considered to be significant to the concepts of conditioning. The finding by the above authors is stated in the following manner:

> The only conditions imposed upon the stimulus by the classical chain of elements are the criteria implicit in the thresholds of each element; if the distal stimulus is strong enough to surmount the thresholds all along the arc, then the response must occur. In a sense, the threshold is a kind of test, too, a condition that must be met, but it is a test of strength only (p. 371).

The above authors added that an input can be tested in other ways besides a threshold.

According to the above, a threshold is important to each element. Therefore, the stimulus and the response must each have separate thresholds. Going one step further, the implication is made that there may be several thresholds and for the response to occur, all thresholds along the reflex arc have to be overcome. If each element of the arc has a value or strength greater than the threshold value, then the response will occur.

Since the principles and concepts of conditioning are based on the findings derived from investigations of reflex action, it is not improbable that the concept of threshold can be applied to the study of behavior or, in this instance, communicative behavior. When considering the behavior of an organism, the organism in most cases is exposed to a large number of stimuli. It can be said that there may be numerous potential stimuli for any organism, but only a few will become effective stimuli that affect the organism's receptors. The strength of an effective stimulus is great enough to overcome the threshold of that element. The strength of the potential stimuli which do not become effective stimuli are not strong enough to surmount the threshold of that element. There is no guarantee, however, that a response will occur when the stimulus value or strength is greater than the stimulus threshold, since the thresholds of all elements must be overcome prior to the occurrence of a response. It is possible to assume that the response has a threshold. And for a response to be emitted the value or strength of the response must be greater than the response threshold. This concept of threshold is central to the theory of conditioning and is thereby a feature in the development of the model.

The terms differentiation and discrimination, while sometimes confused, are important to a thorough understanding of the conditioning techniques. Both are concerned with processes used in the procedures of operant and respondent conditioning. Differentiation is usually associated with operant conditioning methods. The response is the concern of this process. A. W. Staats and C. K. Staats (1963) state that "differentiation denotes the change that takes place in the variations of a class of responses through the selective reinforcement of some of the variations" (p. 85). In other words, when the researcher strengthens certain responses of a response class through selectively reinforcing only those certain responses, then he has differentiated out these responses into a new response class. Those responses not reinforced will extinguish.

There remains variation in the differentiated responses. With the new class of responses a new point will be present around which the variation will occur. If the experimenter is interested in a specifically defined response class, then through continued selective reinforcing of certain variations of the responses these incidences of behavior will occur more frequently and other variations will occur less frequently. Essentially, the response class will move toward the class defined by the experimenter. The organism can be conditioned to respond in a specific way, if this procedure is gradually increased. The term successive approximation refers to this series of differentiations (Staats and Staats, 1963).

While differentiation is concerned with the response, discrimination involves stimuli and is a separate process. "In both the respondent and the operant paradigms the occurrence of the reinforcing stimulus can be made conditional upon the prior occurrence of a specific stimulus" (Terrace, 1966, p. 273). As a stimulus begins to elicit a certain response, a similar stimuli will also elicit the response. However, if a reinforcing stimulus follows a response only when a certain stimulus is present and never when different stimuli are present, then only the specific stimulus will elicit the response. Discrimination training is used to refer to this procedure and the stimulus that only elicits the response is called the discriminative stimulus. H. S. Terrace (1966) points out that a discriminative stimulus "'sets the occasion' for the occurrence of a conditioned operant" (p. 272).

The concepts of baseline and extinction are also important to a conditioning program. Baseline refers to the state of the dependent variable prior to conditioning. The researcher is interested in the number of occurrences or the strength of a certain behavior. The procedure is simply to record the behavior of interest during observation periods. The number of baseline sessions will be dictated by the purpose of the study or conditioning program. According to J. J. Boren (1966) "The ideal behavioral baseline should be stable. Stable means that the behavior remains about the same from one observation period to another..." (p. 544).

Extinction is concerned with the time when no reinforcement follows a response and the frequency of responding decreases. This period occurs after the conditioning program has been established and the subject has reached the stage in development where the performance of the desired response has been successfully demonstrated. "The process of weakening the response by not following it with reinforcement is called extinction" (Staats and Staats, 1963, p. 55). According to R. T. Kelleher (1966) "The popularity of these procedures presumably stems from the assumption that the conditioned reinforcing effects of a stimulus should be measured only when known primary reinforcers have been eliminated from the experimental situation" (p. 174). The procedure of extinction and baseline are to be used in this study.

To this point, certain procedures and concepts concerning both the techniques of respondent and operant conditioning have been presented. The former concerned with pairing of a stimulus with one that elicits a response and the latter affecting behavior by the consequences that follow it. These methods have been used successfully to explain some of the human organism's everyday behavior. The generality of the principle of conditioning can best be summed up by B. F. Skinner (1957). "Men act upon the world, and change it, and are changed in turn by the consequences of their action" (p. 1).

II. CONCEPTS OF CONDITIONING RELATED TO THE STUDY OF COMMUNICATIVE BEHAVIOR

An experimental study in the physical sciences is no simple endeavor. There are complicated and sophisticated apparatus to set up and operate. Meters, microscopes, and other instruments are available enabling the researcher to obtain measurements to the tenth of a degree or even a hundredth of a millimeter. There are exacting and specific procedures to follow so that the relevant variables can be controlled, isolated, and measured. The days of Faraday where magnets, wires, and cells were used are long past. The variables are exactly and specifically defined in the beginning of an investigation. Sometimes the use of sophisticated statistical methods is required.

However, the study of behavior by psychologists and social scientists is seemingly an overwhelming task from which the most optimistic must shrink (Green, 1963). The procedures and the instruments, if any at all, may appear gross and lacking specificity to the physical scientist. The behavior scientist, also, seeks to control, isolate, and measure the variables under investigation. There are procedures to follow and methods for statistical analysis. But the real chore lies in the difficulty of defining those behaviors to study and those not to include. This problem is due to the complexity of behavior itself. E. J. Green (1963) says it best.

> The behavior of an organism consists of a set of continuously changing, interrelated actions. Behavior is not segments, but rather of undifferentiated flux. Regularities present themselves from time to time in poorly defined groupings; the identification of determining variables and the relationships between such broadly defined behaviors at the gross observational level is a challenge... (p. 22).

Behavior is complex and most measurements occur at the observational level.

While any underestimation of the difficulty of this subject matter would be foolishness, the experimentalist can approach it with some optimism. The complexity of behavior can be reduced somewhat by simplifying conditions in a laboratory. A great deal can be done with certain methods of observation. Using several trained observers in a study is such an example. Certain instrumentation is also possible. The means of control can reduce complexity. In fact the reproducibility of an experiment can be found in the degree of control used by the researcher. This test is usually passed easily when it comes to the experimental investigation of behavior (Skinner, 1966).

If none of this is possible, the utilization of a statistical analysis is feasible. This will provide an inferior prediction sometimes, but this can be acceptable (Skinner, 1965). When using statistics, the confidence in an empirical study is directly proportional to the number of subjects used. When using a scientifically sound sampling technique, the confidence can be increased by using more subjects. Specific tests can be used as long as the study is properly designed with the results significant at the level determined by those tests (Skinner, 1966).

The researcher should "select a relatively simple bit of behavior which may be freely and rapidly repeated, [and] which is easily observed and recorded" (Skinner, 1965, p. 46). In spite of the fact that behavior is a response or class of responses, there is still a problem in selecting and defining the response class so that it can be isolated and measured without overlapping and including responses of another class. In any investigation of behavior, the experimentalist must adequately define the one specific class of responses out of the organism's entire repertoire of behavior. If the response class is in the repertoire, it may help to overcome portions of the problem. If, however, the response class is not in the organism's repertoire of behavior, the dimensions of the class of responses must be exactly and specifically stipulated in the beginning of a study.

For scientific use our interest is the probable occurrence of a response from its class, but in the final analysis the data of our study is the frequencies the response occurred. Thus, the experiment must be designed in such a manner that observation and interpretation of the frequencies are possible. In a controlled investigation the conditions which cause encouragement of behavior and competition with behavior are held constant or ideally eliminated (Skinner, 1965).

It can be said that the study of behavior is a difficult and trying endeavor, but through certain techniques the problems can be surmounted. Observation methods provide an excellent means of studying behavior. Statistical analysis is possible. Of primary importance, however, is the proper design and control of the experimental study. The data for the study of behavior is the frequency of occurrence of the response class. Another important feature that can help to maintain the quality of a study is proper formulation of the procedure.

One area where the procedure is refined and the posing of research questions is sophisticated is found under behaviorism. The area is referred to as learning. There is a large body of theory and research techniques are firmly established. Much of the empirical findings are derived from conditioning experiments of lower animals and verbal learning experiments of human subjects. It is suggested that a great amount of the research and theory under behaviorism is applicable to the area of communication. While F. R. Hartman (1969) admits that there are a number of cases where the data does not support the above suggestion, the argument he stipulates is that:

> a) Learning problems translate easily into communication problems. b) Learning research has been very extensive, resulting in a large body of empirical findings and in procedural refinements and sophistication in the kind of question posed. c) Many issues which can be explained through learning research cannot be duplicated in communication research because there are no techniques sufficient for controlling the relevant variables at the more complex level. d) Many of the principles derived from behavioristic learning research find confirmation in the rules of thumb of applied communication (p. 127).

The argument set forth above influenced the way in which the theory of conditioning was utilized in the development of the model.

When the researcher is interested in the examination of communication behavior of the human organism, the complexity of such a study can be overwhelming. While no longer aiming at the infinite spectrum of behavior in general, the experimentalist still must encounter the rather broad spectrum of communication behavior. The complexity is not reduced in a meaningful way. It too is of extreme complication and its examination is no simple matter. B. F. Skinner (1957) states that communication behavior is observed in a crude form and that it is due to a number of causes. A speaker can also be a listener in such a cause. This fact multiplies the difficulty of such an investigation.

It can hardly be said that using one approach or another to study communicative behavior reduces the complexity of the study. This behavior is of great variety and an interest in analyzing it may be derived from many sources. It should be realized that any one classification system may not describe it entirely. But the job of investigating communicative behavior should not cease, since it is a significant part of a culture. While some of the time we act directly with our surroundings, "much of the time, however, a man acts only indirectly upon the environment from which the ultimate consequences of his behavior emerge" (Skinner, 1957, p. 1). George A. Miller (1963) expresses it this way:

> Communication is so pervasively important in all walks of life that every branch of the social sciences is concerned with it, studies it, and adds to the general fund of knowledge about it. The beginning student is often overwhelmed by the variety of forms the study of communication can assume and finds it quite difficult to reconcile one with another or to develop a well-rounded evaluation of the subject as a whole (p. 1).

The variety of forms can be seen in the variety of definitions of communication.

In a recent study of F. E. X. Dance (1970) definitions of communication were examined. The definitions were taken from different disciplines and various publications. Content analysis was performed on these definitions. From the approximately 4,560 words examined, fifteen distinct components were derived. Based on these components, there were three points of critical differentiation--"level of observation, intent of the sender, and the normative judgement of the act" (p. 208). The definition of communication selected for this study is concerned with the first two points. No reference will be made indicating the normative judgement of the act of communicating.

The first point of critical differentiation derived by Dance is the level of observation. For this study it is required to be observable and measurable. In other words, in order to communicate there must be some type of behavior by the receiver that can be observed and measured by the sender. If a person is giving an opinion, he may see a nod of the head by the listener or reader, or may hear an "Oh," "I don't agree," or "Yes." There are many other possibilities, but for communicative behavior it must be both observable and measurable.

The second point of differentiation of definitions is the intent of the sender. Not only does the definition include observable and measurable behavior of the receiver, but the definition stipulates that this is the desire of the sender to bring about the observable and measurable behavior. This desire of the sender must also be in the form of an observable and measurable response. In the study the intent of the experimenter is his response of presenting a pure-tone and dispensing a token to the subject. The definition does not indicate whether the sender is aware of the receiver's behavior. Thus, this is not a necessary condition.

The definition of communication is taken from Complex Human

Behavior by A. W. Staats and C. K. Staats (1963). It states:

> ...communication may be considered as written or vocal speech emitted by one individual that results in either the establishment of new S-R mechanisms in another individual or in the elicitation of S-R mechanisms that have been previously acquired /by another individual/ (p. 185).

The meaning of "S-R" is stimulus-response. While there are many forms used to study communicative behavior, this definition clearly indicates the level of observation and the intent of the sender. There is no reference to the normative judgement of the act, however.

Since the above definition includes both operant conditioning, as well as respondent conditioning, it includes many types of S-R mechanisms with some being successful and some being unsuccessful. If the sender is able to establish a similar S-R mechanism or elicit a similar S-R mechanism in another individual as it does in the sender, then the communication can be considered to be effective. However, if this does not elicit or establish a similar S-R mechanism and establishes or elicits a different one from that which was intended by the sender, then the communication is ineffective.

The effectiveness of a communication will depend on the prior learning of the sender and the receiver. For example, if the speaker says, "all politicians are crooks," and the learning history of the listener is that his favorite uncle is a politician, then the communication is likely to be ineffective due to the different learning histories of the two participants. If both parties to the conversation were in the armed forces together and wrote to respective congressmen to stop them from being transferred overseas to a war zone area, then possibly their histories would be the same with regard to the crookedness of politicians. A. W. Staats and C. K. Staats (1963) state "communication may also fail even when the appropriate.../S-R mechanisms/ are established by the message source" (p. 199). The receiver may not have in his repertoire the appropriate behaviors the sender wishes to elicit. The key to the success of a communication is the learning histories of the participants.

The participants in such a situation may include a speaker and a listener, a sender and a receiver, or a writer and a reader. The behaviors of both parties to the communication can be called the communication episode. B. F. Skinner (1957) points out that

> There is nothing in such an episode which is more than the combined behavior of two or more individuals. Nothing emerges in the social unit.... The separate accounts which result exhaust the episode in which both participate (p. 2).

While Skinner is concerned with verbal behavior, his comments are in order with the scope of communication considered in this study. He refers to a speech episode which this writer will alter to call a communication episode.

B. F. Skinner (1957) in his treatise entitled Verbal Behavior does not prefer the use of the term communication. "Extraneous, misleading properties and events" will be introduced if this term is used (p. 10). He adds further that if the term communication is used it "suggests that the speaker is controlled by a stimulating situation and is especially reinforced by the action which the listener takes with respect to it" (p. 152). Yet, when he uses verbal behavior, B. F. Skinner includes "any movement capable of affecting another organism may be verbal" (p. 14). This can involve written language, sign language, telegraphy, manipulation of physical objects, and auditory behavior which is not vocal such as, gestures, blowing a musical instrument, or clapping of the hands. His definition while seemingly narrow is in fact much broader than the one used in this study.

For this thesis, the written or vocal speech emitted by the sender does not include gestures, sign language, or the manipulation of physical objects. The sender can, however, emit spoken sounds, write symbols, make drawings or paintings, clap his hands and play a musical instrument. The behavior of the other individual in the communication episode can be of a large variety as long as it is the result of the written or vocal speech by the first individual. It may be something as simple as smiling and nodding of the head or as complex as writing an essay, driving a car, or voting. Thus, for the sender the behavior is more specific while the behavior of the receiver can be any behavior included in his repertoire.

For purposes of this study there were four basic elements of communication: the sender, the receiver, the message, and the feedback. In the experiment the subject was the receiver and the sender was the experimenter. Since the model concerned the communicative behavior of the receiver, the sender does not appear in the model. The model was intended to be a tool for the sender. The message which consists of information was the presentation of the stimulus by the experimenter. In the model the message was the input of the stimulus. The reinforcement of the stimulus and the response also could be viewed as part of the message from the sender. However, it could also be feedback to the receiver. This was part of the model and was in the form of tokens dispensed to the subject by the experimenter. In the model and in the experiment the feedback to the sender consisted of the receiver's or subject's responding to the message of the sender. By studying this simple process and determining what these four elements were, an attempt was made to examine these units of communication. An examination of more complex communication must still be broken down into these irreducible units: the sender, the message, the feedback, and the receiver.

The concepts presented in this section are not all those related to conditioning.[2] However, the concepts discussed are important to conditioning when considering the study of communication behavior. The problems of design and control of an experiment are significant for the reproducibility of the study. When behavior is to be investigated, it is necessary to define and delimit those behaviors of interest. The definitions and procedures selected to follow in an experimental endeavor will influence the expectations and the results. In spite of the complexity of behavior and the difficulty of its investigation, the examination of behavior is possible. The techniques of conditioning afford an excellent approach.

Some features of learning theory and its associated research methodology apply easily to the study of communication. Using one approach or another in the study of communication does not markedly reduce its complexity. The definition of communication for this study

[2]Three other theoretical concepts not crucial to an understanding of conditioning are included in the section entitled Problems in the Development of the Model, pp. 60-74.

includes the point that it is the intent of an individual to elicit or establish some observable and measurable behavior by another individual. The effectiveness of communication is primarily based on the learning histories of the participants. The combined behaviors of the participants make up the communication episode. In spite of the variety of forms in the study of this complex type of behavior, the investigation of communication behavior must continue, because it is so important in allowing individuals to interact with the environment indirectly. Also, it is necessary to attempt to understand the process of communication and the many barriers for effective communication between individuals. The task is not a simple one, but it must not cease.

CHAPTER IV

A COMPUTER MODEL OF HUMAN COMMUNICATIVE BEHAVIOR

The purpose of this chapter is to explain the development and formulation of the model, as well as to describe the components and the relation among the components. This is a computer model because the variables are formulated to correspond to the binary nature of a computer. The components and the relationship among the components are illustrated through the use of programing flowchart symbols. Explanations of the symbols used in the model can be found in Appendix B.

