TOWARD
A THEORY OF TWO-PERSON INTERACTION

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ABSTRACT

In this dissertation, a conceptual framework for the study of interaction between two persons is presented. One specific aspect of that framework is selected and an experimental test which focuses on that aspect is conducted. This test is designed to begin the process of refining the original conceptualization.

The conceptual framework utilized stresses the sequential and information-processing features of interaction. The responses of persons are considered to be the result of two processes: one in which an interpretation is made (the "interpretive process"), and one by which that interpretation forms the basis for a new response (the "decision process"). This two-step model of action is used in order to deal with some of the problems created when a simple one-step behavioral model is used to deal with cognitive and linguistic processes.

Since sequential interaction is a central concern in this dissertation, the manner in which interpretations or decisions are changed over time is a crucial issue. It is proposed that the "interpretive process" is best accounted for by a threshold type of operation, whereas the "decision process" might best be dealt with by a more simple learning model. These suggestions are made in order to account for some of the resistance to change which the literature on expectations identifies, and at the same time, the flexibility of response which is found in situations of learning.

Once this conceptual framework is specified, a more detailed elaboration of the "interpretive process" is begun. Two general types of threshold choice processes are described: one which predicts a change in choice after a run of events of the same type, and the other which predicts a change after the differences between two event types reaches a threshold. An experiment is developed which allows one to differentiate which threshold model best accounts for the choices made.

Thirty-five subjects are used and the results support the difference threshold model as the one which accounts for most of the choices. However, the predictive power of the difference model at its maximum is only 84% of the choices made. There is, in addition, some evidence which suggests that the subjects might alter choice models under certain conditions.

Finally, several weak points in the conceptual framework are identified, along with suggestions regarding strategies for future research. Refinements of the experimental design which include greater controls on motivating and memory factors are suggested. Such refinements would allow an even stronger test of the threshold models proposed. An alternative suggestion is that the reseach move to an elaboration of the relationship between events and interpretations or an elaboration of the "decision process" itself.

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INTRODUCTION

In this dissertation we are concerned with developing theory about interaction between two persons. Our intention in the space of this document is not to complete such a development, but only to propose a conceptual framework from which theory might be developed.

The first major portion of this dissertation (Chapters 1 to 3), involves the elaboration of this conceptual framework. In this section, we will elaborate the central concepts and propose a particular way of viewing individuals' choices in an exchange. This framework forms the basis for the second section.

The second section (Chapters 4 to 7), begins the process of refining the conceptual framework by operationalizing one small part of it. In no way is the experiment which comes from this operationalization, designed as a test of the full conceptualization. It is to be considered simply as a preliminary investigation of the utility of the framework. Only through such an elaboration of various aspects of the conceptualization and the subjection of these elaborations to empirical tests can we establish its utility.

The type of interaction with which we are concerned is limited by five general conditions. Some of these conditions were clear from the beginning of our research and they therefore stand as representations of the bounds of our personal interest in this dissertation. Others have been developed as the result of theoretical problems which have emerged as the research was carried out. Taken together, they provide a rather clear outline of the focus of this dissertation.

First of all, we are concerned with interaction only in face-to-face situations. To that extent, our concern will be with "focussed interaction" in Goffman's sense. According to him:

> Focused interaction occurs when people effectively agree to sustain for a time a single focus of cognitive and visual attention, as in a conversation, a board game, or a joint task sustained by a close face-to-face circle of contributors.[1].

By limiting our concern in this way, we have eliminated the effects of delays in communication between persons, problems created by the form in which the communication might be transmitted, and variations in response produced by gross variations in the immediate environment of the interactants.

Second, we are dealing only with face-to-face interaction in which the persons involved are attempting to coordinate their behavior. We will consider only those situations in which the interactants are not intentionally deceptive or operating with strategies of confrontation. Such confrontation or conflict might develop through interaction of course, but we will not deal with those interactions in which it is an initial condition. As a result of this general condition, we will utilize theories relating to information-processing rather than those of conflict or bargaining.

As a third condition, we will deal only with interaction in which the persons involved are interdependent. This means that one person's action has the possibility of affecting the other's; whose action in turn can affect the first; and so on. Single acts are rarely meaningful in themselves, therefore, but only as they occur as part of a sequence of acts. In this concern, we share once again Goffman's perspective and focus; not on the individual and his psychology alone,

> ...but rather the syntactical relations among the acts of different persons mutually present to one another. None the less, since it is individual actors who contribute the ultimate materials, it will always be reasonable to ask what general properties they must have if this sort of contribution is to be expected of them.[2].

Closely related to this position is our fourth condition that the interaction continue over a period of time. Single exchanges will not be considered except as they may be part of a sequence of exchanges. We are assuming that many important aspects of interaction will only emerge after many such exchanges.

The fifth condition which is reflected in our conceptual framework is the central role of interpretations of behavior. We will assume that actions in an exchange do not have unequivocal meanings, but may be interpreted in various ways by the actors involved. This means that interaction, as we have considered it, is an open-ended process which has the potential of developing new forms as the persons interact. Under different interpretations the same act may produce different responses.

If we assume that these conditions operate in interaction, we can see that the coordination of action between persons is potentially very complex. Not only do the individuals involved have the problem of establishing the appropriate interpretation to make of the other's action, but they must also take into account the effect which their own action might have on the other person. If interpretations of action are not shared by both persons, the problems are further increased. Even the process of discovering that interpretations are not shared, or the process of attempting to identify a common basis for forming interpretations, may be instrumental in shifting the original basis for the relationship.

This perspective of interaction is very complex, but we feel that one can introduce into the process, a number of constraints which place limits on it. Individuals are limited by various demands which the other person and the environment place on them. They are also limited by the skills and resources which they have at their disposal to meet these demands. It is through the identification of some of those limits and they way they affect the unfolding of an interaction sequence, that we hope to increase our understanding of interpersonal exchange.

Summary

We are now in a position to specify the central conditions which we require our theory of interaction to satisfy. Since in the discussion that follows, there are many decisions made which reflect these conditions we will specify them in an abbreviated form.

1. The conceptualization must deal with interaction in face-to-face situations.
2. The conceptualization must deal with interaction in a situation where both interactants desire coordination of their activity.
3. The conceptualization must deal with interaction in which the persons involved are interdependent.
4. The conceptualization must allow propositions to be made regarding the ways in which a sequence of interaction, rather than single acts might proceed.
5. The conceptualization must permit one to introduce the effects of interpretations of acts into the interaction process.

SECTION ONE

CHAPTER 1 - THE GENERAL THEORETICAL ISSUES

Within the sociological literature, there are a number of references to the type of interaction with which we are concerned. However, most of the theories in this area deal only with two or three of the central issues we have mentioned and not with all five. It is out of the failure of such theories to provide an integration of these issues that this dissertation will be developed.

Of the five basic conditions which we have specified, the last three are particularly crucial to the direction we have adopted in our conceptual framework. It was in an attempt to integrate the condition of interdependence (condition 3) with that of the sequential nature of interaction (condition 4), that we were forced to invoke the concept of an interpretation (condition 5). Since this is central to our conceptual framework, we will begin our discussion at this point.

Interdependence and the Sequential Nature of Interaction

As we have stated previously, we were interested in an account of interaction which deals with the interdependence of persons in an exchange and at the same time with the exchange as a sequential process. We turned first of all to the body of literature and research associated with game theory in our effort to deal with the interdependence of individuals.[3] Game theory, through its emphasis on the way in which one person's choice or strategy will affect the other person's choice appears to hold a great deal of promise as an account of the mutual interdependence we hope to represent. It allows one to introduce into the exchange, the recognition of such interdependence on the part of the persons involved, and attempts to account for the effects of this recognition.

Game theory is, however, a set of propositions regarding the ideal behavior of a rational person. The central concern is not with the way people <u>actually</u> behave, but with the way in which they should behave if they were behaving rationally. Data regarding actual behavior is sometimes introduced, but only as a means of identifying the major dilemmas which persons face in a choice situation. Since our concern is not with the identification of some best form of interaction, but with the explanation of actual interaction, most of the propositions of game theory are inappropriate.

On the other hand, there are several developments in the social-psychological literature which use the structure of game theory experiments as a framework for propositions of a descriptive or non-normative form. These experiments provide a convenient format for introducing propositions of individual choice behavior into a social context. Both individual choice and the structure of mutual interdependency are conveniently represented by the game theorist's matrix of outcomes.

For our purposes, there are two major theoretical developments which adopt the framework of game theory experiments.

The first involves the extension of learning theory to the point where propositions can be made regarding multiperson interaction.[4] The bulk of this literature rests on the assumption of statistical learning theory, and in most cases involves the development of mathematical models of learning. The second development which makes extensive use of the game theory experimental form is to be found within the literature on exchange.[5] The general orientation in this literature is toward the development of a theoretical basis for collective variables such as norms, status hierarchies, social power relations, etc.

Both of these theoretical developments have something to offer for our concern with dyadic interaction. Learning theory provides a set of propositions about individual choice behavior at a very specific level. Since we are interested in being able to account for interactants' behaviour at each point in an exchange, the level of analysis provided by learning theory can be very useful. It is, in addition, consistent with our desire to examine interaction in which coordination is attempted by both persons involved. Competition or bargaining is not a necessary prerequisite.

Exchange theory offers the possibility of generating propositions which are particularly relevant to social behaviour. Exchange theorists have developed a set of concepts which refer to patterns of interdependence which go far beyond those of learning theory. The notions of "dependence", "social differentiation", and "norm", for example, are much easier to define and deal with in the context of an exchange relation than as a consequence of learning principles. Exchange theory in addition, makes the integration of cognitive aspects of behavior a much more direct matter than does learning theory. One can then include within an account of interaction, the effects of language on behavior.

We do not mean to suggest that these two theoretical developments are mutually exclusive. In fact, the suggestion that there may be some theoretical links between the two has been implied, and in some cases explicitly stated in the literature. Our separation of the two areas is done in order to make clear what aspects of the two theoretical developments are most relevant for our concerns.

One of the most explicit attempts to formulate a theoretical link between exchange theory and learning theory has been made by R.M. Emerson.[6]

In his account of the relationship between the two types of theory, he has taken the assumptions of operant conditioning and used them to provide a theoretical basis for an exchange relationship. From this point of view he has then proceeded to define more general concepts such as power, norms and status, and on the basis of these to generate propositions regarding group structure.[7] Although his concerns are much more general than ours', the theoretical associations he has made suggest that learning theory may well provide a reasonable basis for more general social theory. It seems, in addition, that we might utilize some aspects of learning theory to deal with the sequential interaction part of our concern, and still be able to utilize exchange theory as a basis for understanding the interdependence of persons.

As an illustration of the way this might be done we can refer to the work of Kelley, Thibaut, Radloff and Mundy on the "minimal social situation".[8.] Their research entails the examination of the conditions under which the coordination may occur if persons can only communicate through a simple reward-punishment situation. Their design entails the separation of two subjects by a partition. The only way that one person can communicate to the other is through the use of two buttons; one which is connected to a relatively beneficial outcome for the other person (a score), and the other is connected to a relatively non-beneficial outcome (a mild shock). They were interested in the conditions under which the individuals would move to a mutually rewarding outcome.