The model can be referred to as a conditioning model, because it is based on the concepts and principles of both classical and operant conditioning. However, it is a communication model, since the elements of the model and the relationships among the elements are in a configuration that corresponds to the definition of communication by A. W. Staats and C. K. Staats (1963). In the definition there are two individuals, essentially, a sender and a receiver. This model is concerned with certain variables of the second individual, the receiver, that could help the first individual, the sender, determine the effectiveness of his efforts to communicate. The chapter will include (1) a description of the elements and the relationship between the elements and (2) problems in the development of the model.

I. A DESCRIPTION OF THE ELEMENTS AND THE RELATIONSHIP BETWEEN THE ELEMENTS OF THE MODEL

The primary variables, stimulus and response, and the relationship between the variables are based upon the classical conditioning paradigm (Figure 2) and the operant conditioning paradigm (Figure 3). However, the model is not this simple.

There are secondary variables subordinate to the primary variables. These secondary variables are in the form of questions asked of the primary variables. These questions help to determine the state or condition of the stimulus and response. As the answers to the questions are found the state of the organism can be postulated with regard to the result of a communication episode.

The binary nature of the questions allows the researcher to answer "yes" or "no" to these secondary variables which result in alternate paths being taken in the model. Depending on the paths taken positive or negative values will be established. After proceeding through the model, these values are then summed and compared to another value, the threshold value of the primary variable. If the summed value is equal to or less than the threshold value it is compared to, then the procedure must begin at the starting point. If, on the other hand, the summed value is greater than the value it is compared with, it is possible to continue on to the next sequence of operations.

If the state of the organism is such that the majority of questions are answered affirmatively resulting in mostly positive values being established, then the final set of operations will be reached. These operations involve obtaining a final value which is called the strength of the response or, simply, response strength. The response strength, of course, is the probability of the occurrence of the response given the existing state of the organism and the consequences stipulated by the variables in the model.

Each of the above operations or steps which lead to the final value are formulated to determine whether or not the thresholds will be surmounted (Miller, Galanter, and Pribram, 1968). If the thresholds are surmounted, the response ought to occur. Before proceeding to the specific elements of the model, certain simplifying techniques were used in the model.

The method used to simplify the model concerns the standardization of some of the symbols. All positive values are indicated by a lower case letter of the alphabet. All negative values use a lower case letter, but a prime (') is used; i.e., positive--m, n, p and negative--m', n', p'. The threshold values of the primary variables are indicated by the capital letter T. To designate the difference between the thresholds, different subscripts are used; i.e., stimulus threshold = T_s and response threshold = T_r.

The final approach concerns a technique that is used by many computer programmers. This involves initializing all values, including the threshold values, the primary and secondary variable values, and any corresponding values, to zero. The path in the model can be such that the initial zero is changed to either some positive or negative value. But there will be instances when the path in the model does not change the initially established value of zero. These procedures assist greatly in simplifying the model.

Turning now to the model itself, the first primary variable is the stimulus. Prior to any consideration of the secondary variables, the stimulus must be placed into the process. This operation is referred to as "input the stimulus (S_x) into the model" and is indicated in Figure 7.

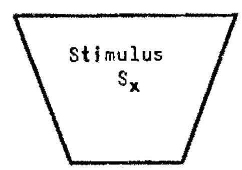


Figure 7. The input of stimulus S_x is shown by this flowchart symbol.

The subscript "x" is used to point up that each individual type of stimulus must be considered separately. A different letter for the subscript would indicate a different type of stimulus. For example, different subscripts would be used to illustrate the difference in the sounds of the car horns of two different automobiles. Also, the subscript can be used to indicate the number of occurrences of a particular stimulus in the model. It is possible, but highly improbable, that a certain stimulus could be placed into the model from one to an infinite number of times.

Once the particular stimulus is placed into the system, the secondary variables are then dealt with. While not in the form of a question, the first secondary variable is the threshold value of the stimulus. The instruction is to set the threshold value (T_s) of the stimulus (S_x), and is illustrated in Figure 8.

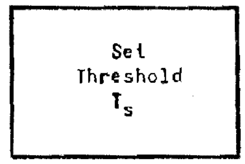


Figure 8. The flowchart symbol with the instruction to set the stimulus threshold, T_S.

The purpose of this variable is primarily concerned with the state of the organism. There are times when an organism is more receptive to certain stimuli than other times. The simplest example of this is when an individual is hungry the threshold for food will be much different from the threshold for food immediately following a meal. This variable will indicate the various states of the organism concerning the receptivity of a stimulus.

The remaining secondary variables with regard to the stimulus are in the form of questions. The first question concerns whether or not the stimulus (S_X) is paired with other reinforcing stimuli. If the answer is yes to this question, a value of p is set which is positive. A negative value is set if the answer is no. The negative value is symbolized by p'. This portion of the model is shown in Figure 9.

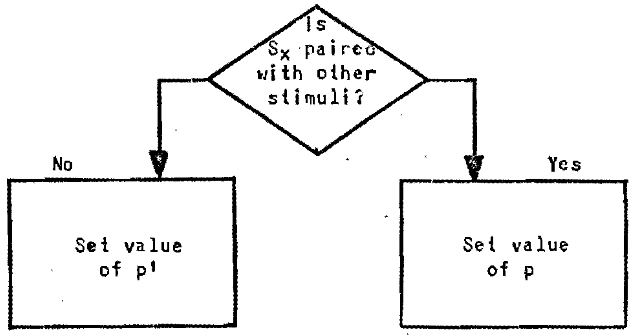


Figure 9. The decision symbol illustrates the values being set depending on whether the stimulus is paired with other stimuli.

The above question is used to determine the neutrality of stimulus (S_x). It is assumed to be a novel stimulus because it is neutral and has had no predecessor in the organism's learning history. It has not been exposed to the organism's repertoire of behavior. This question helps to determine another aspect which could facilitate the success of the communication and determine the state of the organism based on the learning history. The answer to this question will either have a positive or negative influence on the value to be compared to the stimulus threshold.

The next question to be considered concerns whether or not the stimulus (S_x) is reinforced. The process of discrimination or discrimination training is related to this question. When an organism is subjected to a variety of stimuli, it is possible to isolate one stimulus through reinforcement. That is, by differentially reinforcing the stimulus, it comes to be discriminatory for the organism. In a learning situation once the stimulus is reinforced, then any responding by the organism immediately following the reinforcing of the stimulus can also be reinforced. In much broader terms concerning communication it is not difficult to see that some stimuli have a greater value for an organism to respond than others. As before, a yes answer leads to a positive value being set and a negative value is established when a no answer occurs.

Another question that is related to the occurrence of a yes answer in the previous secondary variable concerns the immediacy of reinforcement. In other words, is the reinforcement presented immediately after stimulus presentation? If a reinforcement does not occur until minutes after the stimulus presentation, then the likelihood of that reinforcement causing the stimulus to be discriminatory is assumed to be slight. On the other hand, if the reinforcement closely follows the presentation of the stimulus, then the probability of that stimulus becoming discriminatory is assumed to be high. If a reinforcer closely follows the stimulus presentation, then the previously established positive value "u" is multiplied by a constant called a "now constant." This will result in a value that increases "u". When the reinforcer does not closely follow the presentation of a stimulus, the positive value "u" is multiplied by a "latter constant" resulting in a decrease in the value of "u". The above questions are illustrated in Figure 10.

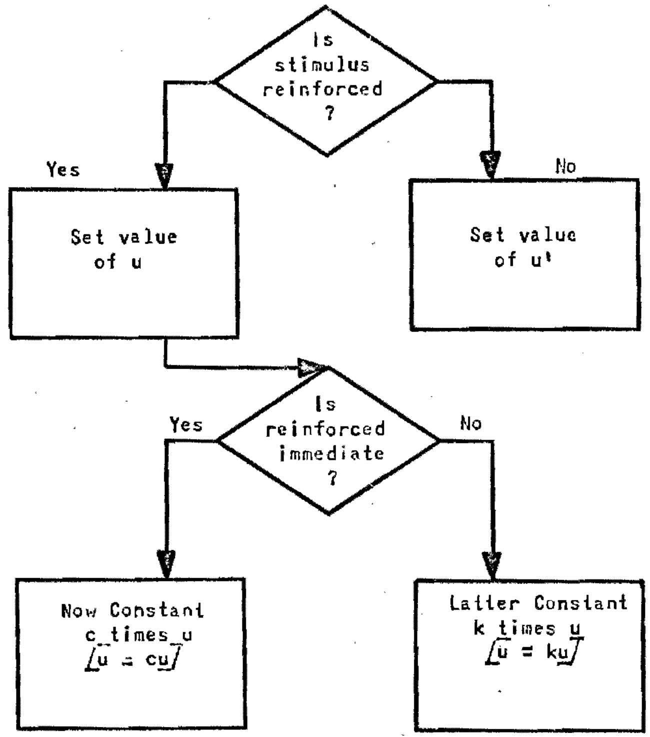


Figure 10. These two decision flowchart symbols illustrate the reinforcement and the immediacy of reinforcement of the stimulus.

The above procedure of multiplying some variable (u) by another value (c) and having it equal to the original variable (u) is a technique used in computer programming. In both cases (ku and cu), the initial value of u is the same. However, when the multiplication of the constant takes place, the value of u will be either larger or smaller than the original u depending on the value of the constant.

The final steps in the sequence of operations concerning the primary variable, stimulus, involve summing the positive values and the negative values. These two totals are then added together giving an algebraic sum. This value is then compared to the stimulus threshold value established earlier in the operation. If the algebraic sum is greater than the value of the stimulus threshold, the sequence continues on to the next primary variable. If the sum is equal to or less than the threshold value, the process will begin again with the same stimulus or a different stimulus. The final steps are shown in Figure 11.

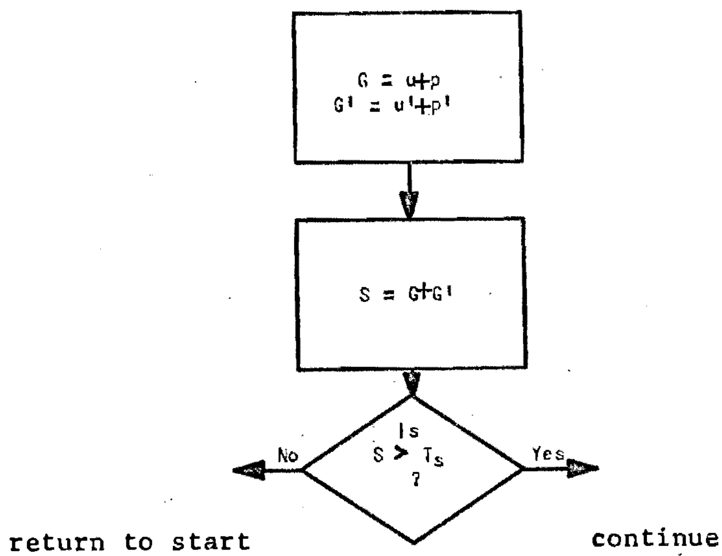


Figure 11. The final steps in the operation of the model concerning the primary variable, stimulus.

The next primary variable is the response. The procedure is basically the same with some of the same questions being asked. Those questions are asked which influence the final value to be compared to the value of the response threshold. The sequence begins by setting the response threshold (T_r) (Figure 12).

Figure 12. The flowchart symbol with the instruction to set the response threshold, T_r.

The first two questions are concerned with the immediacy of the response and the difficulty of emitting the response. To begin with, is the response to be immediately emitted after the presentation of the stimulus? The purpose of this question is to differentiate between the situation where an organism after sensing an environmental event emits a response or the case where the emission of the response occurs a few minutes, hours, or even days later. For example, when an individual is a member of an audience listening to a talk which advocates signing a petition or giving money to a particular cause, the probability of this type of response is greater than the case where the audience is asked to vote on a certain issue days or even weeks later. Thus, the response that is to occur closely following the presentation of the stimulus has a greater probability of occurring.

If this response is relatively simple to emit then its likelihood of occurring is greater than the instance where the organism is required to perform a complex task. For example, a speaker may desire his audience to simply sign a petition, or write a letter to a congressman, or possibly march down to city hall. Each of these responses is a bit more difficult to emit than the previous one. The chance of the simplest response occurring has a greater probability than the more difficult ones. These questions concerning the immediacy and the difficulty of the response are illustrated in Figure 13.

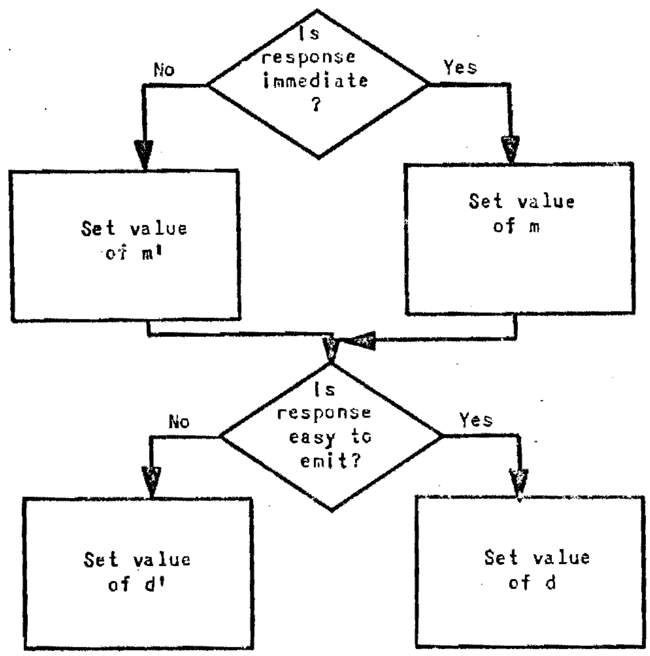


Figure 13. The steps illustrating the concepts concerned with the immediacy and ease of emission of the response.

Concerning this last question, there may be a case where the response is not in the organism's repertoire of behavior. The individual must learn the response and if this does not occur, the communication will not be effective. The communication will not occur until the response becomes part of the repertoire of the organism.

The next two questions are similar to the last two concerning the primary variable, stimulus. Is the response reinforced? Is the response reinforced immediately after it is emitted? Again, as before, the "now constant" and the "latter constant" are used to increase or decrease, respectively, the value associated with the reinforcement of the primary variable (Figure 14). The purpose of these questions should be clear at this point. The more immediate the reinforcement, the greater the probability the response will occur again in the future, since it is the consequences that follow certain behavior which influence its later occurrence.

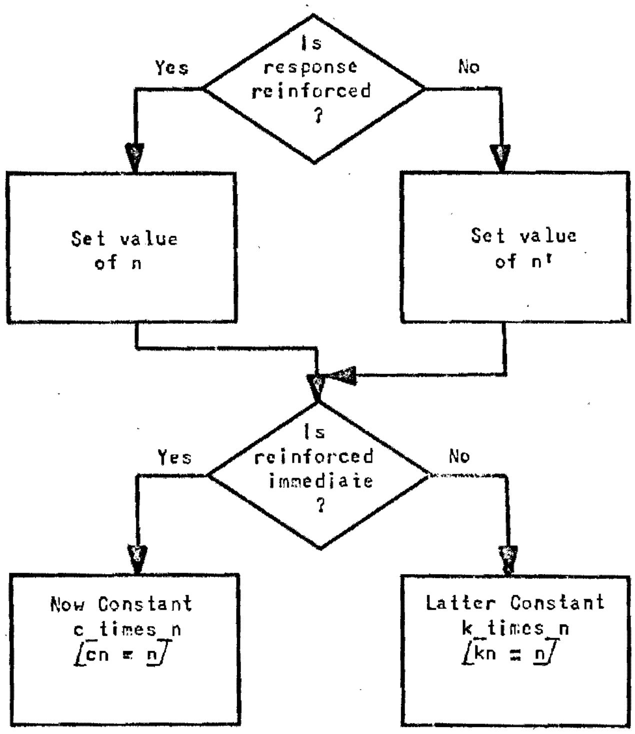


Figure 14. These two decision flowchart symbols illustrate the reinforcement and the immediacy of reinforcement of the response.

The positive values and the negative values are summed. This gives an algebraic sum which is compared to the value of the response threshold. Since this procedure is also similar to what occurred with regard to the stimulus, no additional explanation is necessary. This sequence is shown in Figure 15.

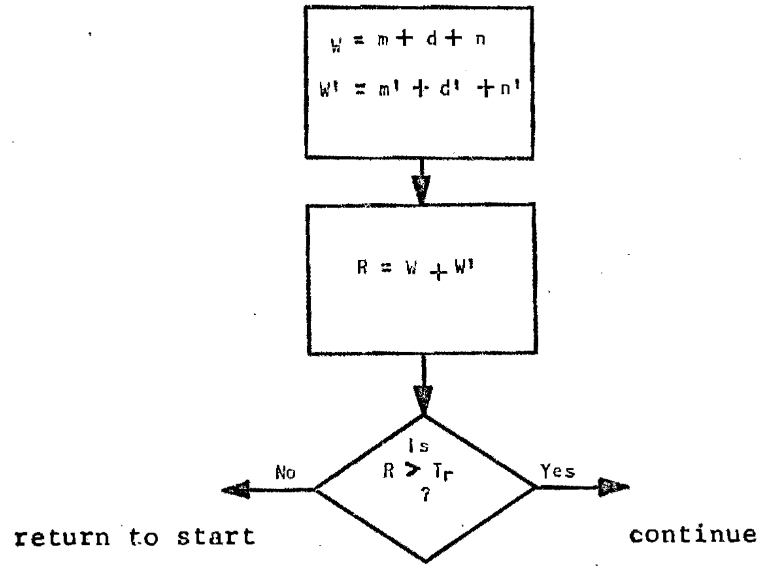


Figure 15. The final steps in the operation of the model concerning the primary variable, response.

If the compared values in the case of the primary variables, stimulus and response, are greater than the respective threshold values, the process will continue to the final steps in the sequence. This concerns the response strength. This involves two simple operations. The first is to take the two compared values ("S" and "R") and add them together. Once they have been added, a constant (q) could be used--such as 0.10, 0.01, or 0.001--to multiply the total by to give a resulting value in the probability form. And this would provide a value called strength of response. This is illustrated in Figure 16.

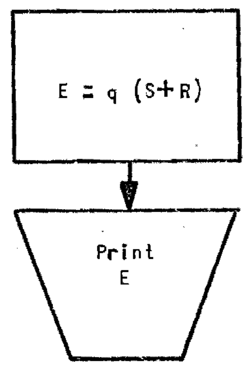


Figure 16. The final steps in the model that allow the derivation of the response strength, E.

This computer model is based on the principles of both classical and operant conditioning. The primary variables are the stimulus and the response. The secondary variables are questions which, in a sense, help to investigate the state of the primary variables concerning the organism. Based on the answers to these questions positive and negative values are established. The positive values increase the probability of a successful communication, whereas, the negative values decrease the probability. The values established in the model are compared with a threshold value. If the algebraic sum of these values is greater than the threshold value, the sequence continues to the final steps which lead to a value termed the strength of the response. The model as developed to this point is shown in Figure 17. Table I is provided to indicate and define various designations used in the model.

TABLE I

THE LETTERS AND THEIR PURPOSE FOR THE MODEL

Letter	Purpose
S_x	To designate the particular stimulus being placed into the model.
T_s	The value of the stimulus threshold.
p and p'	The positive and negative indicators, respectively, of whether the stimulus is paired with other reinforcing stimuli.
u and u'	The positive and negative indicators, respectively, of whether the stimulus is reinforced.
c	To indicate the fact that the reinforcement was immediate.
k	To designate that reinforcement was not immediate.
G and G'	The positive and negative sum of the positive and negative indicators, respectively, concerned with the stimulus.
S	The algebraic sum of G and G'.
T_r	The value of the response threshold.
m and m'	The positive and negative indicators, respectively, concerned with the immediacy of the response.
d and d'	The positive and negative indicators, respectively, of the ease of emitting the response.
n and n'	The positive and negative indicators, respectively, of whether the response was reinforced.
W and W'	The positive and negative sum of the positive and negative indicators, respectively, concerned with the response.
R	The algebraic sum of W and W'.
E	To indicate the value of the response strength.
q	To designate that a function of S plus R is equal to the strength of response, E.

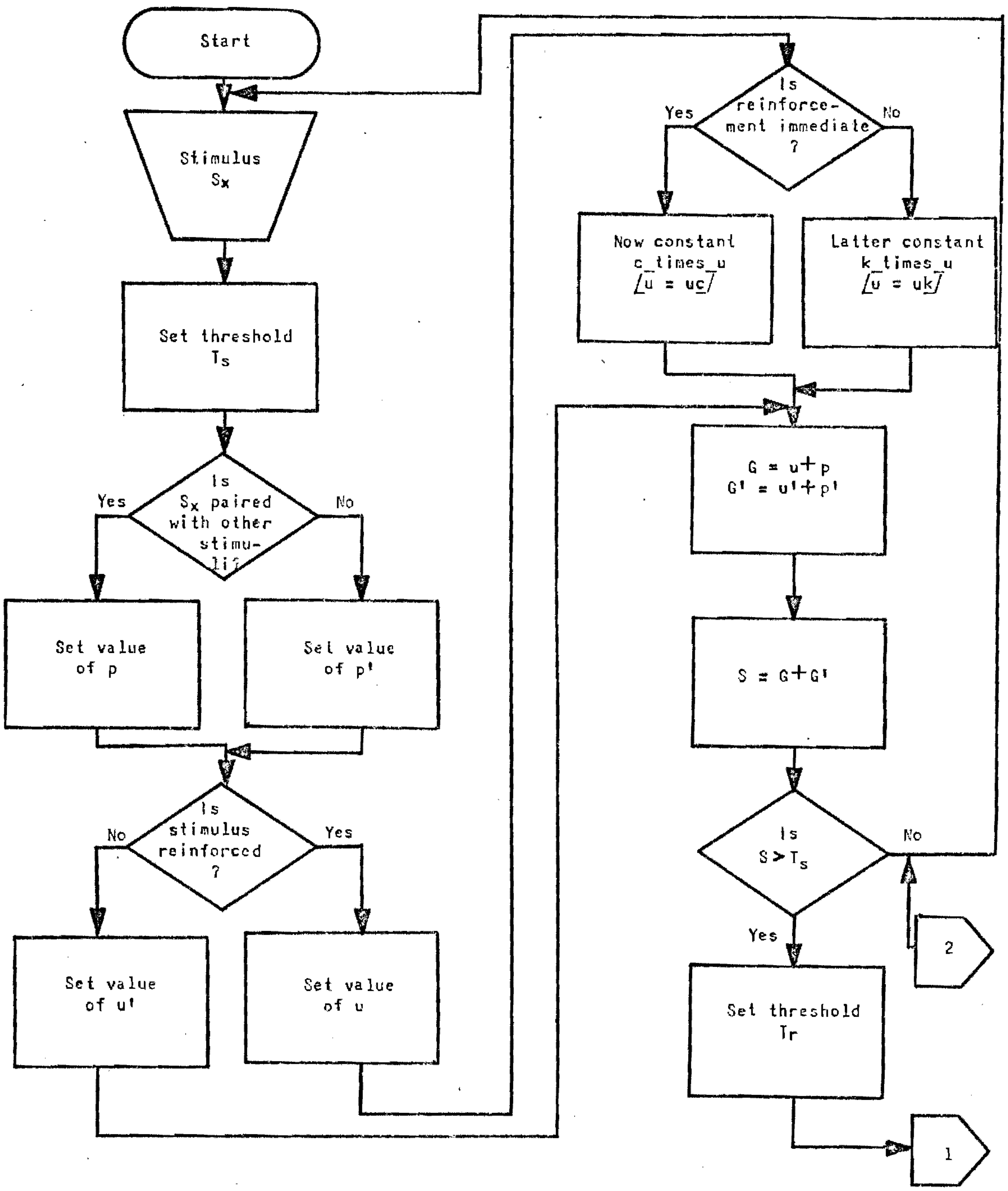


Figure 17. The entire model is illustrated with its components and the relationships among the components.

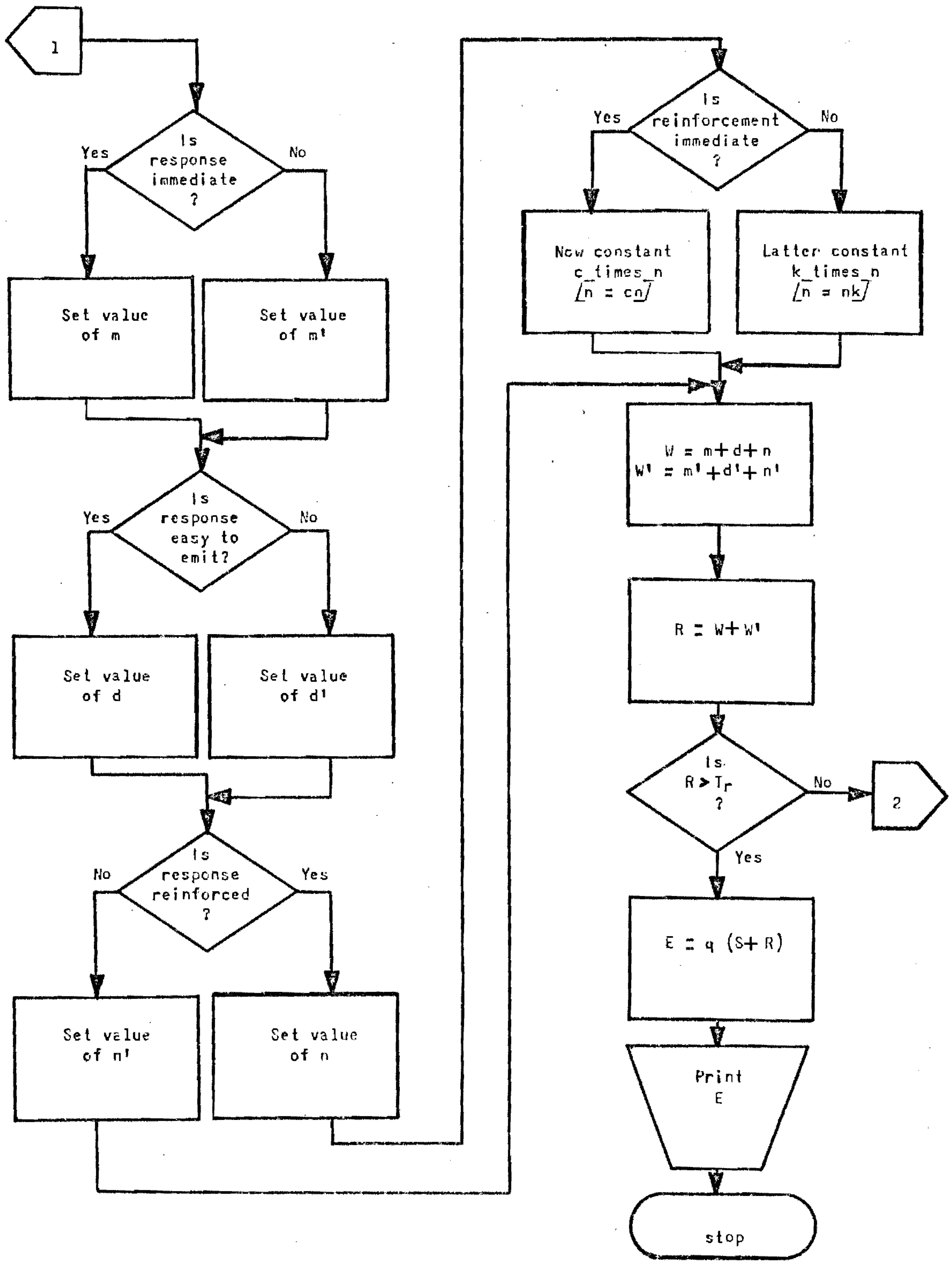


Figure 17 (cont.)

II. PROBLEMS IN THE DEVELOPMENT OF THE MODEL

In Chapter II it was pointed out that the process of abstraction is an important feature of model building. That is, the correct selection of the components and the relationship among the components is as important as the rejection of certain elements not relevant to the particular model. In the case of the model just proposed, there are problems that make the final selection of the elements and their relationships a difficult task. It is the purpose of this section to discuss and attempt to resolve these problems, at least, as they may influence the model.

The first problem to be considered is that of attention or more specifically the attending response. It is ignored by many psychologists and D. E. Berlyne (1951) suggests that this should be dealt with by behavior theorists. There are only a few scholars who have concerned themselves with attention. J. G. Holland (1958) found that the detection of signals during monotonous tasks serve as reinforcement for observing responses. L. B. Wyckoff, Jr. (1952) and A. W. Staats and C. K. Staats (1963) indicate that attention is important and subject to the same rules that control other behavior. A threshold is considered in a discussion of attention by Berlyne (1951), but he stipulates that the factors influencing attention are features of the stimulus itself. Each of the above sources is concerned with only observing type response where an individual visually focuses on features of the stimulus pattern. Of primary interest here is attention dealing with all the senses of an organism.

In the early stages of development of the model attending behavior was defined as the class of responses that make possible the detection of the stimulus out of the whole mass of stimuli that are present. While similar to the concept of discrimination this behavior was considered different because of an interest in a general response class which makes possible the detection of a stimulus. Attending behavior was then operationally defined as a change in the pattern of observable behavior. The example considered for this went as follows: When a man is sitting in his easy chair reading the newspaper or watching the television and a fire engine goes by the house with its siren blaring, the change in the pattern of his behavior was considered attending behavior. The man might have gotten up and looked out his window, simply cocked his head, or made some comment to his wife. This concept of attending behavior was represented in the model.

Attending behavior was handled in much the same manner as the response sequence in the previous section. The sequence of steps involved with attention followed the stimulus (S_x) input step. It began with the establishment of a threshold value for attending behavior. This was followed by several secondary variables in the form of questions. Is attending behavior exhibited? Is attending behavior easy to exhibit? Is attending behavior reinforced? Is the reinforcement of attending behavior reinforced immediately following its occurrence? Positive values and negative values--associated with yes and no answers, respectively--were added to give an algebraic sum. This value was then compared to the threshold value. Table II is provided to indicate and define designations used for the attending

TABLE II

THE LETTERS AND THEIR PURPOSE FOR THE ATTENDING BEHAVIOR SEQUENCE

Letters	Purpose
a and a'	To designate positive and negative indicators, respectively, of whether attending behavior was exhibited.
e and e'	The positive and negative indicators, respectively, of the ease of emitting attending behavior.
b and b'	The positive and negative indicators, respectively, of whether the attending behavior was reinforced.
B and B'	The positive and negative sums of the positive and negative indicators, respectively, concerned with attending behavior.
A	To designate the algebraic sum of B and B'.
T_a	The value of the threshold of the attending behavior.

behavior sequence. The steps concerned with attending behavior are illustrated in Figure 18.

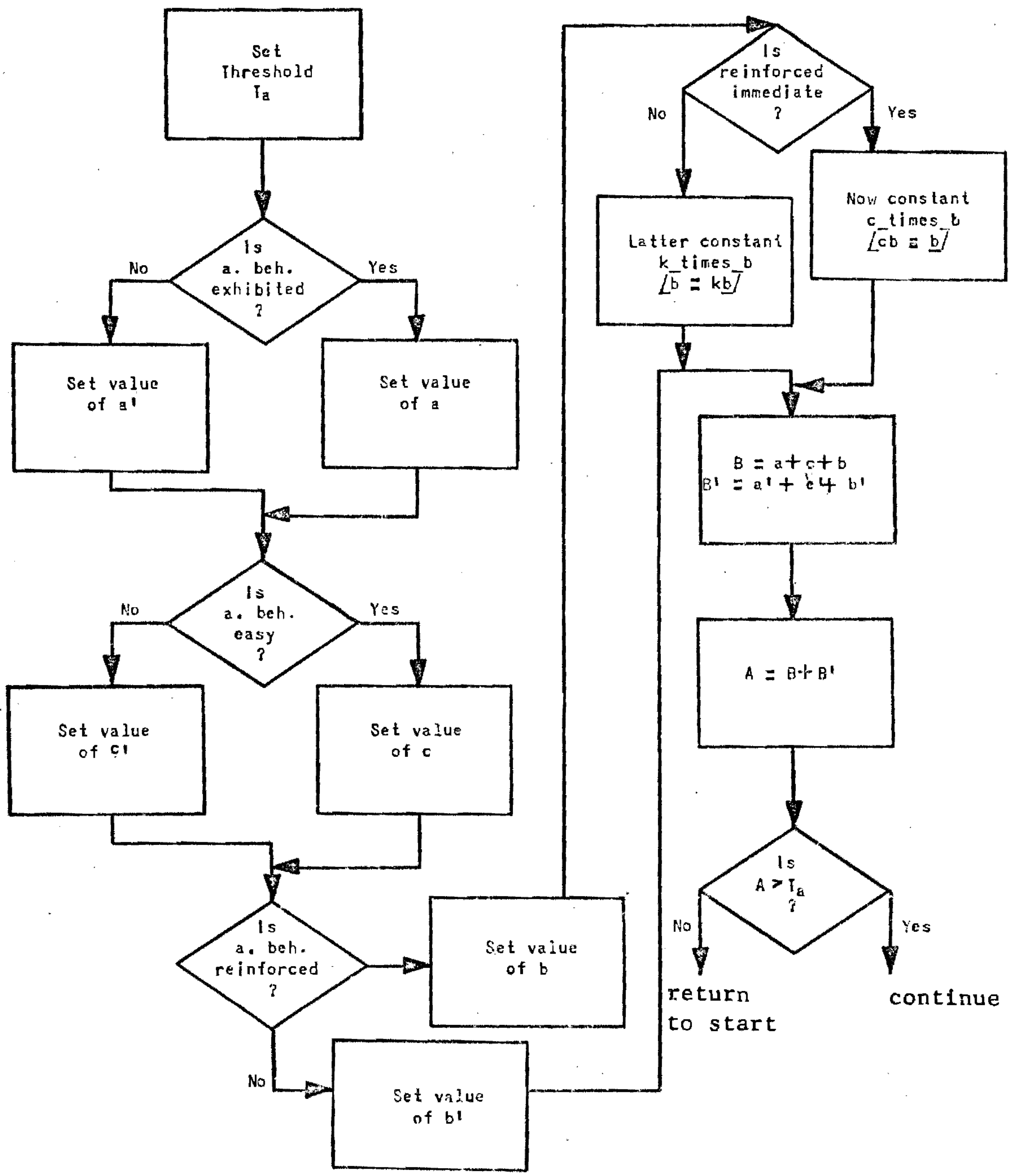


Figure 18. The sequence of attending behavior is illustrated.

This definition and explanation of attending behavior represented above was not sufficient, because the best description of such an episode suggested by the example was that the stimulus was the sound of the siren and his behavior was emitted as a result of the stimulus.

While the concept of attention has not been dealt with extensively in the past by experimentalists, some modern theorists, such as C. L. Hull, K. W. Spence, E. R. Guthrie, and B. F. Skinner, have discussed the problem of attention. They realized that the occurrence of a certain stimulus was not a reliable predictor of a given response. Consequently, the problem of attention was a major hurdle in the analysis of many empirical findings. H. S. Terrace (1966) adds

> It should be especially noted that describing an unreliable relationship between the controlling properties of a stimulus and a response as attention is a different matter from explaining the complete or partial absence of stimulus control. The use of attention as an explanatory principle in these instances is begging the question, and seems to be nothing more than a mask for our ignorance concerning the establishment of stimulus control (p. 289).