In this research and in a number of other studies which used a similar design, five factors were considered to affect the rate at which coordination occurred. The first factor involved the variation of the type of response which subjects were permitted.[9.] In some experiments, the subjects were allowed to respond whenever they chose (the "simultaneous" condition). In others, they were only permitted a response after they had received a stimulus from the other person. This meant that they took turns responding (the "alternating" condition). The second factor involved variation of the severity of the shock received,[10.] and the third factor involved variation of the importance of the reward (operationalized by the value of the positive outcome).[11] The fourth factor involved the variation of the manner in which interdependence was obtained. For one condition, the subjects could give each other a shock only, for another condition, they could give each other a score only, and for a third condition they could give each other a shock or a score depending on the button which they pushed.[12] The fifth factor introduced was the awareness which the subjects had of the experimental setup. In the "informed" group, they were told that they were interacting with another person and the details of the links between them were outlined (except, of course, for the information regarding which button was a shock and which was a score). In the "uninformed" group, the subjects were not told that they were interacting with another person.[13]

Of these five factors, the influence of the first four can be explained using two types of theoretical accounts. The first is a behavioral theory of learning and the development of differential response rates. The chances of an individual repeating the button he pushed is increased if he received a beneficial outcome from the other subject. If the outcome is not beneficial, the chance of a repeat is lowered. Coordination then, is simply an outcome of the reward-punishment structure of the experiment. The second account is taken from game theory and it refers to the strategies which the subjects use. The authors suggest that the subjects use a win-stay/ lose-change strategy in the experiment. The effect of such a strategy is the same as that predicted by the behavioral account above; if the subject wins, he repeats his last move, if he loses, he pushes the other button. On the basis of the experiment to this point, the relative utility of the two accounts cannot be determined, although the ad hoc nature of the "strategy" account makes it the weaker of the two.

It is also the case that to this point, Kelley, et al. have provided a formulation of interaction which seems to deal with the central factors in our concern. Their experiment deals with face-to-face interaction in which coordination of the action is the objective. In addition, the persons are interdependent and they interact over a sequence of exchanges. It is also formulated at a level which permits one to make predictions about the likelihood of certain responses from trial to trial. So far our conditions are satisfied.

Limitations of the Behavioral Account

There is one problem which remains, however, when we introduce the fifth factor (awareness of the experimental conditions) into the "minimal social situation". Kelley, et al. found that if they informed the subject that he was interacting with another person, the time taken for coordination was reduced.[14] To account for this they utilized the ad hoc proposition that the effect was due to the subjects' use of the strategy of stabilizing their own behavior temporarily and observing whether the other person's behavior was stable (implying that he is receiving positive scores) or fluctuating (implying that he is receiving negative scores). There is a problem with this particular account of the behavior since it merely redefines the pattern of action without placing it into some more general theoretical context. It is, therefore, more in the order of a description than an account of the behavior under study. It does, however, point to the theoretical weakness of the "stragegy" account.

A similar problem arises if we attempt to account for the results of this experiment using behavioral theory. In the "minimal social situation", informing the subjects of the structure of the experiment altered nothing in the form of the interaction they had, but it did affect the result of that interaction. The subjects were quicker to coordinate their behavior. To account for this change, we can no longer depend on the behavioral theory which has been adequate to this point. To do so would mean that the set of instructions regarding the experiment would have to be understood in terms of the response rates of the subjects. This would mean that the language and associations of the instructions would have to be interpreted in terms of reinforcements, rewards or conditioned responses. This may not be an impossible task, but there is reason to believe that it is an extremely difficult one.[15.] It was in attempting to deal with this theoretical weakness, that the third major condition in this dissertation was introduced.

The Introduction of an "Interpretation"

As an alternative to an examination of the way in which the instructions might be included in a behavioral account of the "minimal social situation", we began to consider modifications of this point of view. The simplest way was to introduce a new factor or factors into the relationship between a stimulus and a response. We could then consider that the instructions have an effect on these new factors and in that way influence the response rates.

To proceed in this direction, we will be introducing into the behavioral account an hypothetical construct, and with it a new set of problems. The introduction of such a construct can only be justified if it simplifies what would otherwise be a very complex explanation. To develop this more complex explanation would take us into the area of language learning and verbal behavior. Since we were primarily interested in interaction, and not in the details of a behavioral account of language and behavior we decided to accept the introduction of an hypothetical construct as a simplifying device. In this way we introduced a mediating process between the receipt of an outcome and the pressing of a button in the "minimal social situation", or, in general, between an event and a response.

Between the occurrence of an event and the response which an individual makes on the basis of that event, we are proposing that a process of interpretation occurs. Certain aspects of the event (stimulus) are selectively perceived or emphasized by the individual and it is this new set of events which are acted upon. In a general sense, the original event is "interpreted", and on the basis of that interpretation, a choice is made. Thus the "same" event may be responded to in different ways depending on the particular interpretation made of that event.

Although the notion of an interpretation is as hypothetical as the idea of a strategy, we feel that there are certain advantages to its use. A strategy is a much more inclusive term than an interpretation; it refers not only to the relationship between a set of events, but to the consideration of future possibilities, the evaluation of certain ends or goals and the selection of one over the other. An interpretation, on the other hand, can be dealt with as a coding process which is more easily related to propositions of a behavioral nature. As a result, propositions regarding change in interpretations are easier to generate and test than are propositions regarding changes in strategies.

Since the notion of an "interpretation" as we have conceived it is viewed as a coding process for events, we do not have to abandon principles of behavior theory or learning theory in order to use it. As we will show later, it is still possible to view the "interpretive process" as one in which stimulus-response learning takes place. We are introducing this concept, therefore, not as an alternative to behavioral learning theory, but as a convenient means by which language and cognitive factors may be introduced into our conceptualization of interaction.

Once we have added the notion of an interpretation to our original set of conditions (i.e., face-to-face interaction, coordination of activity, interdependency, and the sequential aspects of interaction), there are a number of theoretical developments in social theory with which we can deal, besides the "minimal social situation". We will select two of these by way of illustration: the "double bind" theory of schizophrenia[16] and the labelling theory of deviance[17]. In this way we hope to show how the focus of our attention is related to a wider range of issues than suggested by the "minimal social situation", in addition to illustrating the type of interaction which we hope to explain.

Example: The Double Bind Theory of Schizophrenia (DB)

The DB theory of schizophrenia refers to the "damned if you do, damned if you don't" type of situation. No matter what the individual who is the "victim" of the situation does, he will be wrong. Take, for example, the student whose professor ridicules him if he participates in seminars, yet reprimands him if he does not. Within the confines of these two alternatives, the individual cannot win.

The focus of the DB theory is not primarily on the way in which conflict is produced in such situations, but on the way in which the actors' interpretation of behavior is affected. The result of such a situation from an information-processing point of view, is a great deal of uncertainty regarding the appropriate interpretation of the other's actions. If the student interprets the professor's actions as ridicule, he is informed via the reprimand that he is wrong. However, if he interprets the act as something other than ridicule, he will exhibit abnormal responses to the occurrence of ridicule in this and other situations. The abnormal responses which we might expect are very similar to the responses which are found associated to some forms of schizophrenia, Bateson claims.

We might note as well that the results of such a situation are dependent on a series of repeated interactions of the sort we are considering. In that sense, the professor-student example is limited. The type of exchange it refers to could be seen as a single episode. In such a case, we would not expect that the results predicted by Bateson, et al. would emerge. Should it be part of a lengthy set of interactions, however, there would be sufficient time for the abnormal interpretations and responses to be learned and possibly extended to situations beyond that represented in our example. Once that has occurred, the prediction made by the authors of the DB theory are likely to be observed.

This emphasis is consistent with our concern for a sequence of actions rather than with individual acts. In order for the persons involved to develop a set of interpretations to the point where a contradiction in injunctions is made, a history of communication is required. In addition, it is only after a series of such contradictions that the effects of the DB on interpretations is produced. Without a sequence of interactions it is presumed that the exchange may produce conflict or confusion, but not the development of abnormal modes of action which the DB theory seeks to explain.

The third condition in our concern, that of interdependence between the interactants, is also basic to the DB theory. The problems of coordination are not viewed as problems of each individual, but problems which arise as the result of each other's action. As one person attempts to anticipate an action of the other and to respond appropriately, he inadvertantly affects the basis for that action in such a way as to increase the likelihood of the action occurring. The same procedure is repeated as the interactants attempt to develop a reliable set of expectations on that new basis. In the previous example, the student can be seen as one whose attempt to satisfy the demand to speak creates a basis for ridicule. Similarly, the professor's demand for participation increases the likelihood of silence. It is in this type of interaction that the problems associated with the DB arise.

In the same way that certain aspects of the "minimal social situation" could not easily be explained by a behavioral theory alone, the phenomenon dealt with by the DB theory must refer to an hypothetical process of interpretation. In order to account for the phenomenon of schozophrenia, the authors have introduced the idea of a conflict between interpretations. The problems of communication which are predicted by the theory, are problems of making the proper interpretation of acts and events for both oneself and for others.

The DB theory is one of the few theories which deals explicitly with all those aspects of interaction with which we are concerned. This is usually because most theories of interaction are developed at a more general level of specificity. Nevertheless, we feel that many of the issues with which we are concerned are issues related to these more general theories. As an example of this type of theory we will examine the interactionist theories of deviance which focus on the labelling process.

Example: The Labelling Theories of Deviance

Most labelling theories of deviance assume that interactants are interdependent and that interpretations are important in understanding interaction. The special feature of the theories of the labelling process is the way in which they combine these two assumptions with the sequential aspects of interaction.

Several of the interaction theories of deviance, for example, suggest that the labelling of a deviant may be much more the result of the accumulated effect or qualitative shifts of several minor incidents over time rather than than the result of one single event.[18.] Sampson, Messinger and Towne suggest that it is only after the successive "collapse of accommodative patterns between the future (mental) patient and his interpersonal community"[19.] that institutionalization is considered. To the patient, Goffman suggests, this is experienced as a "kind of betrayal funnel" in which "Passage from person to patient may be effected through a series of linked stages, each managed by a different agent."[20.] Minor variations from expected behavior, for example, may be sufficient to raise the possibility that "all is not well" with a friend. Once this possibility is raised, it increases the chance that future acts will be interpreted as evidence for that belief. It may, in addition, effect a shift in the type of behavior we show to that friend, thus increasing the possibility that his behavior will be "strange". Through the accumulation of such "strange" behaviors and the qualitative shifts in behavior which are produced, the communication and behavior may become more and more difficult to comprehend and hospitalization may occur. Once hospitalization occurs, the same type of process may continue, with the establishment of hospitalization itself serving as a basis for interpreting future acts.[21]

To the extent that we are concerned with making predictions about specific acts in an exchange, we will have to develop a slightly different formulation than the interactionists, however. In order to account for the course of an interaction, we must find categories of acts which assure that the assignment of acts to categories is unequivocable. It is with respect to this necessity for a precise and general classification of acts that the language of the interactionists is insufficient. Up to this point in time, most of the empirical research of the interactionists has focussed on the way in which <u>particular</u> labels or identities are developed or changed in interaction. The main problem with these studies from our point of view is that they are often relevant only to the identity under consideration and they do not allow propositions to be made about the process of establishing labels or interpretations in general. One can find research on the process by which persons are identified as mentally ill or homosexual, for example, but very little regarding the similarities in the identification process for the two labels.

In those cases where general propositions are developed,[22.] they are usually formulated at a level of analysis which does not permit one to make predictions regarding the evolution of particular acts in an exchange. This is due, on the one hand, to the difficulty of measuring some of the crucial variables in a specific interaction sequence, and, on the other hand, to the limited range of applicability of some of the categories. Goffman, for example, relies heavily on such notions as "deference", "demeanor", "embarrassment" and the "rules of conduct"; all variables which are either extremely difficult to measure or they are not mutually exclusive and thus do not permit predictions regarding a particular sequence to be made.

Research Strategies

It is in trying to deal with the problem of prediction that we affect the level of our research to the greatest extent. Since we would like to develop theoretical propositions which allow us to predict over sequences of acts, we are necessarily engaged in the problem of trying to use variables which are sufficiently general to represent a wide range of actions, yet not so general as to make the propositions about those actions untestable. Since we were concerned with developing propositions regarding the effects of interaction over a series of acts, the possibility of using simulation techniques for the development of the theory was considered. Such a procedure would be a great advantage since it provides a means of reducing the time required to examine the implications of a particular theoretical model for a long sequence of acts. If one can specify a single exchange sequence with sufficient clarity to simulate it, then it becomes a relatively simple operation to see what would happen over a series of such sequences by using computer or logical techniques.