One answer to this dilemma may be offered by L. B. Wyckoff (1952) who postulated an intervening response. He labelled this response an "observing response" and indicated that it was a necessary condition for a stimulus, or certain features of the stimulus, to gain control over a response. The use of the term observing response does not seem to assist in solving the problem. It is just another label. The point of significance is that the observing response is related to the stimulus features.

Remembering that Berlyne (1951) suggests that the factors influencing attention are features of the stimulus, itself, the answer to this problem seems to lie in the concept of stimulus control.

> Stimulus control refers to the extent to which the value of an antecedent stimulus determines the probability of occurrence of a conditioned response. It is measured as a change in response probability that results from a change in stimulus value. The greater the change in response probability, the greater the degree of stimulus control... (Terrace, 1966, p. 271).

The concept of attention is sometimes used in cases where the stimulus does not control a response. In other words, when there are failures to establish stimulus control, these instances are said to be failures in attention. Thus, in these cases attention and stimulus control are synonymous.

Based on the point made by Berlyne where attending behavior is a feature of the stimulus, the argument in favor of the concept stimulus control by Terrace (1966) is more satisfactory for the purposes of this model. This concept is to be included in the model and is shown in Figure 19.

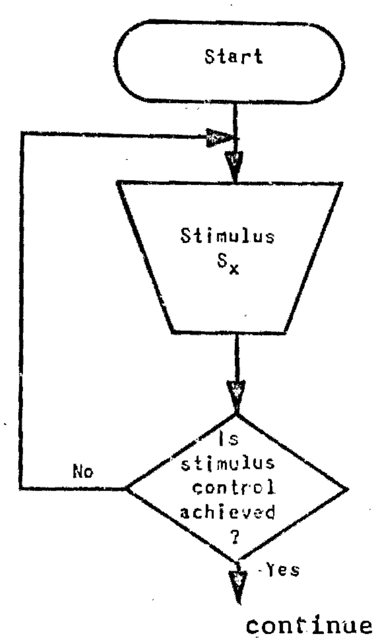


Figure 19. The component of stimulus control is shown with the relationship it will assume in the model.

The reason for this arrangement is due to the idea that unless stimulus control is achieved the learning process will not continue. Bearing in mind, also, the lack of attention has been associated with failure to learn conditioned behavior. Therefore, concerning communication, to reach the desired response, stimulus control must be obtained. In an example of an editorial writer, the stimulus (the article) must be read before any response can be expected to be emitted. While the problem of attention has not been resolved, the model seems more complete by including the element of stimulus control.

The next problem is concerned with the response class called <u>resistive behavior</u>. When first gathering theoretical information to incorporate in the model, an article was read summarizing some of the postulates of learning theory that could be considered in the study of communication theory. According to F. R. Hartman (1969) resistive behavior to a particular stimulus takes several forms, such as "attacking it, competing with it, or avoiding it" (p. 276). This type of behavior could be of value to the study of communication behavior.

As in the case of attending behavior, a sequence is included in one of the original formulations of the model. A threshold of resistive behavior is included, as well as one question to determine whether or not this type of behavior is exhibited. The value associated with the answer is then compared to the threshold. These steps follow the portion of the model concerning the stimulus and are illustrated in Figure 20. Table III is provided to indicate and define various designations used for the resistive behavior sequence.

TABLE III

THE LETTERS AND THEIR PURPOSE FOR THE RESISTIVE BEHAVIOR SEQUENCE

Letter	Purpose
T_h	The value of the threshold of resistive behavior.
v and v'	The positive and negative indicators, respectively, of whether resistive behavior was exhibited.
V	The algebraic sum of v and v'.

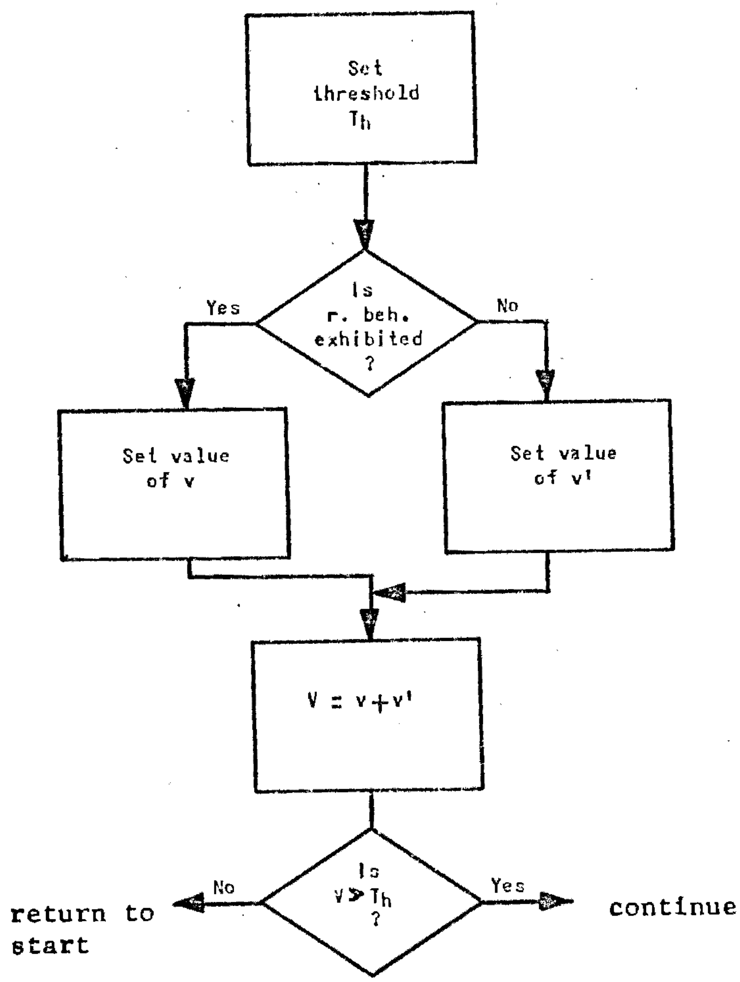


Figure 20. The sequence of resistive behavior is illustrated.

According to the above, resistive behavior does influence the final value of the response strength.

For purposes of this study, however, resistive behavior is not included. Based on the definition of communication where it is the intent of the source to elicit a specific observable and measurable response, then resistive behavior would include those responses that are not the intent of the source to elicit. In the case of the editorial writer who desires his readers to write a letter to a certain governmental agency in support of his position, then any other behavior is not what the writer desires. The reader may simply just read the article, but the reader could also write a letter to the agency which is not in favor of the writer's position. The reader may even write a critical letter to the writer. These suggested behaviors, while not exhaustive of the possible behaviors that could be performed by the reader, could be viewed as resistive behavior.

While not all behavior is resistive behavior, resistive behavior is a part of those behaviors the source does not desire to elicit. In the model this type of behavior will be considered as an opposing influence to the value of the response strength. That is, it would decrease the probability of responding in a given way. If the probability of a particular response class is one tenth (0.1), then all other responses in an organism's repertoire of behavior would be included in the remaining nine tenths (0.9). Resistive behavior would also be a part of the remaining probability. Therefore, resistive behavior is not to be considered in the model.

The third problem concerns threshold values. Should threshold values remain constant or fluctuate for different trials of the model? Or do thresholds vary in real life circumstances? Concerning the case where food is a stimulus, the stimulus threshold would seem to raise and lower depending on the time of day, on the previous meal, or even on the type of food. Since, for most individuals, some foods are more preferable and times of day are more desirable for eating, it can be said that the threshold would fluctuate in value. This could also be true of the response threshold. After several trials, the respondent may become bored, exhausted, or full in the case of eating. Thus, thresholds are to vary in value. It is a relatively simple task to include this characteristic of thresholds in a computer model.

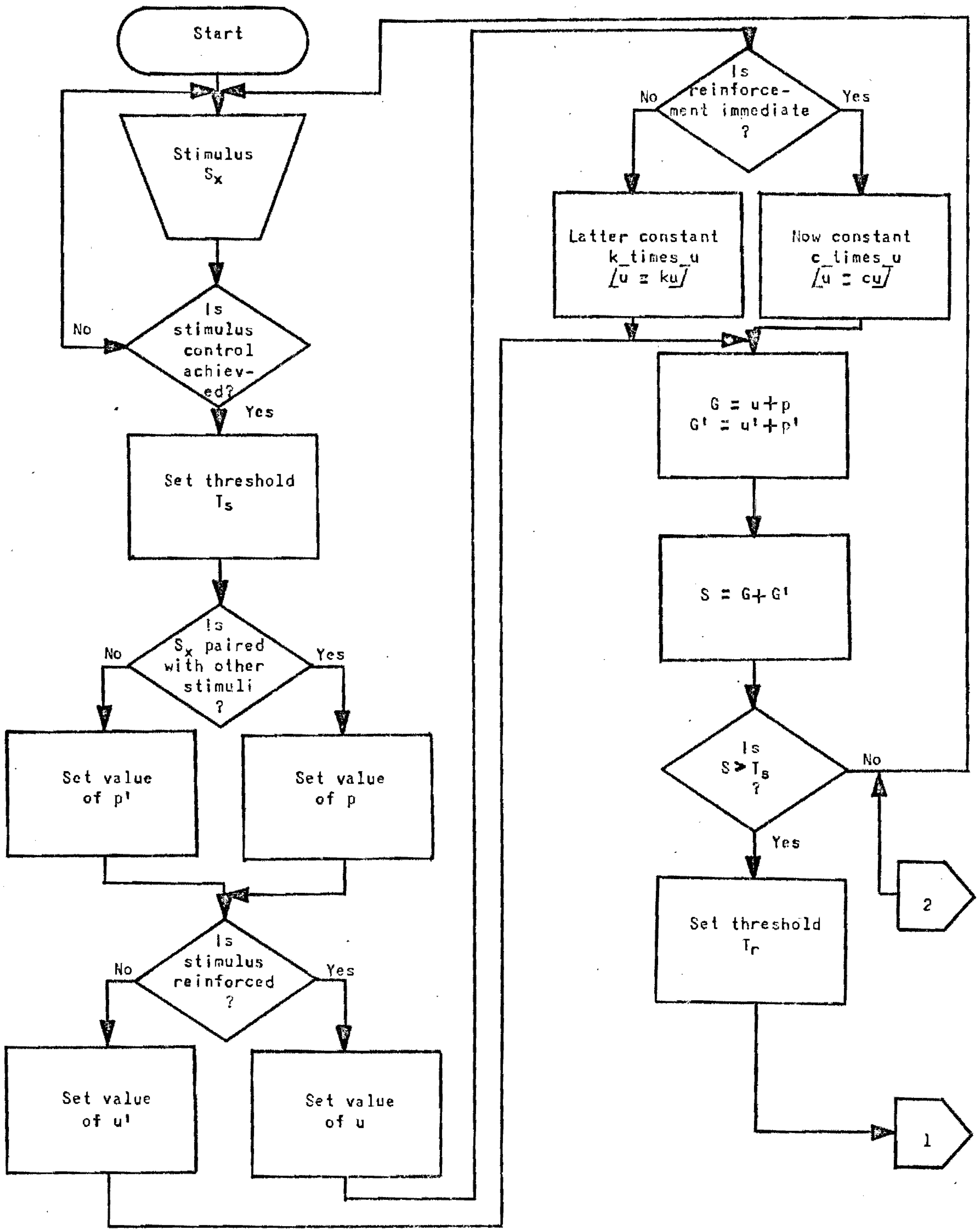
The next problem to consider in the development of the model is whether or not the stimulus should have a numerical value. In the present configuration of the model there is no value assigned to the stimulus (S_x). Just as some food is more preferable to an individual, it would seem that various stimuli would have various values to an organism. For example, usually, for the music-lover not all types of music are equally pleasing. The different types of music could be given a numerical score indicating the preference one kind of music would have over another. It would appear that a solution to this problem is rather simple.

However, since the threshold values of the stimulus will fluctuate, any stimulus value will be reflected in the value of the stimulus threshold. If one stimulus is preferable, then the threshold will be small in value. On the other hand, for a stimulus that is not so desirable, a larger value will be assigned to the threshold. A small value of the stimulus threshold will allow the elicitation or the establishment of the S-R mechanism to be much easier, while an undesirable stimulus with a larger value will cause the establishment or elicitation of the S-R mechanism to be more difficult. Based on this reasoning the value of the stimulus will be reflected in the threshold value of the stimulus.

The final problem concerns the relationship among the elements of the model. More specifically, should the process continue to the final step of printing the response strength (E) on every trial rather than returning to the beginning when a threshold value is equal to or greater than the value it is compared to? If the process did continue, it could provide the source with useful information concerning the communication. This would not represent reality. The theory of conditioning expresses reality and the theory is represented in the elements and the relationship among the elements of the model. Since the model is based on the principles of conditioning, it closely follows the definition of communication by Staats and Staats (1963). If the source does not elicit or establish the S-R mechanism in the intended receiver, the communication does not take place. This does not mean that the process continues to the final stages. The source is not provided with information concerning how much more reinforcement, stimulus control, etc., is needed to bring about the desired response. The process is halted as the receiver behaves in a manner not desired by the source. Thus, the model will continue to have the existing relationship among the variables and the process will not continue to the final stages on every trial.

Based on the concern for reality, the relationship among the variables of the model is unchanged. The threshold values can vary, because they reflect the state of the organism toward the variables included in the model. The fluctuation of the stimulus threshold value, also, reflects the status of the various potential stimuli for the individual at any given moment. Resistive behavior, while possibly an important factor in communication, is to be included in those behaviors that the source does not intend to elicit or establish.

Attention or attending behavior is not included in the model. Stimulus control is incorporated into the model in the place of attending behavior. Each of these problems is important to the development of a good model. The revised model is shown in Figure 21.



<u>Figure</u> <u>21</u>. The revised model is illustrated with its components and the relationships among the components.

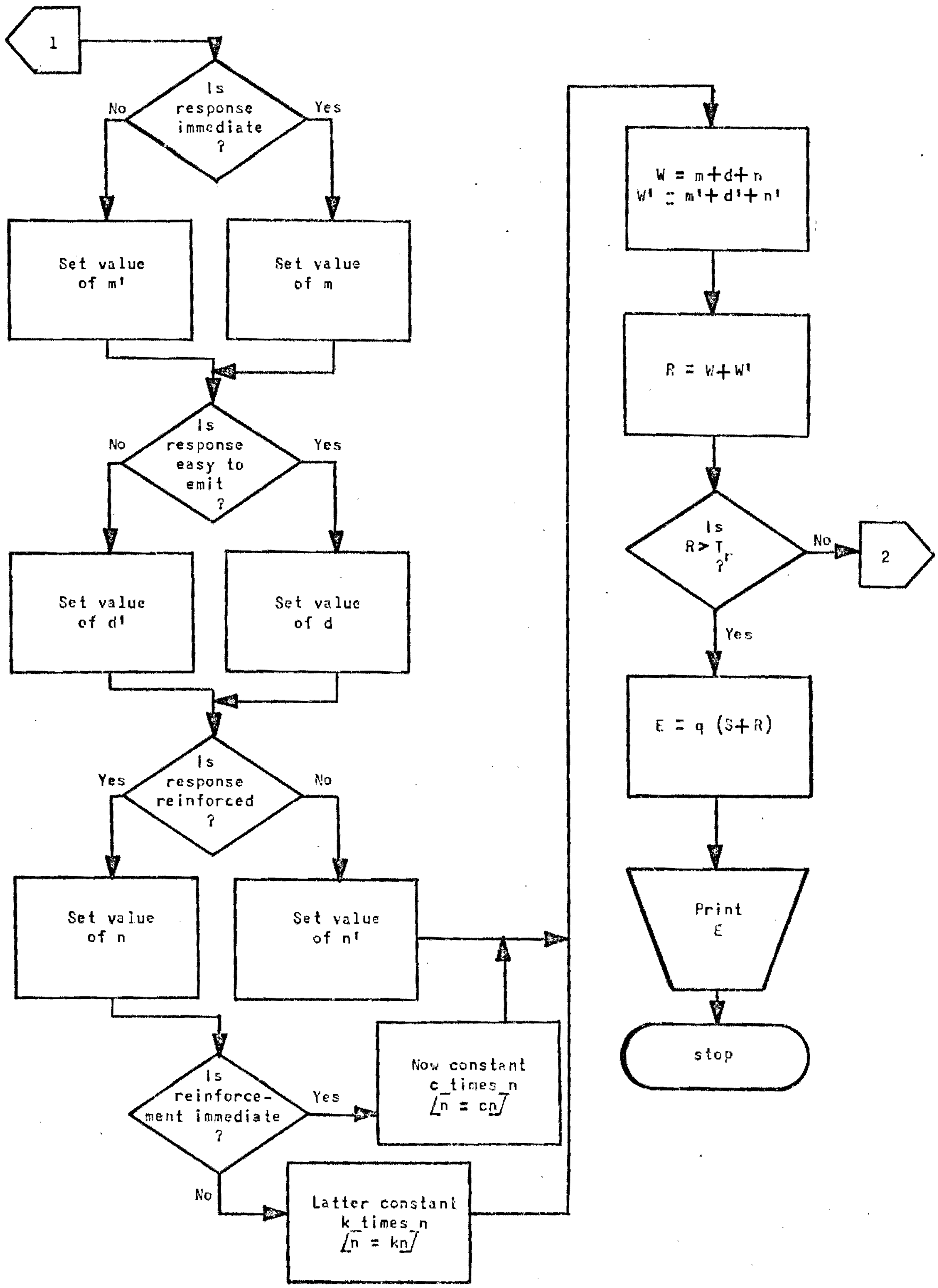


Figure 21 (cont.)

CHAPTER V

THE EXPERIMENT

It is the purpose of this chapter to describe the experiment. The following areas facilitate a description: the subject, the physical environment, the equipment, the reinforcers, the stimulus events, the response events, the procedure, and the limitations.

I. THE SUBJECT

The subject selected for participation in the study was a seven-year-old boy with normal hearing (see Appendix D) and apparently normal intellectual functions. He could follow directions. Probably the most important reason for the subject's selection was that he was naive to the experimental manipulanda, as well as the theory and practice of conditioning.

II. THE PHYSICAL ENVIRONMENT

The experiment was held in a small therapy room approximately 10 feet by 10 feet, that was relatively free of distractions. The room contained a table and four chairs, one at the front of the booth for the subject, one at the experimenter's position, and two others along the wall behind the subject. On the table were a portable audiometer and an experimental booth (Appendix E).

III. THE EQUIPMENT

The instrument used to present the stimulus was the MAICO Model

MA-16. This diagnostic audiometer was a small, light, all-transistor, portable instrument with eleven air conduction and eight bone conduction test frequencies. This instrument was calibrated to meet the requirements of the U. S. Standards Institute. The MAICO audiometer was recalibrated on July 31, 1970, and a -5 decibels (abbreviated db) correction factor was necessary when using the right earphone at 250 cycles. The accessory equipment was located in a small storage compartment and included 1) a double headset with cord, 2) a bone conduction vibrator with cord and headband, and 3) a three-wire power cord with adapter plug. The headset was color coded so that the right earphone with a red band around it could be distinguished from the left earphone. The audiometer was placed to the left of the experimental booth on the table facing the experimenter (Appendix E).

The wood constructed, experimental booth consisted of the following: 1) an open window for the experimenter; 2) a bank of five lights; 3) a Gerbands four pen recorder with a paper speed of six (6) centimeters per minute; 4) a universal bucket dispenser with seventy buckets (Appendix C); 5) an overhead light for illuminating the face of the experimenter; 6) a receptacle tray and dispensing tube assembly; and 7) a console at the experimenter's position for operating stimulus events within the booth (see Appendix C) (J. F. Maurer, 1968).

The separate toggle switches (a, b, c, d, and e) on the console (7) operated each of the lights in the bank of light (2) within the booth. The bank of lights consisted of four yellow lights and a red light at the top. Each of the yellow lights was wired in series with the first recording pen on the event recorder (3). The second pen and the universal bucket dispenser (4) were controlled by the toggle switch (e) which illuminates the red light. The third pen was controlled by the stimulus toggle switch (stim). The response toggle switch (ur) operated the fourth pen on the event recorder.

Although only three recording pens were used, three different colors of ink were used in the pens on the event recorder to assist in the interpretation of data. Green and red ink were used in the second and third pens, respectively, while black was used in the fourth recording pen. The first pen was not used.

A stop watch was taped to the experimental booth in front of the experimenter to the side of the open window (1). This watch was used to time each experimental period in the therapy room.

IV. THE REINFORCERS

Marbles were used as tokens. Once a number of marbles had been collected by the subject, he could exchange the marbles for a toy or an edible. This exchange only occurred after the experimental period and the prizes had to be set aside until the final experimental period of the day had been completed. The selection of toys and edibles was made after an interview with the mother of the subject.

At the beginning of each day the toys and edibles were displayed for the subject. When he took his chair for the experimental period, the subject could not see the prizes.

The toys included various types of masks and figurines, as well as small planes and Matchbox cars and trucks. The edibles included small bags of peanuts and Cheese Snaps. Instructions were read to the subject at the beginning of each day which included the number of marbles required to earn for each toy and each edible.

While no words were exchanged between the subject and the experimenter during the experimental periods, there were numerous conversations that occurred at other times. Although this aspect must be considered as a function of the reinforcing program, it is impossible to measure its overall influence upon the conditioning program.

V. STIMULUS EVENTS

Since a stimulus is defined as an environmental event which an individual is capable of sensing, the stimulus selected for the experiment came within the general definition. The stimulus event was the presentation of the puretone from the MAICO Model MA-16 to the subject. The selection of the particular level and magnitude of the tone was made after a hearing test had been administered to the subject by the graduate intern in Audiology at Portland State University (Appendix D). The tone selected was for the right ear at 250 cycles with a hearing level of 20 decibels (corrected to 15 db). This tone was used throughout the conditioning program. The third pen on the event recorder was used to record the presentation of the stimulus.

VI. RESPONSE EVENTS

Since a response is defined as a behavioral event that is observable and measurable and elicited as a result of a stimulus, the response selected in the study came within the general definition.

The response was operationally defined as the subject turning his head to the left. It was necessary to be more exacting by specifically indicating the coordinates of turning the head to the left. This was accomplished by placing a small piece of masking tape on the left earphone.[3] The size of the tape was 1/4 inch by 1/8 inch and placed on the foam rubber cushion 5/8 inch from the edge of the rubber. Figure 22 shows the position of the tape on the headphone.

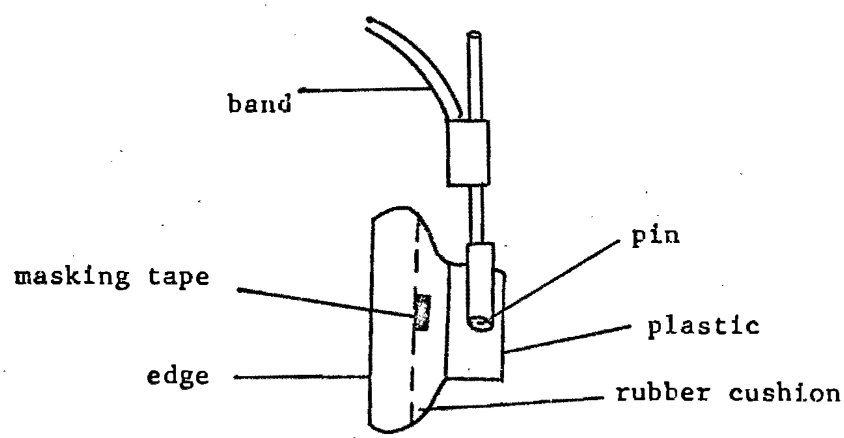


Figure 22. The experimenter's view of the masking tape and its location on the left headphone.

When the lateral movement of the subject's head to the left caused the tape to disappear from the experimenter's view and then reappear by a right lateral movement, this was considered one response event. The fourth recording pen was used to record the response event.

VII. THE PROCEDURE

The experiment consisted of three parts. The first included the

[3]A similar piece of tape was placed in the same relative position on the right earphone during the baseline periods.

baseline periods and the second was made up of the conditioning periods. The last part of the study involved the extinction period. The procedure in each of these parts was generally different for each one, but there were several steps that were included in more than one part of the study.

At the beginning of each day of the experiment, instructions were read by the experimenter to the subject. There were two different instructions used; one set was for the baseline periods (see Appendix F) and the other was for the conditioning periods (see Appendix G). Occasionally, the experimenter read the instructions prior to the beginning of either the third or fourth period of a day. Also, at the beginning of each day of the conditioning periods, the prizes were set out along the back wall for the subject to view when the instructions were read.

During every period of the study the subject was seated in the chair in front of the experimental booth, then the headphones connected to the audiometer were placed over his ears. When he was seemingly comfortable, the experimenter took his position in the chair in front of the console. Each period was approximately ten minutes in duration.

The first six periods consisted of the baseline periods. On the first day three practice periods were held. This was to familiarize the subject with the laboratory environment. One problem that was overcome as a result of this day was the size and location of the masking tape placed on the headphones. It was necessary to change the location and reduce the size of the tape for the remaining periods in the study.

During these six periods, the stimulus was presented to the subject, approximately every 15 seconds. The stimulus was held for about 2 to 3 seconds. The stimulus events were recorded, as well as the turning of the head to the left. One other response was also recorded during these baseline periods--the turning of the head to the right.

The first conditioning period was the fourth period of the second day. This period consisted of reinforcing the stimulus. In other words, the stimulus was presented and the dispensing of a token immediately followed. The stimulus was presented every 15 seconds and held for about 2 to 3 seconds. The stimulus events and the dispensing of the tokens were recorded on the event recorder. This concluded the periods of the day.

The next part of the study concerned differentially reinforcing successive approximations to the final response. During the four periods that occurred on the third day, the stimulus was presented and any response where the subject moved his head to the left was reinforced with a token. That is, any successive approximation of turning the head to the left was reinforced, but this required each response to be closer than the previous one to the final response. Since the reinforcing dispenser was on the right side of the experimental booth, initially any movement to the front was reinforced. The stimulus during the four periods of the third day was presented only when the subject was faced to the front. The dispensing of tokens and the presentation of the stimulus were recorded.

On the fourth and fifth days the procedure was essentially the same as occurred on the third day. There were five experimental periods on the fourth day and three on the fifth day. Again the successive approximations to the final response were differentially reinforced. The reinforcers and the stimulus events were recorded on the event recorder. One thing different on these two days was that the stimulus was presented for about 2 to 3 seconds every 15 seconds. The occurrence of any response events was also recorded. The last period of the fourth day the subject was performing almost correctly. That is, he was presented with a tone and the lateral movement of the head to the left caused the tape to disappear and reappear. The response event was then reinforced.

On the sixth day there were three conditioning periods. The stimulus was presented and the subject would emit a response event. This was reinforced with a token. During these three periods the subject responded correctly. The occurrence of the stimulus events were at the same rate as in the previous period. The stimulus events, the response events, and the presentation of the tokens were recorded on the event recorder.

The final period of the sixth day involved the extinction procedure. That is, the stimulus was presented and the subject emitted a response event. But in this case the response event was not followed with a reinforcer. The correct responding extinguished after a short time. The stimulus presentation and the response events were recorded. This concluded the experiment.

VIII. LIMITATIONS

Most studies conducted in a laboratory are limited in their observations. The subject was placed in an unnatural environment. He was required to wear earphones and remain seated in front of the experimental booth which helped to draw attention to the equipment itself. Seating the subject restricted possible variation in movement if the subject would have been standing. The portable audiometer and the experimental booth served as silent participants to the experimental situation. Having the subject sit silently and giving him the opportunity to earn prizes were unnatural. The experimental setting placed the subject in these circumstances. However, it would not have been possible to control variables in field work to the degree that a controlled environment in a laboratory could.

This study is also limited in that only one subject was used in the experiment. Time was a limiting factor in this study, also, because the study was carried out for about an hour a day for seven days. A two day break occurred after the first four days due to Saturday and Sunday. Conclusions drawn by the writer from the results of the experiment will have these limitations in mind.

CHAPTER VI

RESULTS AND DISCUSSION

The purpose of this chapter is to present the data derived from the experiment as well as including discussions of these findings in light of the two questions introduced in Chapter I and with regard to the model itself. This chapter will include the following: the results and discussion of the experiment, a discussion of the model, and a discussion of the proposition and the related questions.

I. THE RESULTS AND DISCUSSION OF THE EXPERIMENT

Generally, the experiment accomplished what was proposed, since a new S-R mechanism was established. However, there were some problems and implications of this study that will be considered in the following discussion. The results of the study will be discussed with regard to the following: the stimulus events, the response events, and the successive approximations.

Table IV summarizes the data derived during the experiment. The first three periods include data obtained during the baseline periods. Periods number four through nineteen represent the data from the conditioning periods and the last period in the extinction period. In order to understand the data in Table IV, an explanation of several of the symbols is required. The Symbol "S_i" is used to indicate the number of stimulus events, while "S^{r+}" is the number of tokens dispensed. The number of correct responses of turning the head to the left and the number of responses of turning the head to the right are

TABLE IV

A SUMMARY OF DATA DERIVED FROM THE EXPERIMENT

Period No.	Time	S_i	S^{r+}	R_l	R_r
1	10:00	39	-	7	10
2	10:00	38	-	5	9
3	10:00	39	-	5	11
4	10:15	40	37	-	-
5	10:00	24	15	4	-
6	12:00	31	28	0	-
7	9:45	26	16	0	-
8	10:30	11	9	0	-
9	10:00	35	6	0	-
10	10:00	38	8	1	-
11	10:00	41	7	0	-
12	10:15	41	29	25	-
13	10:00	39	7	7	-
14	10:00	37	9	9	-
15	10:00	39	13	13	-
16	10:00	39	21	21	-
17	10:00	39	39	39	-
18	10:00	39	39	77	-
19	10:00	39	39	87	-
20	12:00	47	-	34	-
Total	204:45	719	321	334	30

represented by the symbols "R_l" and "R_r", respectively.

Stimulus Events

The stimulus events were the presentations of a puretone at 250 cycles to the right ear of the subject. The number of stimulus events per period, usually, ranged from thirty-five to forty-one. A total of 719 stimulus events occurred during the study. Generally, the stimulus was presented every 15 seconds for about two to three seconds. Throughout most of the experimental program the stimulus was presented at a 15 db hearing level.

However, during periods number four through eight, there were some exceptions. The first concerns the hearing level of the tone. During these periods the experimenter attempted to present the tone below the hearing threshold of the subject. In the beginning of these periods the stimulus was presented as follows: the first tone at 0 db, the second at 5 db, the third at 10 db, and the remainder at 15 db. Since the subject was asked to raise his hand only when he first heard the tone, it was assumed he would raise his hand at the 15 db level. The assumption was based on his hearing test (Appendix D). However, the subject would raise his hand either at a lower level of the tone or even when no tone was presented. This seemed to be due to the noise in adjacent rooms and in the hallway outside the therapy room. Consequently, throughout the remainder of the program the stimulus was presented only at the 15 db hearing level.

The second exception was concerned with the number of stimulus events for period five through eight. The experimenter only presented the tone when the subject was sitting in his chair with his body facing the front. As a result of period number four when the stimulus was reinforced, the subject turned his entire body to the right with a large amount of straying activity. The subject's straying activity consisted of looking at the reinforcing dispenser, glancing around the room, playing with the headphone cord, laying his head on the table, and tilting back in his chair. Beginning with period nine, the subject would spend less of the experimental period turned to the right.

The final comment concerns the stimulus events in period four. This was the first opportunity the subject had to earn some tokens. Once the marble began following each stimulus event, the subject turned his body to the right. He remained turned to the right facing the token dispenser for the entire period. Toward the end of this experimental period the subject would be emitting some straying activity, but when the tone was presented, he would face the dispenser and the straying activity would cease. Due to the small time delay between the stimulus event and the appearance of the token, it is possible that the subject understood he was being reinforced for turning to the right rather than the stimulus, itself, being reinforced. This aspect is impossible to determine or measure, but may be a consideration in the difficulty of turning the subject back to the left and in the validity of the model. The fact that the stimulus was reinforced may have been a confusing aspect to the subject for the learning that followed in the conditioning program. This feature may be seen by an examination of the line B in Figure 23.

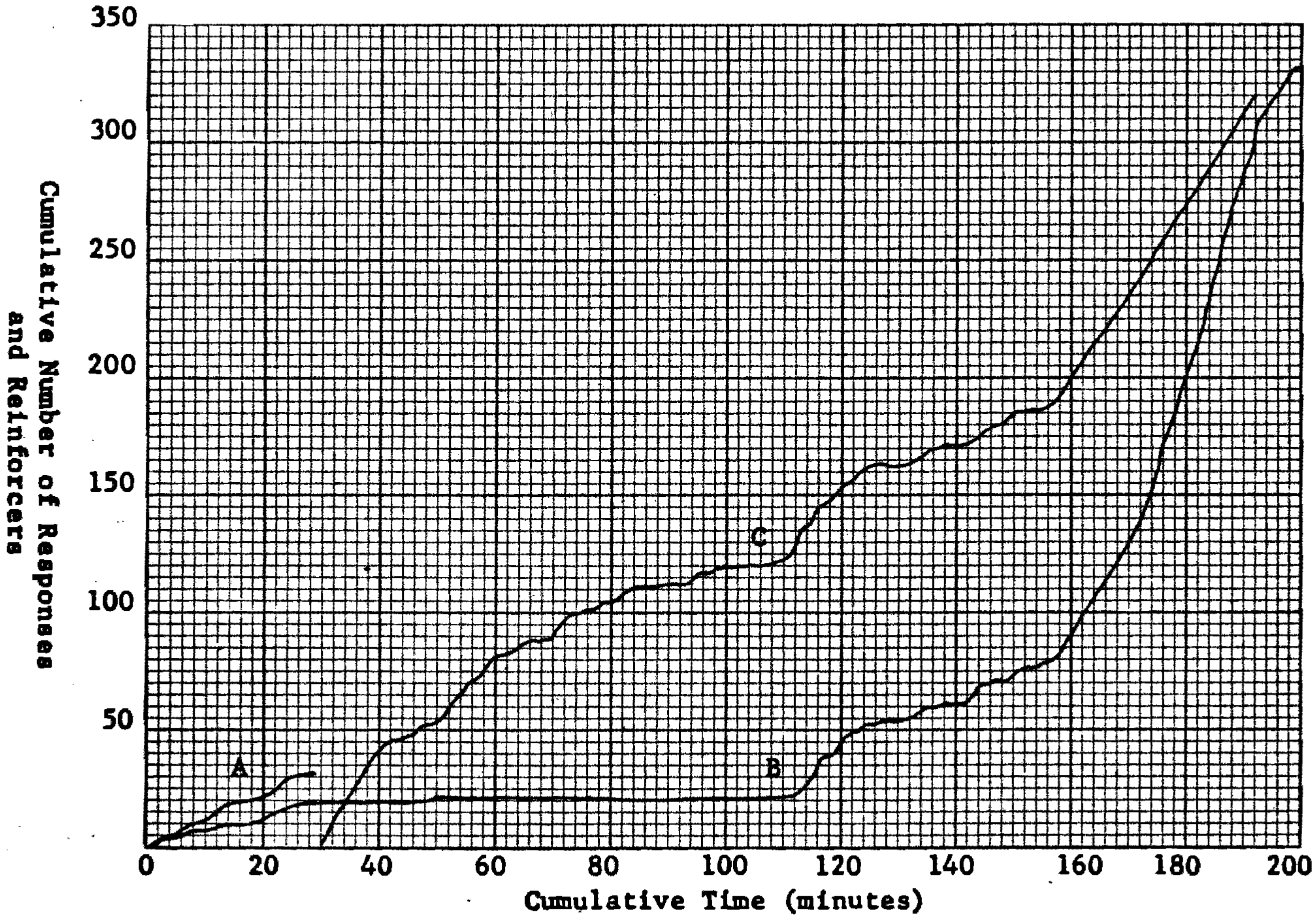


Figure 23. This graph illustrates the cumulative number of responses and reinforcers presented. Line A indicates the cumulative right turns and line B indicates the cumulative number of correct responses, while line C shows the cumulative number of tokens used.