Although we will not include a full simulation of our theoretical model in this dissertation, we mention this issue because it has influenced the level of theoretical development used. Since we hope to move in the future to simulation techniques, we have utilized concepts and propositions which are consistent with such a strategy. It also means that we have been willing to propose a specific set of propositions regarding how individuals make choices even though they are hypothetical at many points. We feel that the problems of identification which such a strategy poses are offset by the advantages which it offers for theoretical elaboration of interaction processes over time.

One further effect of our concern with testing our conceptualization of interaction is that we have had to settle for research which relates to only a small part of our framework. At the level of generality in which our conceptual framework is developed, there is really no way that the entire framework can be subjected to an empirical test. As an alternative, we have decided to focus on only one aspect of the framework, develop propositions regarding it, and then subject that aspect to a test. This is a long way from conducting a "final" test of a theory, but it does provide a basis for explicating the conceptual framework in a manner which integrates theory with empirical investigation.

CHAPTER 2 - A CONCEPTUALIZATION OF INTERACTION

A basic condition with which we began this dissertation is that the persons in interaction are mutually interdependent. This means that one person's action at one time may affect not only the other's action, but through that other person, it may affect his own action at a later time. Under such conditions the identification of influence between persons over a series of exchanges may soon become very complex.

Since the complexity is seen to be the result of the interdependency and not necessarily the process by which each person chooses his action, it may be that relatively simple choice processes produce complex patterns of interaction over time. This leaves us with the possibility of accounting for a wide range of behavior by using very simple theoretical propositions about how people make choices. It is on the basis of this possibility that our strategy of conceptualization will be developed.

In addition to the effect of interdependence between interactants we have mentioned a second factor which might increase the complexity found in most interaction situations. This factor is the interpretation of acts. We have given a central position in our conceptual framework to the effect which such interpretations might have on interaction. Since we assume that the same act may be interpreted in many different ways at different times, we make it possible for a great deal of ambiguity to be introduced into interaction.

This ambiguity is not unwelcome from a theoretical point of view. It may stem from a relatively simple process of interpretation development and change, thus allowing a great deal of explanatory power to such a process. We will assume that this is the case and develop our research strategy on that basis.

Since the process of interpretation change is to be integrated into the conceptualization of the choice process, we will begin our discussion with an account of the meaning of interpretations. The particular definition we will give to this concept is designed to provide a conceptual link between a static understanding of the term and one which can be applied to a sequential interaction situation. In the process of making this link, we will also tie the notion of interpretations of sequential events to the concept of expectations.

On the Concept of "Interpretations"

We have chosen to introduce the hypothetical construct of an "interpretation" into the process of individual choice since it seems to simplify drastically the explanation necessary for phenomena such as the "minimal social situation" and the DB theory of schizophrenia.

The precedent for such a concept is found in many areas in the social sciences, from linguistics to psychology. In most of this literature, however, the notion of an interpretation is developed with regard to characteristics of objects,[23.] or single acts,[24.] rather than sequences of acts. Our problem will be to give the concept of interpretation some theoretical meaning with respect to such sequences. In order to do so, the first step will be to relate the concept of interpretation to the concept of expectation.

Coordination of activity between persons depends on the ability of each person to anticipate to some extent the behavior of the other. Before we say "hello" to a stranger, it is necessary to make some assumptions about whether he speaks our language, will welcome the gesture, or is about to attack us. Different tasks and different situations will affect the detail with which such expectations are developed, of course, but for our purposes it is sufficient to claim that some anticipations of action occurs.

In a sequence of actions, such expectations can only be generated if the present act is perceived to be a part of a pattern of action which is as yet incomplete.[25.] For example, if we saw a man board a bus we might expect that he would soon place a ticket or money in the box, since paying for a bus ride is usually part of a pattern of activity which includes such things as waiting at the bus stop, getting on, paying, etc. Should the passenger put a gum wrapper in the box we would be surprised, since that is not usually associated with the acts which preceeded it. It is this process of relating an act to previous action which we will refer to as the process of interpretation.

We may note at this point that the concept of an interpretation as we have outlined it, may be represented within the framework of an association theory of behavior or concepts.[26.]

If we interpret the process of relating one act to another as the development of a type of associational tie, the language of associations can be used. Thus, the generation of interpretations might be seen as the assignment or reassignment of weights to various associations, either at a cognitive or behavioral level. We do not intend to fully elaborate this theoretical link at this time, but it is mentioned as an indication of the possible utility of our conceptualization for other theoretical developments.

Once an interpretation of an act is made, it may provide a basis upon which expectations of future acts may be generated. Since the act is identified with reference to some pattern of events, we may expect future actions to be consistent with the completion of that pattern. Only in the case where the pattern is complete does the interpretation fail to provide a basis for generating expectations. In our example above, we might expect the passenger to proceed to a seat (or stand if the bus is crowded) after placing a ticket in the box, to signal when he wants to get off, and to get off when the bus stops. All these actions are consistent with the pattern which we might call "taking a bus ride". After the person has got off the bus, that pattern is terminated and we must look to another pattern in order to form an expectation of his action. This pattern may be more general (e.g., "going to work") or more specific (e.g., "walking"), but once identified it can provide a basis for expectation at least at some level.

In this way then, the concept of an interpretation in sequential action is linked with the idea of expectations insofar as an expected event requires an interpreted one. At the same time, we have linked the concept of an interpretation to a consideration of the acts which preceeded that action, and to the identification of that action as part of a pattern of acts. To the extent that one has identified a pattern in the acts occuring in an interaction, we will consider that he has made an interpretation of those acts. For example, if I were to perceive that all your acts toward me were beneficial to me, I might expect that they would continue to be so. As we have outlined our use of the concept of interpretation, we would consider that I had interpreted your acts in a particular manner (we have attached the label "beneficial" to that interpretation) which generates an expectation about what I might expect from you in the future.

Whether this anticipation occurs at a conscious or unconscious level is of secondary importance to the above proposition. We are merely suggesting that one treats the persons involved as if they considered the possible outcomes of their action.[27] It is necessary for them, at some level, to be aware of their own activities, the other persons' acts and aspects of their environment, but it is not necessary that all these things are consciously considered in the process of interacting.

There is one aspect of our use of "interpretation" in the example above which can be used to make the concept applicable to a wide range of issues outside of the context of sequential interaction. When we referred to the linguistic category of "beneficial" as a category which might express an interpretation of a person's action, it was used merely as a shorthand way of identifying that pattern of everyday action which I perceived. In a similar way, the use of categories which identify types of communication or interpretations of events (e.g., "angry", "helpful", "necessary") can be seen as convenient ways of identifying a certain pattern of events which one has found or expects to find. For example, we might interpret an individual's act to be "friendly", "hostile" or "confused". We will consider each of those terms to be significant insofar as it points to a pattern of action which has occurred and may continue to occur on the part of that individual. If the person's actions are generally beneficial to us, we say he is "friendly", if they are harmful we say he is "hostile", if they are unpredictable, we say he is "confused" or "confusing". By viewing the categories "friendly", "hostile" or "confused" as meaningful only with respect to patterns of action, our previous use of the concept of interpretation is shown to be related to a more common type of usage of the term.

The use of this conceptualization of "interpretations" can be found in philosophy and psychology. G. Ryle, in his discussion of human motives treated the attribution of motives as an inference from patterns which are perceived in behavior.[28] A man who is greedy, for example, is a man who in the past has always kept things for himself and who we can expect to keep things in the future. The term "greedy" becomes a convenient shorthand form of identifying a relatively complex set of behaviors.

Attribution theory can be seen as an extension of this perspective to the point where various conditions necessary for the attribution of motives or causes are specified.[29] H.H. Kelley, in his discussion of the attribution process refers to the interpretation of events as a logical operation based on a series of criteria for testing the validity of the attribution.[30] He suggests that persons utilize the four criteria of "distinctiveness", "consistency over time", "consistency over modality" and consensus" in order to establish that their attributions or interpretations about others' behavior are valid. Although the attribution theorists focus primarily on the process by which verification is established, their theory implies that attributions are representations for patterns of behavior in the same way that we have used the notion of "interpretations".

D.T. Campbell, in his discussion of attitudes implies a similar perspective.[31] He proposes that attitudes be treated as reflections of behavioral patterns, either experienced or anticipated. He suggests that by so doing, one does not lose explanatory power and at the same time one gains by making propositions about attitudes easier to test. In a similar way, we expect that such a view of the notion of "interpretations" will enable us to develop propositions regarding changes in sequential behavior.

Although none of the examples above deals in detail with behavior over time, they are all consistent with an approach which views interpretations or attributions as representations of behavior over time. In the case of attribution theory there is a distinction made between behavior patterns over time and patterns over modality, but there is no suggestion made that the process of establishing validity in each case is different. The attribution theorists are primarily concerned with the type of information considered for verifying attributions, not with the details of the process of confirmation. Our focus on this process in the second section of this dissertation may then be seen as an attempt to develop this aspect of their theory, at least insofar as the dimension of time is concerned.

Up to this point we have made a theoretical distinction between acts and the interpretation of acts, yet conceived of interpretations as reflecting the perception of certain patterns of acts. It is clear from this conceptualization that the relationship between interpretations of acts over time is not a simple one. The identification of a particular pattern of action at one time will influence the way in which subsequent acts are perceived in a sequence of action. For example, if we view an individual's action as threatening up to a certain time, we will more likely see a smile on his part as devious, than if we had perceived his previous actions to be friendly. Our response to his "devious" smile may in turn serve to increase the chance that his acts will continue to be threatening in the future. Such processes can be seen as those of the "self fulfilling prophecy" type which Merton and Rosenthal have explored in detail.[32]

When we consider the function of language in the development of interpretations, we find that there is a similar nesting type of relationship between linguistic categories as there is with the interpretation of acts over time. Just as acts may be interpreted in various ways (and expressed in linguistic categories), so can these interpretations be seen as elements of more general patterns which, in turn, form the basis for more general interpretations. This logical possibility forms the basis for the idea of a "logical level" of analysis which plays an important part in the DB theory.[33]

As a theoretical consideration, the possibility of persons developing interpretations of interpretations provides a powerful explanatory notion for complex behavior. It means that persons can identify more and more abstract patterns of events or behavior, successfully adapt to a wider variety of situations and communicate a great deal of information very quickly. For example, instead of describing the behavior one might find at <u>each</u> bus stop, one can talk about "getting on the bus", and in turn, one can talk about getting on the bus as part of more general types of interaction. The elaboration of such general patterns and the integration of them into our language may be considered as a major factor in the organization of behavior.[34]

From an empirical point of view, however, we are left with a problem. If we are to examine the process by which interpretations are identified or changed, we can never be in a position where either previous interpretations or more general interpretations do not play a part in persons' behavior. This means that we can only deal with the change of interpretations within a context of previous interpretations. For example, we will find in our experimental procedures that the instructions given to the subjects play an important role in biasing the patterns of events which they expect to find.

A Conceptual Framework for Interaction

On the basis of this account of interpretations, we can now begin to specify a general conceptual framework for information-processing on the part of individuals in an interaction. We will view persons as processors of information who interpret events and make decisions about their future actions on the basis of these interpretations. Within any situation both interpretations and decisions are not static, but shift from moment to moment. We will focus not on the substance of these shifts, but on the possible regularities we may find in the way in which these shifts occur. The behavior of a dyad is then proposed to be the result of a series of such decisions in which one decision affects the likelihood of the next occurring.

At the most general level, we are viewing interaction as the result of two individuals' cognitive systems with a communication link between them. This means that we must specify our assumptions regarding the way in which an individual might process the information he receives, and then tie them into a system of communication.

Within this framework, we will find that a convenient way of conceiving of acts of individuals is as a sequence of emissions (the acts) from a particular source (the individual). Following this lead we can then find an analogy for the problem faced by individuals in interaction in the theoretical developments of sequential analysis.[35] This is a technique of analysis for situations where one must make judgements about characteristics of the source of some emissions on the basis of patterns in the emissions which one receives. A typical problem of sequential analysis, for example, would be to make a judgement about the quality of a batch of transistors as they come off the assembly line. By examining the quality of a short sequence of these transistors a reasonably accurate judgement can be made, not only of the quality of the batch, but of whether it is necessary to continue sampling in order to satisfy a particular level of statistical confidence.

We will view the problem of interaction in a similar way. In an interaction, one is confronted with a sequence of behavior from another person, and on the basis of that sequence one must make a judgement about the likely sequences one can expect in the future. As we have pointed out in our discussion of the notion of interpretations, this can be considered the same as the problem of identifying some characteristic of an individual on the basis of his behavior. The identification of such a characteristic (e.g., he is "friendly") will then serve as a basis for the prediction of future acts on the part of that person. At this level it is analogous to the judgement of the characteristics of a population of transistors on the basis of a sequence observed from that population. The characteristic of the population, once identified, serves as the basis for generating expectations about future occurrences.

In a situation where the source of emissions is unchanging, the problem of identifying characteristics of the source may be relatively straightforward. However, we would like to develop theories about an interaction in which one person's action may affect the state of the other and thus the nature of the other's responses. The situation then becomes more like that of the social science researcher whose measuring technique affects the variables he is attempting to study.[36] The very process of trying to find out what produces the behavior studied ends up affecting its nature.

This possibility makes the research problem extremely difficult, for ourselves as well as for our hypothetical social scientist. However, to include it as a central feature of interpersonal interaction makes it a very powerful explanatory concept. Most of the literature on the self-fulfilling prophecy[37] for example, postulates a mechanism of feedback such as the one we outlined above. In this case it is proposed that the expectations of an individual (as reflected in his behavior) are a major causal factor of his expectations being fulfilled. In the interactionist literature as well, the development and maintenance of deviant careers is often considered to be dependent on a similar process.[38] In this case, the identification of a person's behavior as "strange" and the subsequent reactions to his behavior on that assumption is considered to be a main factor in the labelling of that person as "mentally ill", "homosexual" or in some other way "deviant". Each action in the exchange taken one at a time is not sufficient to account for the development of the label, but it is the result of an accumulation of exchanges; each one moving the relationship farther and farther from its original position.

Individual Cognitive Operations

In order to complete the general conceptualization, it is necessary to make some specific propositions regarding the way in which the individuals in an interaction will process the information that they receive. The processes we will introduce are based on the general interaction model suggested above, but they introduce features of individual behavior which will allow us to make predictions about specific types of behavior.

As the general conceptualization suggests, persons are expected to identify some characteristic of the other individual on the basis of his behavior, and then use this characteristic as a basis for the prediction of future acts by that person. This suggests a two-step model for individual action; the identification of a characteristic or characteristics, and the choice of action based on that identification. The processes involved in each of these steps might be very different.

In our discussion of the concept of interpretations, we had suggested that the identification of a characteristic might be considered equivalent to an interpretation of a sequence of acts as part of a pattern of acts. Through such a process, past actions become associated to present ones and to the possibilities for future actions. If, for example, on the basis of a number of unexpected reactions, we had come to question our interpretation of our friend's behavior, we might try to find some interpretation which would make sense of those reactions. If one is found, it would allow us to identify those reactions as part of a pattern and to form a basis on which future actions might be anticipated. This identification of some past action as part of a pattern is the first step of the two-step process. We will refer to this as the "interpretive process".

The second step of the individual's cognitive operations is one which generates a response on the basis of the interpretation made in the first step. Once we have decided that our friend is "upset", and even if we interpret it as a sign of his recent divorce, (for example), we are still in a position where we have many possible courses of action for responding to him. The interpretation we have made does limit the range of responses to some extent, but it is not likely to be sufficient to account for the actual response we make to him. The process by which this final response is made, we will refer to as the "decision process".

Whereas in the interpretive process we will emphasize theories of perception and cognition, in the decision process we will utilize theories which involve the consideration of utilities, preferences and outcome likelihoods. In both of these processes, we will rely to a great extent on theories of learning in order to account for the way in which associations between actions and interpretations are developed and changed. The specific theories which we use will be discussed as we detail the two processes.

Divisions similar to the two processes we have identified are not new to the psychological literature. For example, D.H. Lawrence suggests the possibility of introducing a "coding response" into the stimulus-response paradigm.[39] By the "coding response" he refers to an operation which codes sensory input into a particular code item. This means that the stimuli are transformed according to a set of rules into some kind of representation of the stimuli, much like the behavior of the Other in our formulation is transformed according to the interpretive process into an interpretation of the behavior. It is this representation of the stimulus (in Lawrence's terms, the "stimulus-as-coded") which is directly associated with the overt behavior.

There are as well a number of theories of signal detection which make a distinction between an activation process and a decision process.[40] Since the characterization of each of these processes is usually in the symbolic language of mathematics, they have in general, wide applicability and the possibility of encompassing several different substantive theories of the process. Many different processes may be invoked for the manner in which the transformation probabilities might be developed and changed. Most of these signal detection theories locate the learning process (which involves changes in the transition probabilities) in the alterations of the parameters in the decision process alone. Since the activation process in these models is most similar to the interpretive process in our theory, the fixed parameters in that process will not provide the opportunity for change which the interpretive process proposes. In spite of this, however, the formal techniques demonstrated in signal detection theory are useful for the derivations from the model which we will specify.

In the literature of physiology as well, there is some indication that individual action might be usefully seen as the result of two major steps. As a result of investigations of speech defects, A.H. Luria, suggests a differentiation between an instruction centre and an action centre to account for certain behavioral problems.[41.] His work focuses primarily on the function of speech in the formulation of instructions for action. The evidence in his investigations suggests a close relationship between speech instruction and the ability to act, particularly at a cortical level, or where subcortical damage has occurred. Both levels appear to operate quite independently, even to the point where one can take over some functions of the other should there be the need.

Another physiological study by H.R. Schaffer makes the same distinction between cortical and subcortical activity and suggests that stress may increase the amount of subcortical activity in problem-solving.[42] Both of these formulations are consistent with a division of action into two major areas; one having to do with complex conceptual operations (involving strong ties with language) and one having to do with simpler operations such as those proposed in association learning. The former is analogous to our "interpretive process" and the latter to our "decision process".

A Model for Interaction

In the development of our conceptualization we have made a distinction between an individual action process and an interaction system. That this distinction is somewhat arbitrary is reflected in the specification of the individual action model which follows. The first two elements of the model refer to concepts which are not simply about individuals, but about the links between persons. The first limits our concern to individuals in interaction and the second provides a basis for communication between persons. These two elements are necessary in order to move from individual action to dyadic interaction. They occur at this point in the discussion because they are basic elements of the individual action model.

We will present the action model in the notation of set theory. This is meant more as an heuristic device than as an attempt to present a formal theory of action. It will allow a reasonably clear reference point for the elaboration of the conceptualization in the future, as well as a means of integrating possible disparate research enterprises. A similar format will be adopted when we come to operationalize various aspects of the conceptual framework in the second section of this dissertation. We will identify particular assumptions which we feel are central to the operationalization, but we will not provide an account of all the assumptions made in the process.

S.1. Set P = {x,y,z,...,q}

This set consists of the persons or groups in the interaction.

Up to this point we have mentioned only two individuals in our discussion. The specification of set P allows the possibility of three or more persons to be included in the interaction. Although we will not develop this condition in this dissertation it is not without plausibility and for this reason we allow the general statement of the conceptual framework to include more than two.

The interaction system as it is specified may also be applicable to groups, and the relationship between groups. There are several examples in the literature of political relations where models of individual relations have been fruitfully applied to the relationship between groups.[43] For this reason, we are leaving open the possibility of including groups in the model.

S.2. Set C = {a,b,c,...n}

This set refers to communicative acts which persons may perform.

For our purposes, a communicative act must be recognizable by all the interactants. By recognition we do not mean to imply conscious awareness only, but include as well perceptions of activity 'below' the conscious level. The central consideration is that the activity must be available for perception and not hidden to view or below some threshold of recognition. In this way each act has a potential for influencing the other person. One line of empirical investigation would be the identification of those factors which influence such perception.

It is clear that the definition of an act at this level leaves a great deal to be desired insofar as clarity is concerned. Our strategy will be to tolerate this unclarity at this point since it allows a wide range of application, but to place severe constraints on it when it comes to the formulation of a particular example.

S.3. Set I = {i,j,k,...p}

This set consists of interpretations which may be assigned to communicative acts.

In order to form a basis for developing the notion of interpretations as a coding process, we will take a slight diversion in the discussion.

The idea of a code was originally used in theories regarding the communication of information. In that context, it referred to the process by which language, or the elements of a language, were transformed into another set of elements. For example, the code devised by Morse was one which transformed letters or sometimes words into sequences of sounds or lights of a certain duration. These sequences could then be transmitted by means which the original letters or words could not. (E.g., light or electrical impulse) The code consisted of a set of correspondence rules regarding the letters and sequences. So long as the persons at both ends of the line used the same rules, messages could be sent and understood.

Since that time much work has been done on the characteristics of codes themselves.[44] This work has generated a set of theorems and conceptualizations of the implications of codes which makes the term useful for many other situations besides the transmission of messages in a narrow sense.

A crucial aspect in the expansion of the notion of code has been the link between codes and structure or pattern. Codes impose a structure on otherwise random events. This may be done in a number of ways. A code may extract only certain aspects of the event in the way that an ear responds only to physical vibrations or a ruler is sensitive only to distance. In the former example, the mechanisms of the ear transform an event into vibrations and eventually electrical impulses to the brain. In the latter example, the ruler transforms the event into a value on a scale. By the utilization of a code, the events which occur are transformed into some other event which is part of a pattern or structure of events.

Such a coding operation is consistent with our view of the way in which meaning is given to events in an interaction sequence. We will assume that the events which occur are nonmeaningful to the interactants until they are associated with patterns of acts which the actors conceive. The identification of such patterns can be considered as a type of coding operation in which events are related to other events.

There are a number of ways in which we might analytically represent the pattern or structure of such coding operations. Each representation involves two factors, however: a set of code items and a set of rules of correspondence between events and the code items. The rules of correspondence may be represented in two different ways, although at a theoretical level they are equivalent. First of all, we might think of the code as a set of constraints on the distribution of possible interpretations in some situation. In this formulation, the focus is on the relative likelihood of certain events with respect to other events. This comes to us from the formulation of information theory and the definition in technical terms.[45] A second method is to speak of a code as a set of rules. The rules are used to guide us in the assignment of events of one type to events of another. A good example of this type of code is the transformational grammar developed by Chomsky.[46] Both of these interpretations of a code will be dealt with in more detail when we come to discuss the relations between acts and interpretations.

In summary, there are two aspects of our digression which are important to the discussion. First, is the relationship between the notion of a coding operation and the notion of structure. Second, is the equivalence for our purposes of the notion of a code, a constraint and a rule or a set of rules. These terms all may be used to specify a relationship between two or more events.

In the language of our basic model, the set of interpretations constitutes the set of code elements which are available to the interactant. From the previous discussion, we can see that the coding operation links the communicative act to a pattern of other acts. For example, when we identify an event as a "foul ball", we conceptually link it to all the other activities, events and persons who are included in the game of baseball. Similarly, when we interpret a person's actions as those of a "teacher", we imply a wide variety of other related activities on the part of other persons, such as "students", "administrators", "parents", etc. Clearly, the substance of these associations will shift according to time, social and cultural factors, but the theoretical structure remains the same.

The most typical identification of code items comes from the language that persons use. At this point, it is not crucial to our theoretical model whether the code items are strictly identified with particular linguistic categories used by either actors or analysts. Rather than limit ourselves by introducing such substance into our discussion, we will tolerate the empirical ambiguity of the concept until we come to test various aspects of the model. It is important to note, however, that the notion of a code does provide a basis for relating language and communication to our model.

The mechanism for theoretically relating a communicative act to a code item will be referred to as the "coding process". This process is represented by means of the following definition.

R.1. IN is a quaternary relation, in particular, a subset of $P \times C \times P \times I$ such that $(x,a,y,i) \in IN$ iff $x \neq y \wedge$ person y interprets act a by person x as i.
The relation IN is the coding process mapping communicative acts of person x to interpretations by person y.