Response Events

The response event consisted of the subject's lateral movement of his head to the left resulting in the disappearance of the piece of masking tape on the left headphone and a lateral movement back to the front causing the tape to reappear. During the baseline periods a response event of turning the head to the right was also recorded. There was very little variation in the number of right and left turns of the head in the baseline periods. The number of right turns was 10, 9, and 11, while left turns were 7, 5, and 5 for periods number 1, 2, and 3, respectively (see Table IV).

Of concern throughout the remaining experimental periods was only the left turn of the head. The subject only emitted 4 and 1 correct responses during periods 5 and 10, respectively, while there were no correct responses during periods number 6, 7, 8, 9, and 11 (see Table IV). This fact is also illustrated in Figures 23 and 24. During period 12 the subject turned to the left after the stimulus event and did not turn back to the front until the tone was presented the next time. From period 12 through period 19 the number of correct responses did increase.

Between period 12 and 13 there were two days when the experimental program was not carried out. This break was due to the occurrence of the weekend. Consequently, this break may explain the drop in number of correct responses from period number 12 to 13 (see Table IV). The rate of responding (Figure 24) and the percent of stimulus control also decreased in period 13 (Figure 25). From period 13 through

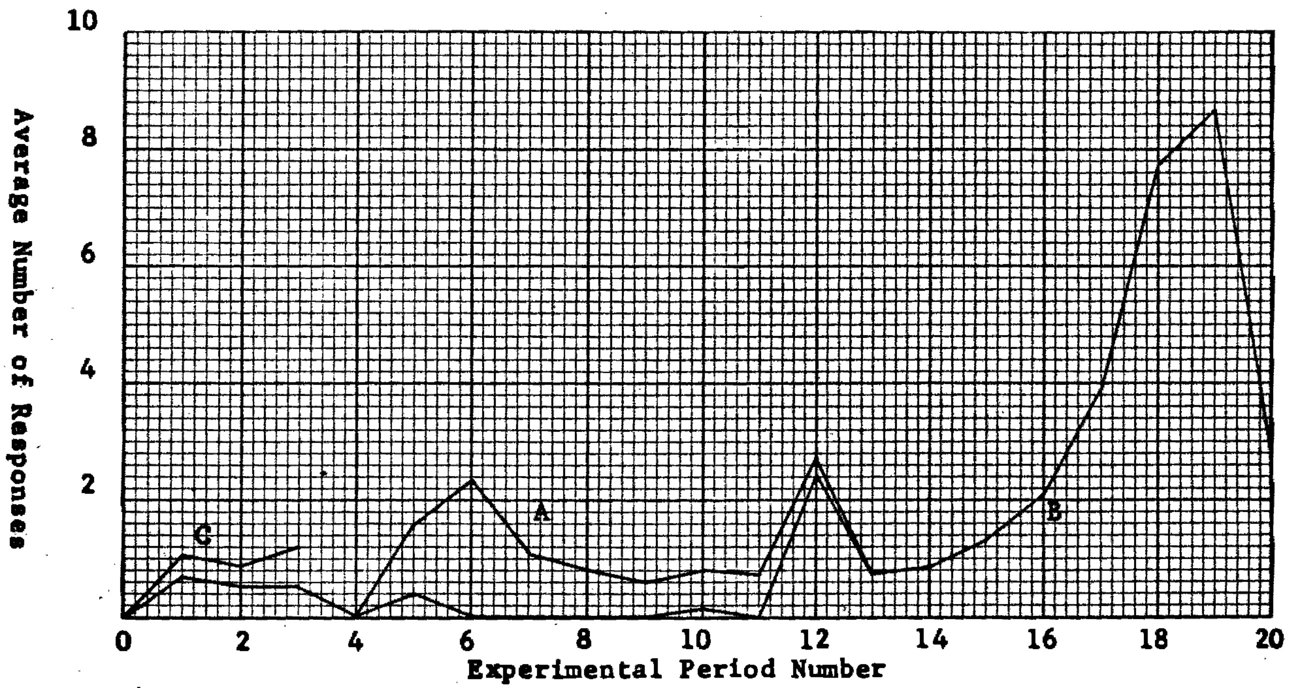


__Figure 24__. This graph represents the rate of responding during each experimental period. Line A represents the number of successive approximation per period, while line B represents the average number of correct responses per period and line C indicates the rate of right turns during the baseline periods.

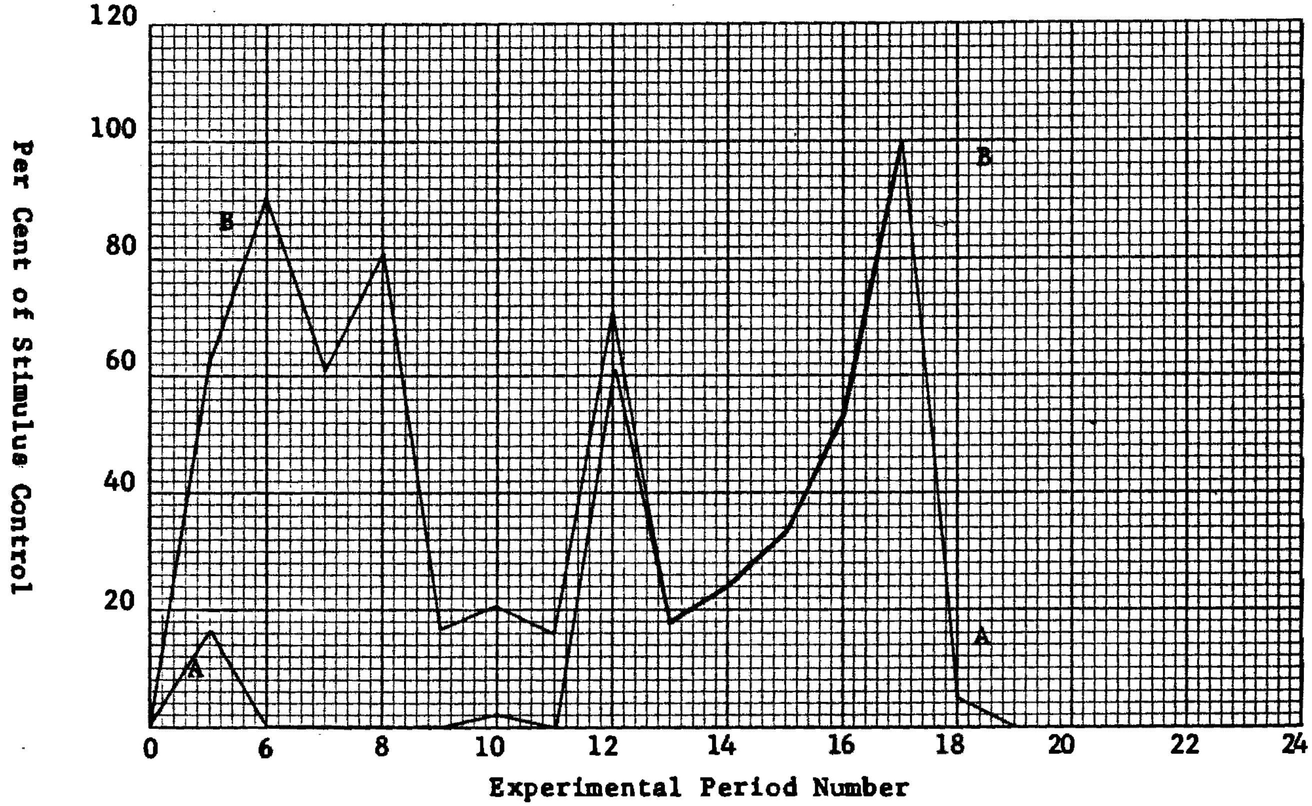


Figure 25. This graph illustrates the per cent of stimulus control during each of the conditioning periods. Line A is the per cent of correct responses per number of stimuli presented and line B is the per cent of reinforcers presented per number of stimuli presented.

period 19 the rate of responding and the number of correct responses increased steadily.

On the final day the subject performed the S-R mechanism correctly in periods 17, 18, and 19. During 18 and 19 the subject was responding more frequently than the number of reinforcers dispensed (see Table IV). This fact is also demonstrated by the slope of lines B and C in Figure 19 between 171 minutes and 191 minutes. Line B is much steeper than line C. The subject would turn his head to the left two to four times between stimulus events, but would only be reinforced for the response that immediately followed the stimulus event. In period 17 there was one hundred per cent stimulus control. For each stimulus event there was one response event for which the subject received one token. In numbers 18 and 19 the per cent of stimulus control dropped considerably (see Figure 25).

During the final period the extinction phase of the program occurred where no token was received after the correct response. For the first 2½ minutes the subject responded at the same rate that occurred in period 19. During the next four stimulus events (approximately 1 minute) the subject did not respond. This was followed by two shorter intervals of responding following the tone presentation. In the final 4½ minutes, the subject began emitting the straying activity (see Figure 23).

Successive Approximations

As noted earlier little or no correct responses were emitted from period 5 through period 11. On the other hand, there were a number of tokens dispensed to the subject (see Table IV). What occurred during these experimental periods was that the successive approximations to the correct response were reinforced. Since the subject had turned to the right in period four, the experimenter reinforced any response that followed the stimulus event where the subject moved his head or body back to the front. In most cases the subject would turn to the right at the beginning of these periods. During periods 5 through 10 he would stay turned to the right from 2 to 8 minutes of a period. Finally, in period number 11 the subject sat facing the front.

It is assumed that each token dispensed in periods 5 through 11 is a record of a successive approximation to the correct response. For this reason the cumulative number of reinforcers in Figure 23, the rate of reinforcement in Figure 24 and the per cent of reinforcers per number of stimulus events in Figure 25 are included. In Figure 23 the number of reinforcers dispensed does increase between 40 minutes and 110 minutes. From 110 minutes to 160 minutes the two curves (B and C) have almost identical shapes and slopes because only correct responses are reinforced. In Figure 24 while the rate of correct responses is zero in periods 6, 7, 8, 9, and 11, the rate of successive approximations is above zero. In spite of a zero per cent stimulus control for correct responses in Figure 25 during these experimental periods, there is a much higher per cent of stimulus control due to the consideration of successive approximations.

There was a great deal of time (over 60 minutes) required to move the subject back to the front as a result of period number 4. The reason for this seems to lie in the concept of probability of a response. In the baseline periods there were more right turns of the head than left turns. The stimulus was presented to the right ear. The reinforcing dispenser was to the right side of the experimental booth. If there was confusion on the part of the subject as a result of period 4 as to whether the stimulus was reinforced or his turn to the right being reinforced, this would also increase the probability of responding to the right. It is seemingly due to these reasons that the subject's responding to the right is considered to be of high probability and thus his responding to the left of low probability. This in turn could explain the amount of time required to shape the behavior of the subject to respond according to the desire of the experimenter.

II. A DISCUSSION OF THE MODEL

Not all the components of the model (Figure 21) were dealt with in the experiment. However, those considered will be clarified. The elements concerned with the primary variable, stimulus, included the stimulus threshold, the pairing of the stimulus with other reinforcing stimuli, the reinforcement of the stimulus, and the immediacy of reinforcement. The elements concerning the response variable were the immediacy of the response, the ease of emitting the response, the reinforcement of the response, and the immediacy of the reinforcement. The following is a discussion of these elements of the model with regard to the results of the experiment.

There is one concept which is set apart from the rest of the model and that is the decision symbol concerned with stimulus control. In period number 17 the subject began responding correctly and a 100 per cent stimulus control was achieved, while in periods 18 and 19 for every stimulus event there were two to four response events. This is illustrated by the drop in per cent of stimulus control of line A in Figure 25. The occurrence of 100 per cent stimulus control is the more desirable state. Thus, only for period number 17 would the process continue in the model.

The next question which is closely related to the above discussion is whether 100 per cent stimulus control is necessary. Based on the results of the study and on the definition of communication by Staats and Staats (1963), a value of 100 per cent stimulus control must be achieved. In other words for every stimulus event there should be one response event.

The last and probably most important question concerning this concept is whether it is in the correct relationship with the remainder of the model. If the model was only concerned with behavior which is already established by an organism, then the concept could remain in the same relationship. However, the model is to account for behavior as the organism establishes the new S-R mechanism, also. Consequently, the portion of the model involved with stimulus control is to be placed immediately following the sequence concerned with the primary variable, response.

The Primary Variable--Stimulus

The first secondary variable concerned with the variable stimulus was stimulus threshold. The value of the stimulus threshold was established by the hearing examination administered to the subject.

The fact that the experimenter did not obtain the desired results when the tone was presented at different levels is not sufficient to eliminate the concept of stimulus threshold. The procedure used by the experimenter did not succeed. Also, this points out that the two means of presenting a tone to the subject, one by the portable audiometer in a room with little sound proofing and the other in a sound proof room with a different puretone instrument, were not similar and thus the same results should not have been anticipated by the experimenter. This component of the model was the only secondary variable in the model where a value can be clearly assigned as a result of the experiment. Based on the study, the concept of stimulus threshold remains a valid concept.

The next secondary variable to consider is whether the stimulus is paired with other reinforcing stimuli. The answer to this variable with regard to the study is negative. Although the stimulus was reinforced for one period, there was no pairing of stimuli in the sense of the classical conditioning principle. There can be no value assigned to "p'" as a result of the negative value. Very little can be said that establishes the validity of this secondary variable and its importance to the model. Since there is little reason to maintain this variable, it will be rejected from the model.

The third secondary variable is whether or not the stimulus is reinforced. An affirmative answer is given to this question. However, it is doubtful whether this variable is valid for the model, since the stimulus did not become discriminatory for the response and there was a great amount of time required to establish the desired S-R mechanism. In fact it would seem that this was a contributing factor in making the right turn more probable than the left turn. It would be difficult to assign a value to the variable "u" as a result of the positive answer and on the basis of the findings of the experiment.

The related question concerning the immediacy of reinforcement must also be answered positively. As noted before, there was a momentary delay between the stimulus event and the token presentation, although the reinforcement was relatively immediate. Since the subject turned to the right at the beginning of periods 5 through 8 and stayed in that position for varying lengths of time, it would seem that the reinforcing of the stimulus was a detriment to the establishment of the correct response event. These two secondary variables related to the reinforcing of the stimulus did not accomplish what was intended. Consequently, they will be eliminated from the model.

Generally, the portion of the model concerned with the stimulus seems not to have correctly represented the behavior of the subject. While the stimulus threshold is a fairly sound concept, there is doubt as to the validity of the remaining secondary variables concerned with the stimulus. Little can be discussed about the pairing of the stimulus with other reinforcing stimuli. On the other hand, a rejection of the two secondary variables concerned with the reinforcement and the immediacy of reinforcement of the stimulus is necessary. Based on the results of the experiment, the latter three secondary variables used to determine the state of the organism with regard to the stimulus will be eliminated from the model.

<u>The Primary Variable--Response</u>

The only secondary variable of the model in the sequence concerning the primary variable response that cannot be discussed as a result of the experiment is the response threshold. This does not signify that it is not a valid concept for the model. Although no values can be assigned to the remaining secondary variables of this portion of the model, they will be discussed in light of the findings of the experiment.

The first variable is whether the response was emitted immediately following the stimulus presentation. The answer is yes. Once the subject learned the correct response and began performing it correctly in period 17, the response occurred immediately following the stimulus event. Admittedly, the case of the subject emitting a delayed response was not considered in the experiment. While not proving the validity of its importance to the model, this secondary variable is to remain a component of the model.

The next secondary variable is whether the response is easy to emit. Again, the answer is affirmative. There were no other responses established in the experiment. It would seem that this response should be considered easy since the subject was capable of doing it; he did not need to leave the therapy room to perform the response, and it was not necessary for him to acquire any special material to respond correctly. This secondary variable will remain in the model.

The last two secondary variables of the primary variable response are concerned with reinforcement of the response and the immediacy of reinforcement. The response was reinforced and the reinforcement closely followed the occurrence of the response. Very little discussion is needed concerning these variables, since the two secondary variables are related to established principles of operant techniques. Once the subject began to respond correctly, the rate of responding increased due to continuous reinforcement which closely followed the response. These two variables are not to be excluded from the model.

Thus, this portion of the model concerned with the response variable is not to be modified or rejected. Based on the results of the experiment their importance to the model is confirmed.

III. A DISCUSSION OF THE PROPOSITION AND THE RELATED QUESTIONS

In Chapter I the proposition introduced concerned whether individual communication behavior can be simulated by a digital model. The proposition was followed by two questions. A discussion of these questions and the proposition are to be presented in light of the findings from the experiment. The first question to consider is whether conditioned behavior is serial in nature. The behavior conditioned in this study of turning the head to the left and back to the front as a result of a prior stimulus (the puretone) can be easily viewed as serial in nature. After period number 4 when the stimulus was followed by a token, the subject was differentially reinforced for any response involving a slight or partial turn to the left. Since the subject was facing to the right, this involved presenting a token for a response to the front. Slowly, the subject moved back to the front and eventually the head turned to the left. Next, the subject would face the front when the stimulus was presented and then turn his head to the left only returning his head to the front for the next stimulus event. After he began responding correctly, the next step involved shortening the time between the stimulus event and the response event. The establishment of the S-R mechanism was a smooth process leading up to the final correct response chain.