This relation provides a technique for the specification of constraints on the possible interpretations which may be associated with acts. The coding process for these acts can be represented by means of a specification of the nature of IN.[47] Constraints on this coding process become constraints on behavior to the extent that the process limits the response alternatives available.

R.2. OUT is a quaternary relation, in particular, a subset of $P \times I \times C \times P$ such that $(x,i,a,y) \in$ OUT iff $x \neq y \wedge a$ is a communicative act which person y does after x does an act which is interpreted by y as i.
The relation OUT is the link between interpretations and communicative acts by person y.

This relation represents the "decision process" in our model. It is the process which associates interpretations with acts for each person in the interaction.

Both of these relations refer to the logical structure of our conceptual framework rather than to propositions which constrain the associations possible. Since these associations may be represented in many different ways we will digress at this point to make clear the way in which we will portray them.

Representation of Associations

A general representation of the relations IN and OUT taken independently may be made in a pictorial way by representing associations from some elements to others as lines. In the case of IN the elements would be those of set C and set

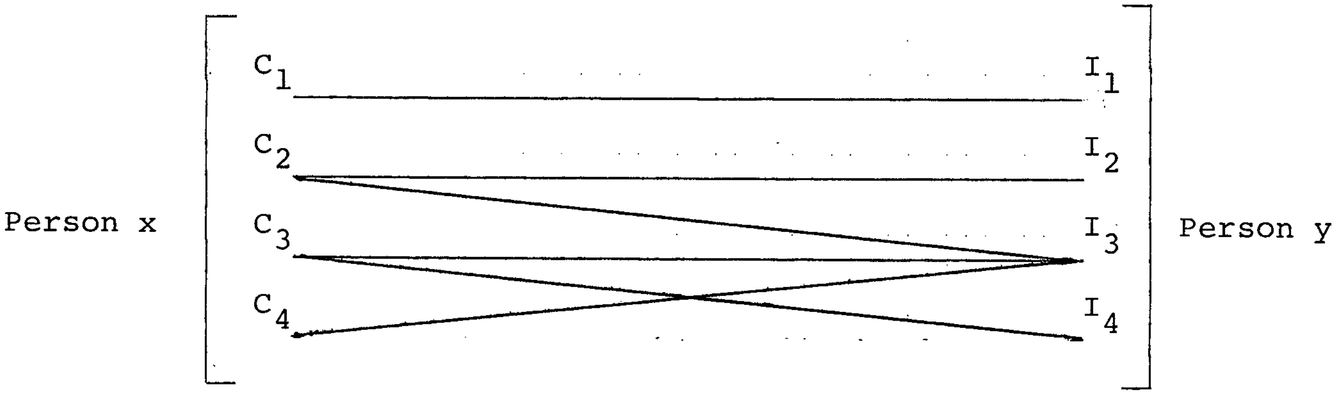
I; that is, acts and interpretations, Figure 2.1 represents one possible arrangement of such associations. As a set of ordered quadruples the same arrangement may be represented as: $\{(x,C_1,y,I_1),(x,C_2,y,I_2),(x,C_2,y,I_3),(x,C_3,y,I_3),(x,C_3,y,I_4),$ $(x,C_4,y,I_3)\}$

There are several features of this particular relation which are noteworthy. One act may be associated to more than two different interpretations, (e.g., C_2 is associated to I_2 and I_3; C_3 is associated to I_3 and I_4). Similarly, more than one act may be associated to one interpretation. (e.g., C_2,C_3 and C_4 are all associated to I_3). The representation of a verbal statement in this way requires a greater degree of precision than a linguistic form. As a result, it becomes a relatively easy matter to move to mathematical and formal representations of an interaction process.

Although the representation of associations up to this point has been made in a deterministic fashion, it would be possible to assign weights to the associations at a later date. Such weighting procedures could be used to represent the likelihood for the occurrence of certain associations. In the interests of parsimony, we have decided to begin the development of our model without such a feature, however. It is worth noting that a future structural elaboration

Figure 2.1

Graphic representation of associations



might utilize this possibility.

This particular conceptualization of relations between interpretations and acts has, as well, the advantage of theoretically linking cognitive relationships with learning processes. On the one hand, we have assumed that learning involved the establishment and alteration of associations between interpretations and acts.[48.] At the same time we have considered that interpretations may be represented by the language symbols or signs which are used as a basis for theories of cognitive structures.[49.] The relations (IN and OUT) then, represent certain aspects of the structure of associations assumed by these theories.

We do not want to elaborate in detail these aspects of our model. They are raised at this point for two reasons. First, it is a suggestion of the way in which theoretical links might be developed with these other areas of theoretical development. Second, it will provide a context for our decision to treat interpretations as part of an established system of alternatives in the conceptual and empirical development to follow. In other words, we will assume that the interactants are "educated" to some extent, that is, they have had a sufficient history of interaction to develop a set of associations between acts and interpretations.

CHAPTER 3 - THE PROCESS OF CHANGE IN ASSOCIATION

Now that we have provided a general account of the interaction system, we are in a position to elaborate various aspects of the processes involved when associations between acts and interpretations, and between interpretations and acts change. The reason for focussing on this aspect of the general system is because of our concern for the way in which a sequence of interaction may change over time. In order to make propositions regarding the direction of an interaction sequence we must be able to identify the way in which one person's action affects the other. Since our conceptual framework just presented locates changes in acts in the relations IN and OUT, it is here that we must begin to elaborate our conceptualization.

Since we have limited our discussion to those situations in which the persons are attempting to coordinate their behavior we can view this change as a type of learning process. At each point in the interaction the persons involved are trying to learn what are the "appropriate" actions for that situation. That is, each person is attempting to identify which actions will result in coordination. We may view him as a person involved in the solution of a puzzle which may keep shifting. At each point in the interaction he must make a judgement regarding the type of action which will produce a beneficial joint outcome. In order to do so, he must make some assumptions about the pattern of action which the other person is likely to make, and then adjust his own action to that pattern.

For severely constrained situations, this is usually not too difficult a task. However, most interaction situations are not limited to such a large extent. Each action that a person makes raises the possibility of shifting the pattern of action he might expect from the other. In addition, patterns of action may be identified at many different levels at once. Thus the monitoring of feedback from the other person becomes a crucial process. It is to the effect of feedback that we will now turn.

The manner in which this feedback is handled will be a major influence on the way in which an interaction between persons may proceed. If, for example, judgements regarding the other person are made quickly and altered with little evidence to support a change, we might expect the relationship to be more difficult to coordinate than one in which judgements are formed and altered slowly. In addition, if the judgements based on information at a concrete level of specificity contradict with those based on information at a more abstract level, we might find typical processes or strategies emerging which the interactants use to resolve the issue. By focussing on the way in which such feedback is handled in a sequential situation, we hope to be able to formulate propositions regarding the likely manner in which an interaction sequence will proceed.

In terms of our basic model, the structure of associations which will be altered by feedback can be represented by changes in the relations IN and OUT. Our first research question then is:

> In what ways might the relations IN and OUT be altered by feedback?

It will be apparent from our discussion that we are not concerned at this point with changes in associations which occur when there are more than two persons involved in the exchange. We are concerned rather, with the changes in the associations between acts and interpretations (in the relation IN) and between interpretations and acts (in the relation OUT). More specifically, this means that there are only two persons in the set P. This condition will apply for the remainder of our discussion.

Theoretical Background

At this point we will provide a relatively simple account of the interdependence between IN and OUT as a first step in the elaboration of interaction. The direction for such an account was suggested by both an experimental and a theoretical piece of work.

Peterson and DuCharme were interested in the extent to which persons used information efficiently when changing their inferences regarding the validity of various hypotheses.[50] They conducted a series of experiments in which subjects were asked to estimate from which urn a series of balls were selected. They were given information regarding the total distribution of coloured balls in each urn, and as the balls were picked out they were to give their prediction of the urn from which the balls were drawn, along with the likelihood of the estimate being correct. A comparison was made between changes in likelihood using Bayes' theorem and the data from the subjects. Subjects showed a "primary effect" in their selection of urns; once they had chosen an urn, they were more resistent to change that choice than the predictions based on Bayes' theorem.

Although our model makes no predictions regarding the likelihood functions, the Peterson and DuCharme findings show one effect which is relevant for our discussion. It is the conservative nature of estimates in the face of contradictory evidence.[51] If we see an analogy between persons and their acts in the interaction model, and urns and balls in the Peterson and DuCharme experiments, the two conceptualizations become related. Just as the sequence of balls provide some information regarding the composition of the urn, so do a person's acts convey information regarding aspects of his "nature". Given this analogy, the experimental results support a view that individuals are reluctant to change established interpretations regarding the source of acts, at least with respect to the standard of change suggested by Bayes' theorem.

The Nature of the Change

On the basis of this experiment, we looked for a way in which the stability of the type found could be introduced into our model. The simplest way was to propose that shifts in

IN relations were less likely to occur after an error in coordination, than were shifts in OUT relations. There are two bases for suggesting this particular relationship between IN and OUT relations. The first is an argument from the point of view of information-processing efficiency, and the second is an argument raised by Lawrence in his definition of the coding response.[52].

If we consider the information-processing aspects of individual action, we find that some forms of change on the basis of feedback are less costly to the individual than others. Upon the occurrence of an error in coordination, the individual has the option of changing his interpretation of the past event, changing his choice of action based on that interpretation, or changing both. A person, for example, who suddenly finds his friend showing a great deal of hostility toward him has the option of altering his definition of the other from "friend", to perhaps "enemy", maintaining the definition of "friend" but altering the type of action he will make toward him (being a little more defensive, perhaps), or altering both his definition and his action.

If he changes his interpretation, he most likely will have to reassign meaning to events which have already occurred in the interaction or in similar interactions. Assuming that the relationship has developed over some time, or that similar relationships have been experienced, we would expect that many other events beside the specific hostility are associated to the interpretation "friend".

If one were to redefine the relationship from one of "friendship", therefore, one would also have to reinterpret many other actions which have occurred up to that time. "Gifts" which had been exchanged, for example, would have to be reinterpreted in the light of the new events to perhaps "bribes". Past expressions of affection, in addition, would have to be reevaluated as false. We make this statement on the presumption that individuals attempt to maintain at least some consistency in their interpretation of events.

Even if we reinterpret the relationship as one which was friendship, we escape the problem of redefining past events, but we introduce a great deal more uncertainty into the future occurrences of events which we would have up until that time interpreted as signs of friendship. In addition, we may be forced to reinterpret our relationships with other "friends" as more uncertain.

To change the choice of actions based on relatively stable interpretations involves the adjustment of fewer factors, however. Within the framework of an interpretation there may be many different actions which are consonant with that framework. To move from one to the other may mean a shift in utilities or an adjustment of the outcome likelihood for a particular event, but it does not necessarily mean the adjustment of whole classes of events. The alteration of the interpretation of whole classes of acts may be a rather costly task, both in terms of the time and the problems it creates for stabilizing expectations.

On this basis, then, we are proposing that the most efficient strategy for the information processor is to try a new action before changing the interpretation of the other's past acts. The option of changing both acts and interpretations falls into third place with respect to efficiency since it involves an addition of the costs of both types of changes.[53]

This propostion is similar to D.H. Lawrence's view when we recall the theoretical similarity between his notion of the "stimulus-as-coded" and our notion of interpretations.[54] In his definition of the coding response (the IN relation in our model) he assumes that the response is a reaction, controlled by factors other than the proximal stimuli in a particular situation. In this way, he ties the coding rules to the more stable and unchanging aspects of the situation and the action based on the stimulus-as-coded to the critical or changing aspects of the situation.

By doing so, he provides a reinterpretation of many problems in perception and learning such as the continuity-noncontinuity controversy in learning theory, the measurement of redundancy at the psychological level, shifts in stimulus-response relations as a function of contextual changes, stimulus similarity and transfer of learning issues.[55]

A similar distinction exists in the theory of the attribution process as specified by H. Kelley.[56] Following Bem[57] and to some extent, Skinner,[58] Kelley suggests that the behavior of persons might be separated into two classes.

The first is that class of behaviors which are associated to relatively stable entities in one's environment. It is proposed that this first class of behaviors is largely shaped by social training and is epitomized by naming responses and descriptive statements. The second class of behaviors includes those which are associated to specific properties of the situation of action in which one is located. These are presumed to be responses under the control of specific reward/punishment characteristics of the situation insofar as the actor is concerned.

They propose that the first class of behaviors can be recognized as such by their consistency over time. A type of behavior which is guided by previously learned conceptual categories (e.g., the difference between high and low status) can be recognized by its consistent occurrence at different times and places. For example, if I am observed to show deference to university teachers in a wide variety of situations and over a long period of time, one would be led to conclude that my behavior in that regard was guided by the social category of the teacher rather than by the specific reinforcement contingencies in each situation.

On the other hand, behaviors of the second class are not necessarily consistent over time or situation, but they shift depending on the specific array of reinforcements in each situation. If I did not always show deference to university teachers, for example, but only when a strong reward or threat was apparent in the situation, one could conclude that such deference was within the type of behavior belonging to the second class.

If we were to simply identify our notions of the "interpretive process" and the "decision process" with that of the attribution theorists' conceptualization of stable and proximal features of a situation, we would have a basis for proposing that the changes in the "interpretive process" are less likely to occur than changes in the "decision process". However, our concern with interaction creates special problems for such an identification. Since we have linked interpretations to patterns of action which may occur within an interaction, it is very difficult to clearly establish the difference between stimuli which are linked to a specific situation and those stimuli which are linked to non-proximal features of the situation. Take, for example, a situation in which two strangers are interacting. Presume as well that on the basis of that interaction, at least one of the persons comes to the conclusion that the other person is his friend. (i.e., he makes an interpretation at time t). If we were to accept Lawrence's or Kelley's conceptualization and identify non-proximal features of the situation with interpretations, we would have to identify the behavior occurring before time t as behavior which is not proximal to the situation, since it was on the basis of this behavior that the interpretation was made. This would make the distinction between proximal and non-proximal stimuli useless since at any instant in time, all previous action <u>may</u> be considered non-proximal if an interpretation is made. Thus the identification of an interpretation itself defines what is non-proximal (and proximal) and nothing is added by the introduction of these terms. It also makes the propositions of attribution theory inappropriate, since they focus on the notion of consistency over time. If proximal stimuli are only those relating to the instant of interpretation formation, one cannot establish whether there has been consistency in response over time.

In order to avoid this problem, we must propose a model for the formation and change of interpretations (the IN relation) which permits this change to be dependent on the action (or stimuli) within the interaction itself. Since the same action may also be the basis for changing the OUT relation, the relative stability of the IN relation must be accounted for by the structural features of the IN and OUT relations themselves. Somehow we must devise a model in which the IN relation is relatively sensitive to <u>patterns</u> of action but not <u>specific</u> acts, while the OUT relation is sensitive to the specific acts in the interaction.

We might note at this point that the above argument does not mean that we must exclude from either the IN or the OUT relations, the effects of stimuli outside of the acts themselves. Rather, we have simply focussed on the weakness of the Lawrence and Kelley conceptualizations when it comes to dealing with the acts in an interaction sequence. Since this type of sequence is our primary concern at this point, we have felt that a model for changes in the IN and OUT relations which does not deal with behavior in a sequence must be rejected in favour of one which does.

The Process of Change

One way in which we might build into our model a greater degree of stability for the IN relation over the OUT relation is by means of a threshold model for changes in the IN relation. The theoretical development of such a model has been done to a large extent in the literature on sequential analysis.[59.] This may mean that it will be most appropriate for the type of situation that we are likely to find in interaction. If we allow interpretations to shift only after a particular threshold of responses is reached, we provide for the possibility of a conservative effect in interpretations. This effect stems from two sources. First, it is a result of the lag between the feedback and the effect of feedback. Small changes in the environment show no effect under a threshold model until they pass the point of activation. Between friends, for example, we will often find a great deal of tolerance for acts which in other circumstances may be defined as hostility and betrayal before the friendship might be redefined by the participants. Using the notion of a threshold, we can see those acts of hostility which precede the redefinition of the relationship, as acts which were not sufficiently numerous or severe enough to pass the threshold at which reinterpretation will occur.

The second factor which makes the threshold model resistent to change is a result of the structure of the basic action model. A particular interpretation at time 1 will affect the possibilities for response at that time. In addition, it will affect the impact of the other person's response, since an interpretation of the other's response determines the significance of that response. For example, if we identify an other as a friend, his behavior may have a very different meaning in terms of our responses from what we would give if we identify him as a foe; even if his behavior is the same in both cases. An extreme form of this conservative effect is found in the case of paranoia, where the interpretation of others' actions provides evidence for the validity of that interpretation. We thus find it extremely difficult to alter the interpretations made.

On the other hand, the decisions made on the basis of a particular interpretation (specified in our model by the OUT relation) might be expected to follow some of the patterns of a more simple choice model. Under such a model, error in judgement might be followed immediately by an alteration of the action made, without the delay which a threshold model might imply. It is a relatively straightforward matter to extend a simple choice model to sequential interaction by using some of the models available for simple learning behavior.[60]

This particular formulation of the details of the IN and OUT processes is also reasonable in the light of the action interdependence expected between interpretations and decisions. The interpretive process is a recursive process over time in that its alteration involves its own previous state. Feedback which may reflect on the utility of a particular interpretation is itself subject to a particular interpretation. If we see the other as a friend, for example, we are more likely to interpret his acts (the feedback) as friendly, than if we see him as an enemy. Events which have the potential to reinforce or alter a particular interpretation are themselves dependent on the same interpretation.

In addition to the interdependencies of the interpretive and decision processes we expect to find that the individual processes of the two different persons in an interaction are not independent. A pattern of action by one might be changed as a function of the other's behavior, but it is clear from our model that the possibility of change is a function of the interpretation which the first person has made of the other's behavior. Similarly, the likelihood of a particular interpretation by the first is a function of his own past acts, but they are also a function of the other's action.

It is the interaction between these two change processes that we find most intriguing. The effect of such an interdependence over time might be to move interaction sequences in directions which are not obvious from the point of view of the process involved or from the initial states of the persons involved. It may be that the decision and learning processes are relatively simple and that the complexity of interaction is introduced by the concatenation of these processes and the repetition of them over time.

In summary then, we have chosen two general types of processes to represent the interpretive and decision aspects of individual behavior. We are proposing that the interpretive process is a threshold type of mechanism in which changes are made only after a threshold of some level of excitation is reached. This proposition is made in order to introduce some stability in the interpretive process. The decision process on, the other hand, is assumed to operate in the manner of a simple learning mechanism such as the stimulus sampling models in psychology. This will allow us to represent the sensitivity of individual behavior to shifts in the environment as evident in searching and decision making behavior.

SECTION 2

CHAPTER 4 - OPERATIONALIZING THE THRESHOLD MODEL

In this section, we will begin the process of operationalizing various aspects of the general framework developed in Section 1. Since the general framework can be operationalized in so many ways, there is really no way that it can be tested in total. As an alternative, we have chosen to focus on one small aspect of the general framework and subject it to empirical investigation. As a result of this investigation, we hope to be able to make more aspects of the general framework applicable to research and in this way both test and refine the more general conceptualization.

As a research strategy we will focus on the process of exchange in the interpretive process and attempt to eliminate the effects of the decision process. This strategy is adopted under the assumption that we might be able to identify a relatively simple process for interpretive change, at least at the structural level. Once such a process is identified we can then move on to an examination of the decision process as distinct from the interpretive process and finally to the concatenation of the two in interaction. At each step of the research the results will, of course, influence our elaboration of the conceptual framework for interaction.

In this dissertation, we will only begin the first step. An investigation of the process of interpretive changes will be made through the use of two threshold models for choice.

These models will be subjected to experimental investigation in order to establish their utility for explaining interpretive changes.

The Threshold Model

In our conceptual framework we propose that the process of interpretive change involves the operation of a threshold model of choice. The variety of such models is enormous if one identifies the choice process specifically. Rather than begin such a search, therefore, we began to look for a classification scheme of threshold models which would reduce the alternatives into classes.

A classification of threshold models which seems to satisfy our requirements is suggested by Audley and Pike in their discussion of choice behavior.[61] Their classification reduces the number of models to a set of mutually exclusive types. By an examination of each of the types we can then make a more plausible choice of a particular choice model for interpretive changes.

In all of their suggested models, the actual value or location of a threshold for change is variable, so that it can be adjusted to include all or some of the alternative behaviors which might be associated with a particular interpretation. The difference in their models then, is not in the actual level of the threshold (i.e., the amount of information it takes to change one's mind), but in the manner in which confirming or contradictory information about an interpretation is handled. Two main classes of models are suggested: one in which a choice is made when an absolute threshold of information is reached and one which makes a choice when a difference threshold is reached. In the first type, evidence for and against is added separately in two subsystems and the subsystem to reach a predetermined threshold activates a choice. In the second type, evidence of one type 'cancels out' evidence of another. This proceeds until one type predominates sufficiently to reach a predetermined threshold and a choice is made.

For example, in a binary choice situation, the individual is conceived to be processing information which supports either a choice of 'A' or a choice of 'B'. This information is assumed to be reaching him as a sequence of units. The absolute threshold mechanism will activate a choice when the units related to 'A' reach a particular number or when a particular number of units of one type occur in a row. (E.g., "When 10 events of type A occur, I will choose the act associated with A"; "When 3 events of type B occur in a row, I will choose the act associated with b".) The difference model activates a choice when the units associated with one act exceed those associated with other acts by a particular amount. (E.g., "When 3 more A type events than B type events occur, I will choose A".)

Within each of these models, there are a number of alternative specific models, but each class serves to put the specific instances into a more general framework. For our purposes, this level of formulation allows us to link our interaction model to research in areas which are reasonably well developed, and to identify areas of crucial significance to our theory. This can be done only if we establish the links between the conceptualization suggested by Audley and Pike and our model.

The decision theories suggested by Audley and Pike deal primarily with theories about individual decisions as a function of the stimulus environment. For that reason, they view choice as the result of a sampling of elements of a stimulus. Elements as they are used in such theories are hypothetical concepts which may or may not be directly associated with specific empirical events. For example, one stimulus may result in only one element being sampled by an individual, or it may result in a group of elements being sampled. It is on the basis of these elements, not necessarily the stimulus alone, that a particular choice rule is used to make the decision.[62] Within each empirical study then, the elements must be identified.

Rather than dealing with single choices, however, we are concerned with interaction over a series of exchanges. For our purposes, the language of sequence sampling is more appropriate than the exact form of the Audley and Pike models. To use this language, we must alter the choice models only slightly by referring to sequences of acts over time rather than sequences of elements sampled from an event at one point in time. This is consistent with the notion of a stimulus element, although we may want to vary it from a strict one-to-one relationship between an element and an act. After making this general change we are in a position to use the conceptual tools of choice theory in our analysis of interpretive changes.

Our objective at this point is to conceptualize the interpretive process in such a way that we have a basis for proposing a point at which change in that process might occur. Since we are suggesting a threshold model, the conceptualization requires at least two elements: a unit of activation or element of stimulation and a rule for the identification of the effect of the stimulation. The unit of activation is necessary in order to represent the way in which events relate to the interpretive process. The rule for the effect of stimulation must be established at some level in order to identify a threshold.

As a general theoretical language for these two elements, we will adopt those specified by Audley and Pike. Events (or "other's behavior" in our conceptualization) are assumed to activate units of excitation with a certain probability. These units build up in "subsystems" associated with each of the available responses. In our case, the responses are interpretations, the units of excitation are hypothetical concepts, and the events are left to be identified in particular substantive situations.

As an example of the way in which this general theory may be given substance, we may identify the events as errors in a simple learning situation. A particular interpretive "subsystem" (e.g., "I am learning") may allow a certain number of errors to occur before a success is made. Beyond that maximum number of errors, however, the subsystem will shift to some other one (e.g., "I am not learning").