Behavior at the observable and measurable level can be considered serial or step-by-step in nature. Complex behavior can be broken down into a sequence. However, it must be understood that it is easier to break down behavior once it has been learned rather than attempting to make a prediction when behavior is about to be learned. Thus, it is not difficult to accept Loehlin's (1968) statement where he indicates that a sequential or serial assumption of behavior is a natural arrangement.

The second question is whether conditioned behavior can be explained as a function of the relative values of the thresholds and the strengths of the stimulus and the response. This question is far more difficult to answer than the first. However, based on the experiment and the discussion in the previous section, it would seem that conditioned behavior can be explained as a function of the stimulus threshold and the strength of response. Although no values were assigned to the secondary variables related to the response variable, with a study intended to investigate the relative values of these variables and their influence on the final response value, such an assignment could be made. Each of the above secondary variables was considered in the study and determined to be sound concepts to the model.

The question remains whether conditioned behavior can be explained as a function of the strength of the stimulus and the response threshold. Although the secondary variables in the model concerned with the strength of the stimulus were seemingly found to be confusing factors to future learning, this may indicate that the wrong questions or variables were used to determine the state of the stimulus. There are two alternatives to this situation. First, a different set of secondary variables could be used or, secondly, a value could be assigned to the stimulus with no secondary variables being used. The latter seems the most appropriate, simply because it would be the simplest to incorporate into the model. Thus, with regard to conditioned behavior being explained as a function of stimulus strength, an affirmative answer can be given, if it is assumed that the use of a value being assigned to the stimulus is a preferable alternative. However, this alternative needs to be verified.

There is very little to discuss concerning the response threshold. This concept was not examined in the study and nothing more can be added to the discussion in Chapter III of this concept. Thus, for the present this concept is assumed to be valid, since the concept of stimulus threshold in this case was determined to be sound. If the above assumptions are acceptable then an affirmative answer can be made to the question of whether conditioned behavior can be explained as a function of the relative values of the thresholds and strengths of the stimulus and response.

If the above assumptions were acceptable, then it can be said that human communication behavior can be simulated by a digital model. Since this was an exploratory study, little evidence was gathered and this proposition was accepted on very weak grounds. However, if the limitations of the study were realized and the assumptions were clarified, the acceptance of the proposition should be without reservation. That is, behavior must be serial in nature and be both observable and measurable. Also the correct questions must be asked of the primary variables. Other relevant secondary variables must be determined. The suggested alternative of dealing with the stimulus must be investigated and found to be a valid solution for the model. And finally, studies must be undertaken where the values of these variables can be worked out. Thus it can be stated that at an elementary level there is nothing to contradict the simulation of communication behavior by a digital model.

CHAPTER VII

SUMMARY AND CONCLUSIONS

This final chapter will summarize the information produced by the experiment. The proposition will be stated in the form of a hypothesis followed by the related questions with the respective results. Inferences will then be drawn about the model and its modifications. A section is included which concerns reflections of the author. Suggestions for further research will conclude this chapter.

I. SUMMARY OF THE RESULTS

The original hypothesis was that communication behavior can be simulated by a digital model. The answer to this was contingent upon two questions. Is conditioned behavior serial in nature? Can conditioned behavior be explained as a function of the relative values of the thresholds and the strengths of the stimulus and the response? If these questions were true then the hypothesis was accepted. The following is a summary of the results of the experiment with regard to the questions and the hypothesis.

It seemed that conditioned behavior was serial in nature. The establishment of the S-R mechanism was a step-by-step process. In the beginning of the experiment the subject was turned to the right. Through differential reinforcement the experimenter was able to move the subject back to the front and eventually the subject began responding correctly by turning his head to the left. The experimenter differentially reinforced successive approximations which lead to the reinforcement of the correct response. Thus, this question was answered positively.

The second question was not that simple to answer. It was necessary to consider two parts of this question. The first portion to be discussed concerned whether conditioned behavior could be explained as a function of the relative values of the stimulus threshold and the strength of the response. The section of the model regarding the response variable was based on proven principles of conditioning and was found to be valid in the experiment. The concept of stimulus threshold value appeared to be a valid feature, since a hearing examination gave a level for which the subject could hear an auditory stimulus. Therefore, this part of the second question was affirmed.

The second portion of the question concerned whether conditioned behavior could be explained as a function of the relative values of the response threshold and the strength of the stimulus. Although the concept of a response threshold was not tested in the experiment, it was considered a sound concept and remained a part of the model. It seemed that the wrong questions or secondary variables were considered with regard to the strength of the stimulus. The fact that the subject turned to the right as a result of reinforcing the stimulus seemed to be a detriment to the learning that followed. The secondary variables concerned with the stimulus variable were eliminated from the model. An alternative was suggested where a value could be assigned to the stimulus. If this solution was accepted, then this part of the second question was also affirmed.

Since the two questions were answered positively, the hypothesis was supported. Although this was an exploratory study with a small amount of data being produced, it was determined that at an elementary level communication behavior could be simulated by a digital model.

II. CONCLUSIONS

The results of this study produced some evidence that portions of the model do account for conditioned behavior. Admittedly, the experiment concerned simple responses to simple sinusoidal tones. At a more complex level of both stimuli and responses of an organism, there remain many questions. The fact that the S-R mechanism was established does shed some positive light on the model. On the other hand, a detriment to the learning seemed to be due to the reinforcement of the stimulus. The information provided by the experiment can lead to some cautious inferences about the model.

To begin with, it seemed that the concept of stimulus control was a valid portion of the model, in spite of the apparent incorrect relationship with the components. The decision to move this concept to follow the response sequence of the model appeared to be a sound solution.

Generally, the response segment of the model seemed to correctly account for the conditioning that occurred in the experiment. There were no changes or modifications which seemed necessary for these components and their relationships. Although there was no evidence with regard to the validity of a response threshold, this element was not rejected from its present configuration. Since most of this section of the model was based on proven techniques of conditioning, it was not expected to be eliminated or modified in any major way.

A concept of apparent validity concerning the stimulus variable was the stimulus threshold. In this limited case of an auditory stimulus, there was a value that could be used for a threshold value of the stimulus. There seemed to be no modifications necessary of this concept with the remainder of the model.

The only portion of the model which seemingly did not account for the establishment of the S-R mechanism was the secondary variables regarding the strength of the stimulus. The pairing of stimuli, the reinforcement of the stimulus and the immediacy of reinforcement did not have the influence that was expected. It could be possible that these concepts may be important to other models or in other experiments. However, there was doubt as to their place in this model. Consequently, these secondary variables were eliminated from the model.

A solution to this problem of the invalid secondary variables was to give a value to the stimulus. This value could reflect the individual's preference toward a particular stimulus. That is, what is the state of the organism concerning a specific stimulus? Since the experiment was not sufficient to confirm the idea of a threshold value that would fluctuate increase or decrease to reflect the state of the individual, additional research is needed along this direction. Based on the above inferences a modified model is illustrated in Figure 26.

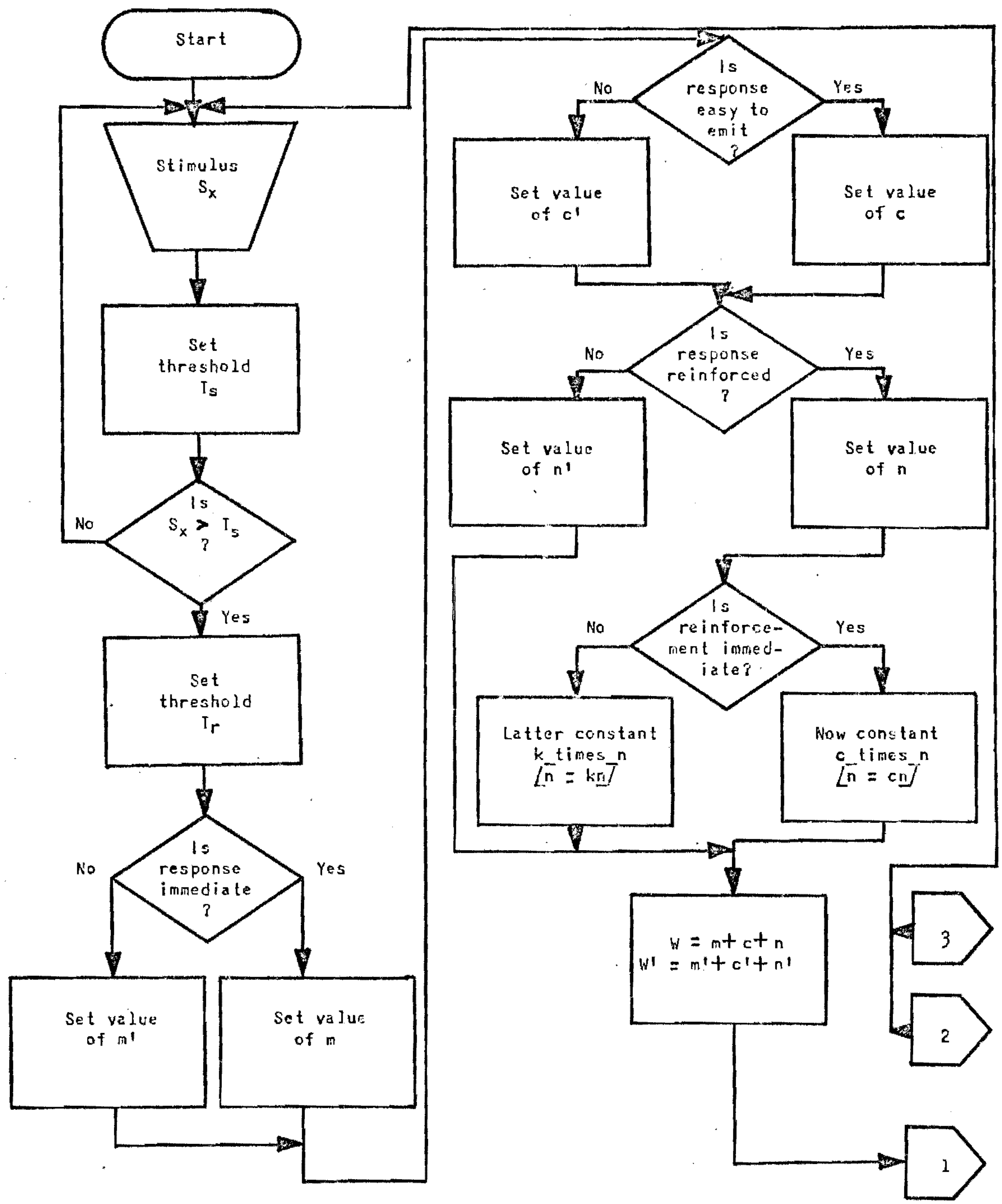


Figure 26. This illustrates the modified model.

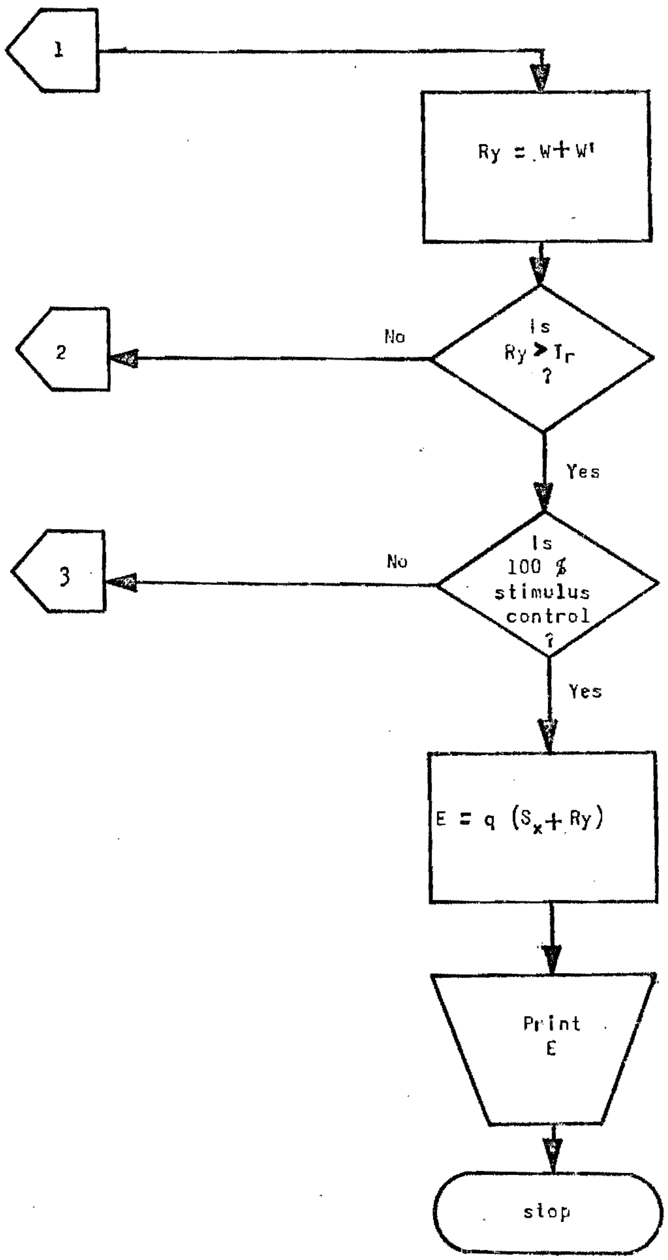


Figure 26 (cont.)

III. REFLECTIONS OF THE AUTHOR

This study seemed to accomplish what was intended. That is, it provided some information about the model and the proposition. Since the experiment concerned a simple stimulus and a simple response, and the study included a fair amount of material on conditioning and simulation, this study must be viewed as a building block for further research concerning communication behavior. There seemed to be nothing in the literature dealing with investigations of communication behavior in general; only specific aspects seem to be under examination. Consequently, the need for such research seems apparent.

The model was designed from the principles and concepts of conditioning. If the argument by Hartman (1969) is to be accepted, a great deal of work is needed to investigate those concepts of conditioning of importance to communication behavior, as well as those that are not significant. The model used only a few of the concepts that seemed to be relevant. From the experiment almost half were found not to be important. Admittedly, the selection may not have been good. But the fact remains that from the results of the experiment some were found to be of apparent importance.

The use of the conditioning principles seems to be as good a foundation as any to begin an investigation of communicative behavior, because the process seems to be sequential and at the observable and measurable level. It seems to provide a basis for breaking behavior down into fairly simple and discrete units. This is good, because studies in most fields ought to begin with the simple before moving to the more complex.

One additional comment seems appropriate. It may have appeared to be difficult to differentiate whether the model and the experiment concerned the study of communication behavior or simply another approach to the study of learning. However, by carefully and systematically defining the irreducible units of communication, this study must be considered as one dealing with communication behavior.

IV. SUGGESTIONS FOR FURTHER RESEARCH

Since this study involved an exploratory investigation of communication behavior, there seem to be many areas where further research is possible. It can be said that this study stated a great deal about very little, because it was an attempt to discover the rudiments of communication. The model itself requires an extensive series of studies. There is a need to know how far the model can be developed to make it a functional simulator of communication behavior. What are the secondary variables that contribute to the strength of the stimulus? Does the stimulus value vary or does the stimulus threshold value fluctuate? What other secondary variables contribute to the response strength? Is there a response threshold and does it vary? Research of this type is necessary not only on a large number of subjects, but also on individuals from various cultural backgrounds. Work is needed on other stimuli and responses, as well as on more complex stimuli and responses.

Once the evidence has been worked out on the model, attempts could be made where the computer is used. After programing the model into the computer, a simple communicative behavior could be studied. The values of the variables could be placed into the computer to determine a response strength. Two studies could be undertaken where a computer is used in one and manual computations in another. Once the values of the variables could be measured, the results would be compared. What are the relative values of the variables? What occurs to the values of the variables when satiation or boredom occurs? What effect do different schedules of reinforcement have on the variable values? Do the variables increase and decrease in the same manner when simple and immediate responses are considered and when delayed and difficult responses are studied? The use of a computer is a necessary step if the model is to be tested.

As the study of communication behavior increases in complexity and the model is tested, it must be understood that the model will not be sufficient to account for all aspects of communication. It will only be concerned with observable and measurable communication behavior. Studies involving higher order processes are needed. At what point should the researcher aim his studies at the inner states of the organism? The model makes no attempt to do this. It may be necessary to turn to other theories of communication. Whether the theory is Information Theory, Sociometry, or Conditioning Theory, each has a contribution to make to the study of communication.

All of these questions and possible areas for further research support what was stated earlier--that the study of communication behavior is a complex and difficult task. Many questions remain unanswered. The use of simulation in the study of behavior is still an infant science. The value of the study of simulation and the construction of models on communication is to determine those factors which influence the process of communication and to uncover a further understanding of human communication behavior.