The account of choice models provided by Audley and Pike can be used to make a very efficient use of the experimental procedure. If we can develop a test which will distinguish between the various classes of choice mechanisms which are suggested, we may be able to eliminate from consideration a great number of choice models as unreasonable. From the point of view of theoretical development this appears to be a most desirable possibility.

The focus for the classification of models which Audley and Pike use is the specification of alternative decision rules for the point at which the process moves from one subsystem to another. They suggest two classes of decision rules. In the language of our model in which subsystems are identified with interpretations, the decision rules may be specified in the following manner.

1. Absolute threshold: In this model, an interpretation will be made as soon as its subsystem has gained a certain number of events as support.

2. Difference threshold: In this model, an interpretation will be made as soon as its subsystem has gained sufficient support events to exceed all other subsystems by a given amount.

The absolute threshold models are subdivided into two further classes by Audley and Pike.

1a. The simple accumulator: In this model, each subsystem accumulates support until one reaches a common threshold value k. The interpretation is made and the total system reverts to the original values.

1b. The runs model: In this model an interpretation is made only when an uninterrupted run of k units of support is received by a particular subsystem.

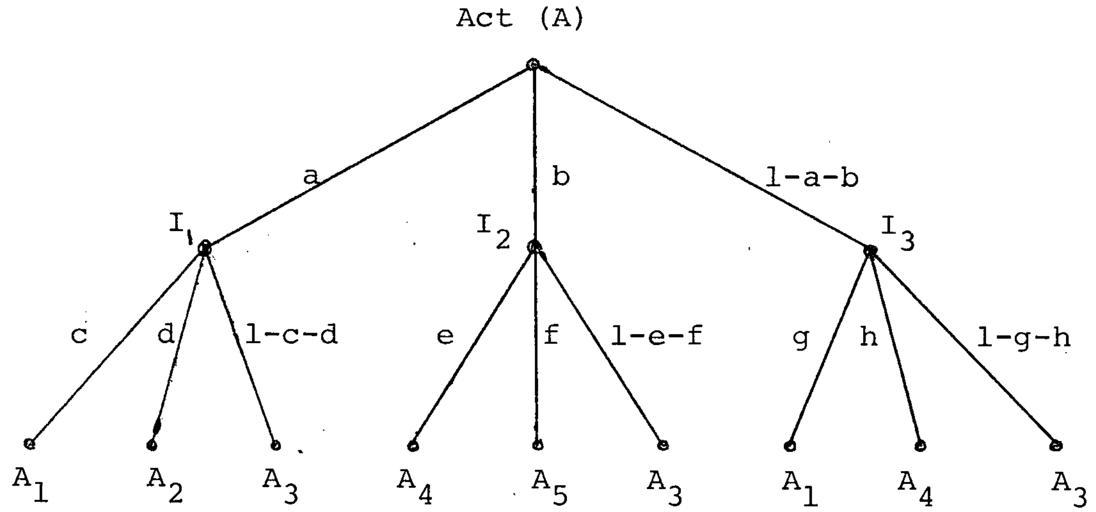
This classification then provides us with three models of the way in which interpretations might be activated or changed; the simple accumulator, the runs model and the difference model. Of these three, the simple accumulator can be rejected from consideration as a likely model to account for interpretation changes. This model assumes that the person choosing is sensitive only to the total number of events for and against a choice and not to the order of occurrence of those events. It makes no provision for the effect which might be evidence against the choice, at least up until the threshold value. For that reason we have decided to limit our research to an investigation of the comparative utility of the runs and difference models.

Representation of the Individual Process

In order to facilitate the discussion of the experimental design and to limit the range of possibilities for the models, we will develop a representation of the interpretive and decision processes in a limited manner. This representation will provide a basis for moving from the general theory to a more specific account of the individual process.

We will deal for the time-being with a process involving two persons, three mutually exclusive interpretations for each person, and three alternative responses for each interpretation. The array of possibilities for one of the interactants can be represented by the branching process in Figure 4.1.

Figure 4.1



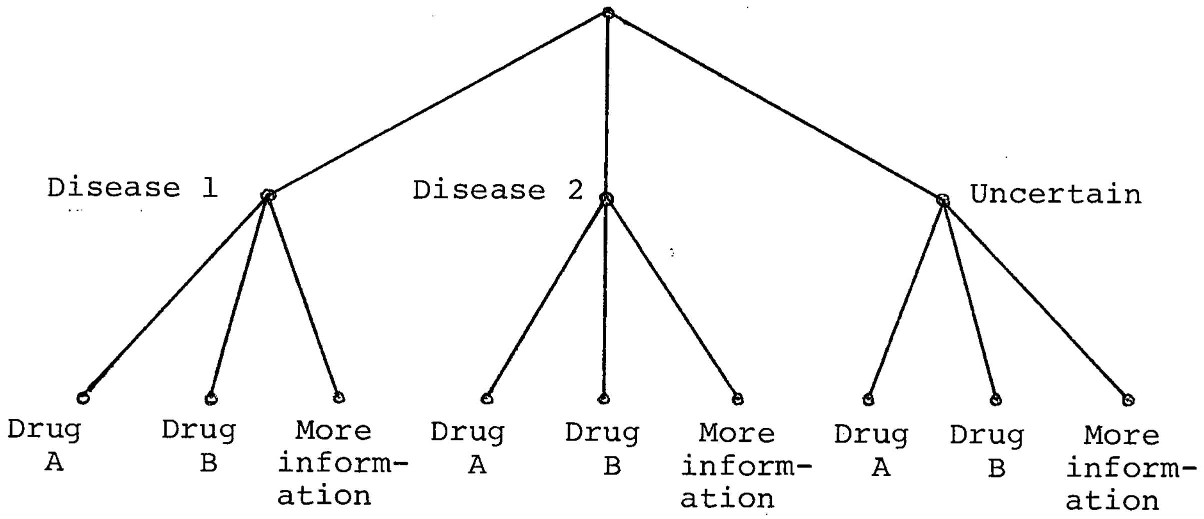
As an example of the way in which Figure 4.1 might represent a substantive choice, we can substitute the categories 'friend', 'foe' and 'uncertain' for I_1, I_2, and I_3 respectively. 'Embrace', 'smile', 'request information', 'kick' and 'punch' may be substituted for A_1 to A_5. This arrangement, of course, leads to a rather simplistic account of the associations for an individual if we see it as a static arrangement. If we introduce into this arrangement the possibility of change and at the same time put it into the context of interaction, very complex forms of activity become possible. At a simple level, we might have a situation where one individual (some person other than self) has a stable association between some act (A) and an interpretation, as well as between interpretations and acts. If I am attempting to develop such an association, the situation becomes one of a simple learning situation. However, if my responses affect the other person's associations, the problem of coordination of activity becomes very complex. If the other person changes OUT relations only (i.e., represented by a change in 'c' to 'h') the problem for myself in attempting to learn appropriate responses is increased. In Figure 4.1, this would mean that I could use the occurrence of response A_1 and A_2 on the other's part to identify I_1 as the appropriate interpretation. If the other person changes IN associations as well (i.e., changes 'a' or 'b') successful coordination by myself becomes almost impossible. In Figure 4.1 this would mean that the occurrence of responses A_1 and A_2 in sequence could mean that the appropriate interpretations are I_3 first then I_1, or I_1 for both responses. In the case where A_1 and A_3 occur, the possible interpretations are increased even more.

It is one thing to learn what responses to make when you know that the other person is a friend, but it is extemely difficult to do it when one is not certain whether he is a friend or foe. A possible representation of this situation can be made by altering the elements of our example in Figure 4.1. If we let A_3 as well as A_1 represent a smile, we introduce into the interaction a possibility for ambiguity which can carry the coordination issue one step further. A smile may be made by either a friend or a foe. This means that the interaction has the possibility of moving either in the direction of an embrace or a punch. Even at this simple level the dynamic features of the model become important. By focussing on the process at this elementary level, we hope to show that complex behavior may be developed out of simple models through the compounding of them. In this case, the significant compounding feature is the introduction of time through the interaction sequence.

CHAPTER 5 - THE EXPERIMENT

The following experiment is designed to examine the relative likelihood of our two threshold models: the runs model and the difference model. In order to introduce sufficient substance into the theoretical model, we have reconstructed the previous type of situation (cf. Fig. 4.1) into the framework of a medical decision. This will allow us a framework in which to test the threshold models outlined above. The 'interpretations' of Figure 4.1 (I_1, and I_2) then become diseases to be diagnosed, and the 'acts' (A_1, to A_5) become the administration of certain drugs or therapy on the basis of the diagnosis (cf. Fig. 5.1)

Figure 5.1



This framework was chosen because it has a great many possibilities for expansion to include more elements of the interaction situation in which we are interested. For example, the number of alternative diseases may be increased from two to as many as one would like. In a similar way, the type of therapy associated with each disease and its frequency of administration may be altered.

In addition, the choice tree may be complemented by another tree representing the patient. In this tree, symptoms would replace acts and they would be related to diseases on the basis of different likelihoods of association. This means, for example, that the "doctor" in the situation may be confronted by symptoms which are ambiguously related to diseases, just as he may have diseases for which a given therapy is prescribed with some uncertainty.

We may add the elements of interaction which are analogous to the condition of interdependency by allowing the administration of therapy and the progress of the disease to shift over time. This situation then becomes more similar to the interaction behavior which we had envisaged in the beginning of our investigation. The administration of a drug may affect the progress of the disease, and the judgement of the nature of the disease on the basis of uncertain information may bias the likelihood of the disease being accurately diagnosed in the future.

This design will also allow the eventual introduction of motivational pressures into the interaction through the manipulation of the seriousness of the disease and the effect of the therapy. To get to this point, however, will take some time. We are satisfied at this time to demonstrate the utility of the design for the central concern of this dissertation.

The General Design

We will now move from a discussion of the general aspects of our model to a specific test of one of its features. The purpose of this test is to select a choice model for interpretation changes. By doing this within the context of an empirical investigation, we will be able to feel confident that we have made at least plausible assumptions about the process. By doing it within the context of our general model, we know where these assumptions fit with respect to other aspects of interaction.

It will be clear that the experiment is related to only a portion of the general conceptual framework. The element of interdependence, for example, will be controlled; only one of the "interactants" will be allowed to change interpretations. In addition, that aspect of the conceptual framework which divides the choice process into two subprocesses is not necessary to account for the data in the experiment. We will design the experiment in such a way that the variation in the decision process will be eliminated. The effect of this will be to permit a one-step model of choice to account for the data.

The reason for adopting this type of a strategy is to examine only one aspect of the conceptual framework at a time. One consequence of this strategy is that we lose some of the theoretical complexity in the experimental situation, but we do end up with a greater degree of confidence in the nature of the process of change proposed. It will become apparent as we proceed, for example, that it is possible to account for the results of our experiment using a one-step model of the choice process. This is an artifact of the experimental strategy we have chosen, however, not the theoretical model. If we were to use simply the one-step model at a theoretical level, we would not be able to extend the analysis beyond the experimental situation we have developed. The problems with a one-step model which we outlined in Chapter 1 would not be dealt with, and the range of phenomena which can be explained by the model would be drastically reduced. Thus, we will view the experiment as a situation in which we have constrained the range of responses in the "decision process", but not eliminated it from the overall process of choice.

The primary problem besides the design framework is the empirical separation of the two models of interpretation change which we want to distinguish. In working out this separation, it was clear that a third possibility is implied as an alternative to the two choice models presented previously. By specifying each of the choice models independently, we assume that persons do not shift between classes of models over time or over decision-type. Since this is always a possibility, we must also consider this in our experiment.

As a result, we are left with three possible choice strategies for interactants which will be investigated in this first experiment. They all propose differences in the effect of information on the change in interpretation which an individual makes. The first suggests the runs model for the process, the second suggests the difference model, and the third suggests an alternation between the two.