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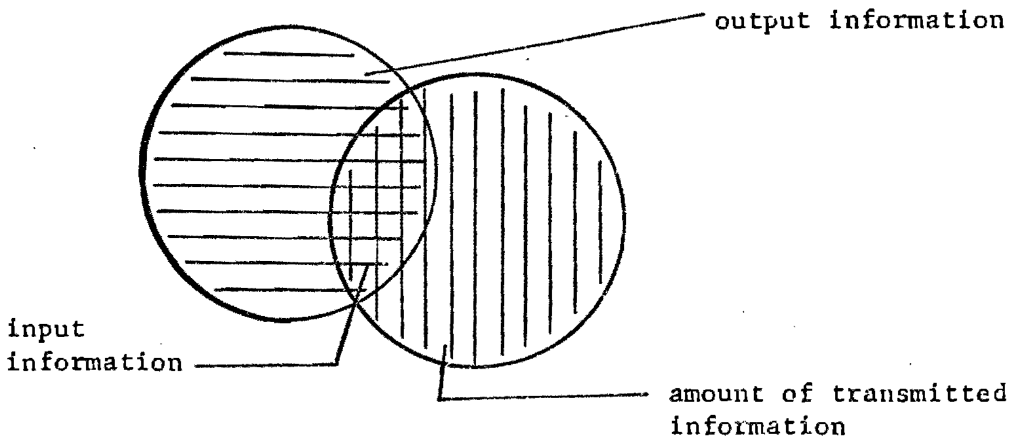
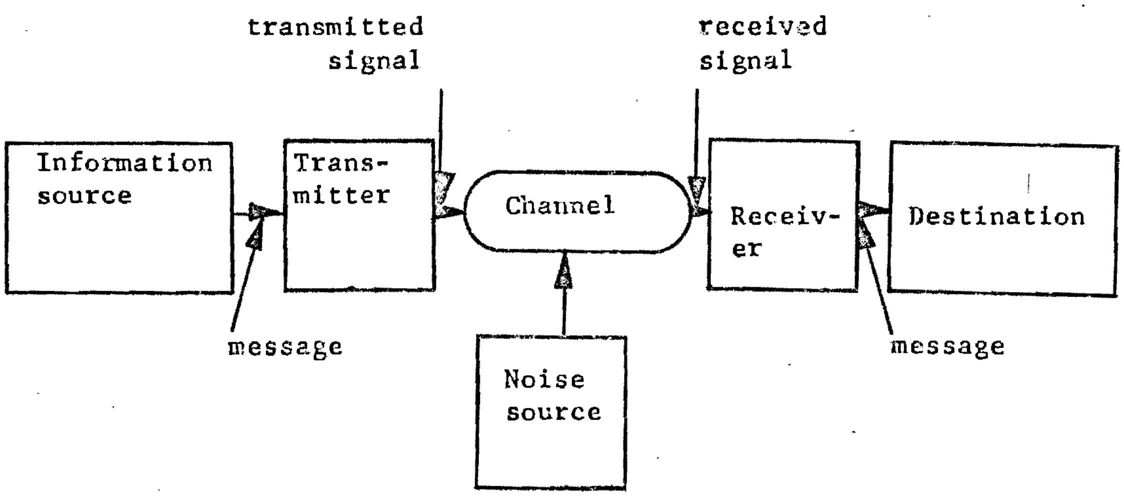
APPENDIX A

FOUR COMMUNICATION MODELS

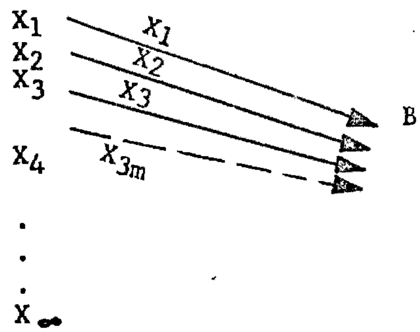


The G. A. Miller Model (Miller, 1956, p. 82).



The Shannon and Weaver Model
(Weaver and Shannon, 1964, p. 7).

APPENDIX A (cont.)



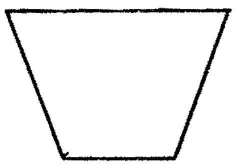
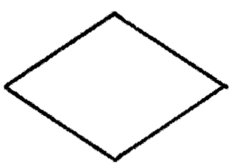
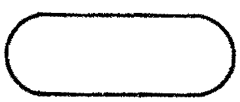
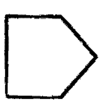
The Westley and MacLean Model
(Westley and MacLean, 1966, p. 81).

Source (S)	Message (M)		Channel (C)	Receiver (R)
Comm. Skills	Elements	Structure	Seeing	Comm. Skills
Attitudes			Hearing	Attitudes
Knowledge	Code		Touching	Knowledge
Soc. System	Content		Smelling	Soc. System
Culture	Treatment		Tasting	Culture

The SMCR Model (Berlo, 1963, p. 72).

APPENDIX B

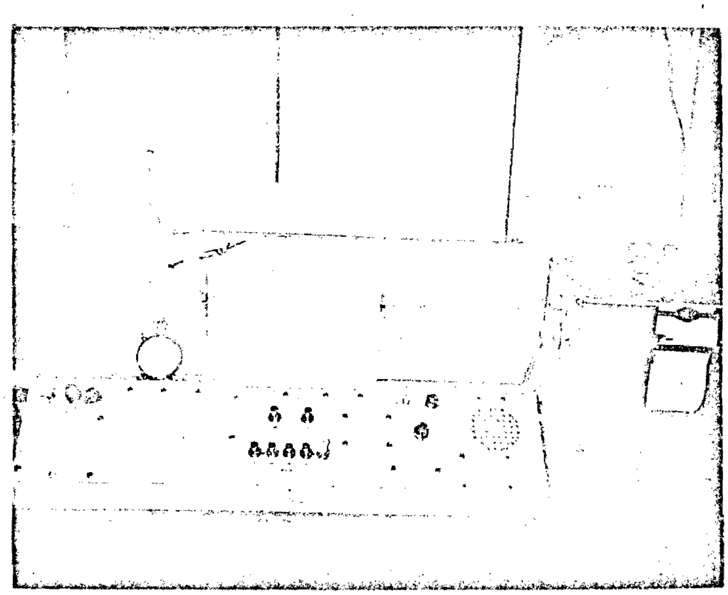
PROGRAM FLOWCHART SYMBOLS

SYMBOL	EXPLANATION
	This symbol represents any function of an input/output device, such as, making information available for processing, making processed information available on tape, etc.
	This symbol represents a group of instructions which perform a processing function of the program, such as, arithmetic operation, storage and retrieval of information, etc.
	This symbol represents a decision function where points in the program may possibly branch to alternate paths based upon the variable conditions.
	This symbol represents a terminal point in the program, such as, the beginning or the end of the program.
	This symbol represents an exit to or exit from a page, that is, from one page to another.
	These symbols are arrows placed at the end of lines to indicate the direction of the processing or data flow.

APPENDIX C

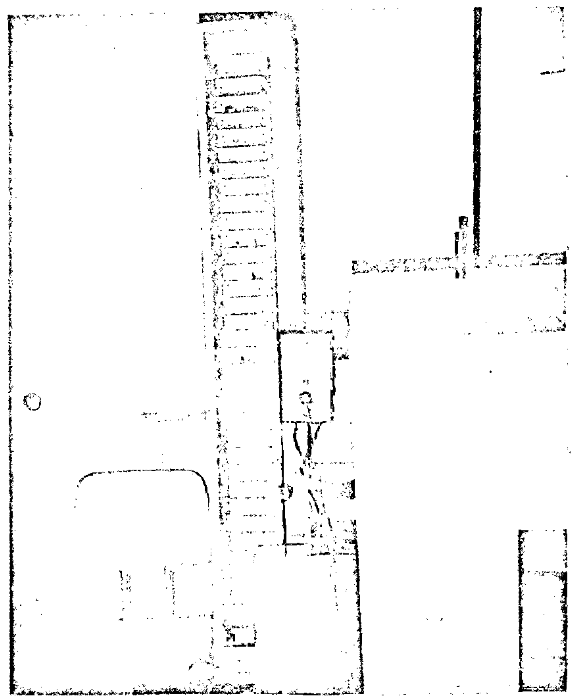
PHOTOGRAPHIC VIEW OF EXPERIMENTAL SETTING

Experimenter's view of subject.

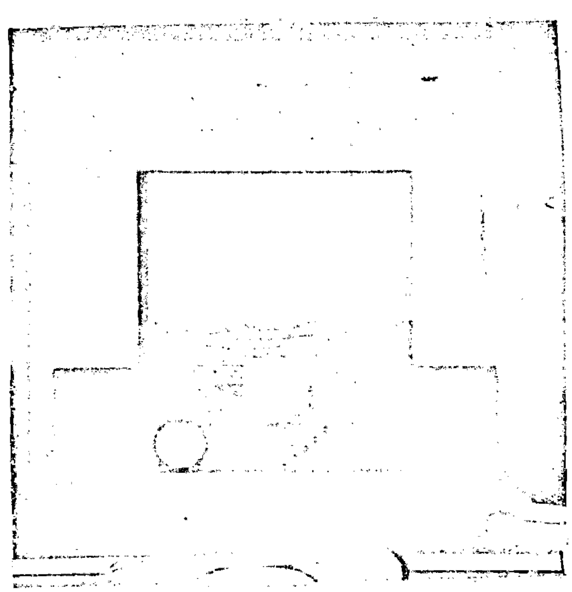


Experimenter's view of experimental booth.

APPENDIX C (Cont.)



Experimenter's view of universal bucket dispenser.



Subject's view of experimental booth.

APPENDIX D

AUDIOLOGIC EXAMINATION REPORT

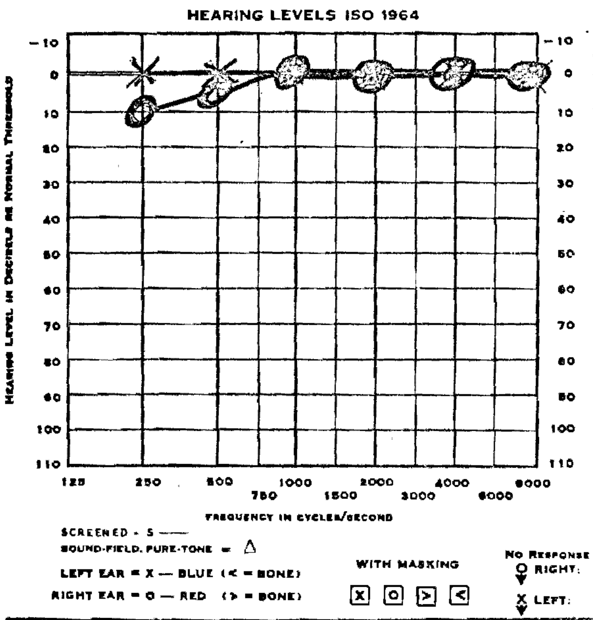
SPEECH AND HEARING CLINIC
PORTLAND STATE UNIVERSITY
P.O. Box 751, Portland, Oregon 97207
Phone: 226-7271, Ext. 595

AUDIOLOGIC EXAMINATION REPORT

AUDIOLOGICAL ASSESSMENT for SCOTT GARLAND Age 7 B.D. 9-8-62

Date 10-14-70 Address

Parents Occupation Referred SP. DEPT.



Hearing: Constant ✓ Varies
Hearing Today: Same ✓ Better Worse
Tinnitus: Right Left

Test Reliability:

	RIGHT	LEFT		RIGHT	LEFT
A.C.	(GOOD)	(GOOD)	B.C.	GOOD	GOOD
	FAIR	FAIR		FAIR	FAIR
	POOR	POOR		POOR	POOR

Audiometer Used: BELTONE 15 C

Masking for Air Conduction: TYPE
For R.E.: Left Unmasked Masked DB
For L.E.: Right Unmasked Masked DB

Masking for Bone Conduction: TYPE
For R.E.: Left Unmasked Masked DB
For L.E.: Right Unmasked Masked DB

Weber Test:

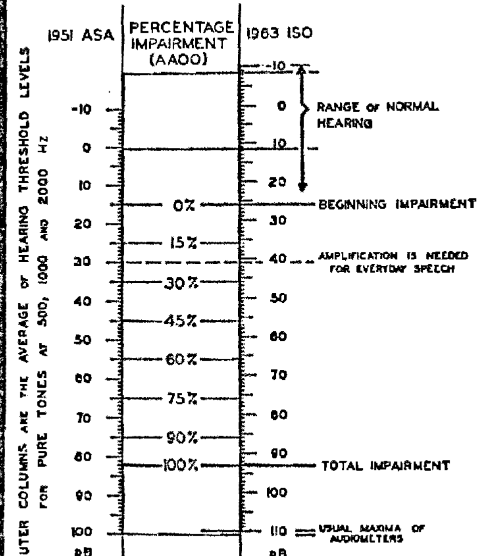
SPEECH AUDIOMETRY

	SPEECH RECEPTION THRESHOLD 1	SPEECH RECEPTION THRESHOLD 2	MOST COMFORTABLE LEVEL 1	MOST COMFORTABLE LEVEL 2	THRESH DISCOMF	DISCRIMINATION SCORE (PB MAX.) 1	DISCRIMINATION SCORE (PB MAX.) 2
RIGHT EAR							
LEFT EAR							
SOUND FIELD							

SHORT INCREMENT SENSITIVITY INDEX

FREQ.	250	500	1K	2K	4K
RIGHT					
LEFT					

SUMMARY OF HEARING LEVELS



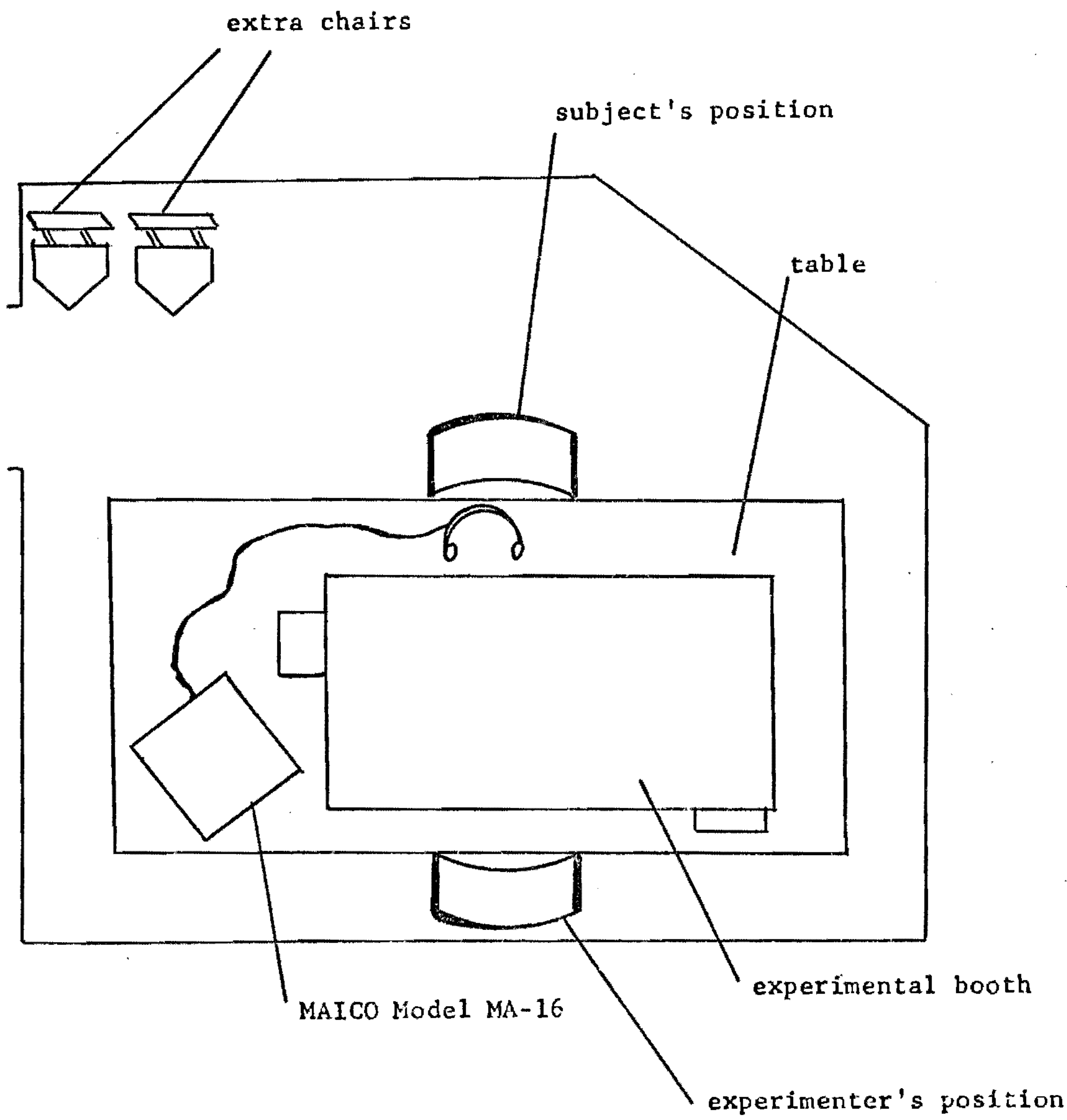
Examiner: Al Hale C.T. [signature], CCC

Remarks and Recommendations:

SEE OTHER SIDE FOR SPECIAL TESTS.

APPENDIX E

DIAGRAM OF EXPERIMENTAL ROOM



APPENDIX F

INSTRUCTIONS FOR BASELINE PERIODS

During the next few days, I am going to observe and record some of your behavior. This piece of equipment will be used to present you with a tone. You will have to wear these headphones to hear the tone. The tone is similar to the one you heard during the hearing test. This apparatus will be used to record your behavior as it occurs. I'll be sitting in this chair and you can sit in that one. After a few of these sessions, you will have an opportunity to earn some prizes. Do you have any questions? Why don't you sit down and I'll put the headphones over your ears and we will begin?

APPENDIX G

INSTRUCTIONS FOR CONDITIONING PERIODS

Now is the beginning of several sessions where you have the opportunity to earn some prizes. If you do something correctly, a marble will drop into the tray. You will not receive a marble when you do something wrong however. After collecting a number of marbles you can turn them in for one of the following prizes:

10 marbles -- 1 bag of peanuts
15 marbles -- 1 bag of cheese snaps
20 marbles -- 1 matchbox car
25 marbles -- 1 small figurine
30 marbles -- 1 airplane glider
35 marbles -- 1 Halloween mask
40 marbles -- 1 Halloween eye
etc.

The first time you hear the tone raise your hand. The next time you hear the tone it is not necessary for your hand to be raised. Are there any questions? Let's begin.