The general structure of the experiment is fairly straight forward. It follows closely the structure outlined in Figures 4.1 and 5.1. A subject is requested to diagnose one of two diseases on the basis of a sequence of blood pressure readings. The subject is told that one disease (Aneurophasia) typically produces a preponderance of high blood pressure (HBP), although it may drop for short periods of time. The other disease (Neurophasia) typically produces a preponderance of low blood pressure (LBP) although it too may show the opposite reading for short periods of time. We have coined the terms "Aneurophasia" (A) and "Neurophasia" (N) to represent two diseases for the purpose of this research.

In order to diagnose these diseases then, the subject must ask for a series of blood pressure readings and look for trends in that sequence of readings. One reading is not sufficient since it may be produced by factors unrelated to the disease. Only by examining a number of readings will a trend emerge.

The subjects are allowed to request blood pressure readings for as long as they like, although they are under one other severe constraint. Not only will inaccurate diagnosis lead to the "patient's" death, but to delay diagnosis (and therefore, treatment) will also result in death to the "patient".

The procedure is carried out at the display terminal of a computer. The program begins with a description of the procedure and of the relations between diseases and symptoms. It gives the first blood pressure reading, and then asks for a diagnosis. At this time the subject may type 'A' if Aneurophasia is diagnosed, 'N' if Neurophasia is diagnosed, or 'B' if more blood pressure readings are required. If a disease is diagnosed, the program will introduce a new patient and proceed with a new set of blood pressure readings. Each time the subject asks for a new reading, the old reading is removed from the screen, a new one is provided, and a request is again made for a diagnosis.[63] This procedure is repeated for five "patients".

The Basic Model and the Experiment

Now that we have a general outline of the experiment, we can move to those assumptions which are necessary in order to operationalize the propositions which we wish to test. This means that we must relate the language of the models to the events in the experiments.

The first set of concepts can be introduced in the same way as the elements of the basic model.

S.1 Set $P = \{s,c\}$

In this set we define only two "persons" who are in interaction; s (the subject) and c (the computer).

S.2 Set C = {'A', 'N', 'B', 'High BP', 'Low BP'}

Set C consists of all the communicative acts which can occur. The first three elements are three letters which the subject can push to diagnose the two diseases ('A' or 'N' for Aneurophasia or Neurophasia respectively) or ask for more blood pressure readings ('B'). The last two elements in set C are the indications of blood pressure readings which the machine can display.

S.3 Set I = {Aneurophasia, Neurophasia, Uncertain}

These elements represent the three possible interpretations which we assume the subject may give to the sequence of acts. The first two represent the interpretation of the sequence of readings as being the result of a particular disease, and the last represents his interpretation of the system as uncertain.

R.1 relation IN {(c, 'High BP', s, An) (c, 'High BP', s, Ne)
(c, 'High BP', s, Un) (c, 'Low BP', s, An)
(c, 'Low BP', s, Ne) (c, 'Low BP', s, Un)}

This relation represents the array of interpretations which we are assuming that the subject can make to the various displays from the computer. In the definition of this relation, we are including only those elements which apply to the interpretation of the subject. Since the machine is programmed to respond in a one-step stimulus-response fashion and not according to the two-step model we propose for the subject, we will not include it in this discussion.

This relation includes elements in which 'High BP' is related to the 'aneurophasia', 'neurophasia' or 'uncertain' subsystems on the part of the subject. This is equivalent to the interpretation of 'High BP' as the result of 'aneurophasia', 'neurophasia', or the production of uncertainty on the subject's part. It also includes elements where 'Low BP' is related to these three interpretations. Thus all the logical possibilities for relating machine responses to subject interpretations are included.

Through the identification of this relation, it is obvious that for each quadruple, the elements c and s are the same. This is one way in which the full account of our original conceptual framework in section 1 is not necessary for the development of the experiment. This is also the case for the following relation.

R.2 relation OUT = {(c, An, 'A', s) (c, Ne, 'N', s) (c, Un, 'B' c)}

In this experiment we will assume that the subject has a very simple relationship between the interpretation and the act he or she will perform. This assumption is based primarily on the instructions which we give. First we allow him only one response for each state he may be in. In terms of our conceptual framework this means that once he has made an interpretation, he has only one response possible. Thus the decision process is, in effect, eliminated. Second, we increase the pressure on the subject to make his choice of action immediately upon making an interpretation. This is done by emphasizing the importance of an early diagnosis. We are assuming that when an interpretation is made, the subject will immediately make a diagnosis which is consistent with that interpretation. In this way we can assume that the decision process is eliminated, since he is unlikely to utilize the choice strategy of delay.

The Choice Models and the Experiment

Up to this point, we have simply related the elements of the experimental design to the theoretical concepts of our basic model. In order to test the choice models which the subjects utilize, we must also link the experiment to the theoretical concepts of the models proposed by Audley and Pike. The following set of assumptions is used to make that link. These assumptions are meant, not as the basis of a formal theory, but only as an indication of those points at which the more critical assumptions are made. It will be apparent, therefore, that we do not provide an exhaustive account of all the assumptions necessary to move from the conceptual framework to the experiment.

ASSUMPTION 1: Each element of set I represents a subsystem associated with an interpretation.

This assumption simply identifies the use of the notion of an interpretation in the basic model with the concept of a subsystem in the choice model proposed by Audley and Pike.

ASSUMPTION 2: Each element of Set C which the computer presents, represents one unit of excitation for each subsystem for the subject according to the following scheme.

HBP = one unit for the subsystem associated with Aneurophasia
LBP = one unit for the subsystem associated with Neurophasia

- If a threshold has not been reached, the subsystem associated with Uncertainty is activated.

This assumption links units of excitation and symptoms. It assumes, as well, that the occurrence of a symptom necessarily has an effect on the state of the subsystem in a particular manner. This part of the assumption is based on the instruction to the subject which links symptoms to diseases in the following way. HBP is symptomatic of Aneurophasia, and LBP is symptomatic of Neurophasia, although they do not relate to the diseases in a deterministic fashion. The subject is informed that Aneurophasia is typically associated with a preponderance of high blood pressure readings, but one must be careful to examine several readings over time in order to look at trends. Similarly he or she is told that Neurophasia is typically associated with a preponderance of low blood pressure readings (cf. Appendix A and B).

The purpose of these instructions from the point of view of the model, was to introduce to the subject an initial structure of associations, and yet at the same time to leave him an opportunity to change them. As we have discussed earlier, it would be impossible for us to create a situation in which there are no interpretations on the part of the subject at least at some level. Our strategy, then, has been to provide the subject with a <u>general</u> interpretation of the events (i.e., put it into the context of medical diagnosis) and a range of possible interpretations within that general framework. We can then examine the manner in which changes are made from one type of interpretation to another within the context we have provided.

The First Mode of Analysis

We are now in a position to specify precisely the inferences we will draw from the way in which the subject behaves. The crucial aspect of the experiment in this regard is the sequence in which the symptoms are presented to the subject. Insofar as the subject is concerned, the association between a symptom and a disease is probabilistically determined. From the experimenter's point of view, this association is purposely manipulated in order to test the three models. The models make predictions about the point at which a threshold will be reached. Once a threshold is reached, we expect the subject to move from a state of uncertainty to one in which a disease is diagnosed. We will therefore be looking at this point as a means of identifying the type of choice model the subject is using.

By referring to Table 5.1 we will show how the sequence of symptoms may be presented to a subject and the way in which the models may be inferred from his or her responses. The symptoms are presented in sequence with their values being either H (High Blood Pressure) or L (Low Blood Pressure). The example in Table 5.1 is of an individual who receives a reading of H for the first trial. Since high blood pressure is typically associated with Aneurophasia, we expect (by assumption 2) that the subsystem for Aneurophasia is excited by one unit. This

Table 5.1

(Example of symptom sequence and level of excitation for one "patient")

Trial No.	Symptom	k Value for Difference Model	k Value for Runs Model	Models supported *if* diagnosis made on trial indicated*
1	H	1	1	D R
2	L	0	1	
3	L	1	2	R
4	H	0	1	
5	L	1	1	
6	L	2	2	D
7	H	1	1	
8	L	2	1	
9	H	1	1	
10	H	0	2	
11	H	1	3	R

*Note: when diagnosis made, sequence of symptoms is terminated.

excitation is the same for both models (the "difference" and the "runs" model) and they therefore are both given "k" value of 1 unit of exictation. The value of k represents the level of the threshold for choice, under a particular choice model. When the value of k reaches the subject's threshold, we are assuming that he will make a diagnosis.

If the subject diagnoses a disease after the acquisition of the first symptom, we are unable to infer which of the two-choice models is in operation. We do know, however, that the level of excitation necessary to reach the threshold is 1 (i.e., $k = 1$). By making the following assumption we can adapt the sequence in such a way as to differentiate between the various models.

ASSUMPTION 3: The level of excitation necessary to reach the threshold (i.e., the value of k) is constant throughout the experiment for each individual. Each individual need not have the same value of k, however.

This assumption can be checked by repetitions of the sequence of symptoms for "new patients" by each subject. For that reason we ask each subject to diagnose for five patients, each patient having a slightly different sequence of symptoms.

If the subject does not diagnose a disease after the acquisition of the first symptom, he or she will receive a blood pressure reading of L (cf. trial 2 in Table 5.1) for the next trial. This symptom is assumed to activate a unit of excitation associated with the subsystem for Neurophasia. Since the difference model predicts that this unit of excitation will interfere with the unit already accumulated for Aneurophasia, we assign a value of zero to the subsystem for that model only. The runs model takes the value of one, since the run of 'H' has been terminated and trial 2 starts a run of 'L'.

Should the subject diagnose a disease after the second symptom, we are unable to infer support for either of the two models. The level of excitation for the difference model is zero, so that we would expect no choice to occur. For the runs model, the level of excitation is 1. Since by assumption 3, the value of the threshold is not expected to change, and we have already passed the point where k equals 1 for the runs model (on trial 1), we would expect no change to occur under this model either. A change at this point would mean either a failure of the models or of the assumptions we have made in order to operationalize the models.

Following the above line of argument, we will be able to identify the models which would be supported if decisions occurred at various points in the sequence (cf. "Models supported" column in Table 5.1). For example, a diagnosis made after trial 3 would support the runs model at k = 2: diagnosis after trial 6 would support the difference model at k = 2, etc. It is important to note that once a diagnosis is made, the sequence of symptoms for that particular patient will stop and the next patient will be introduced to the subject. In that respect Table 5.1 is deceptive if one does not view the process terminating at a point of diagnosis.

The use of the computer will allow us to check out the implications of the subjects' responses with a minimum of effort. Once a diagnosis occurs, the machine will identify the models and threshold values supported by the diagnosis and set up future sequences of symptoms in such a way as to:

1. differentiate the models uniquely
2. check Assumption 3 (re. the stability of the threshold value k)
3. check the possibility that the subject uses different decision models throughout the experiment.

Each subject will be run with sufficient "patients" to check all of these aspects.

Since the problems of making inferences from the sequence increases as the value of k gets larger, we have decided to set up the experiment in such a way that the level of the subsystem thresholds is low. The actual value of k is not of theoretical importance at this time since it may vary within each of the models without making them indistinguishable. Since its value does make a difference to the experimental design, however, we must make an assumption about the way in which it is experimentally integrated into the models.

A high value of k requires in, most cases, the acquisition of more information. This may be costly to the individual and act to influence the value of k.

ASSUMPTION 4: The greater the costs of information, the lower will be the level of excitation required to activate a diagnosis.

This assumption is made in order to provide a basis for design features which can keep the value of k low.

We inform the subject that each time a blood pressure reading is requested it represents the passage of about 30 minutes. We also inform the subject that the disease is usually terminal after 3 days of its onset if no proper treatment is administered. By emphasizing the cost of a slow diagnosis we were able to settle on a research design which kept the k values small.

At the same time that the costs of a slow diagnosis was emphasized, it was necessary to insure that the subjects' commitment to an <u>accurate</u> diagnosis was not jeopardized. The effect of increased pressure for an accurate diagnosis has the effect of increasing the value of k and working against the effects of our demand for an <u>early</u> diagnosis. The effect of this pressure for accuracy can be more formally represented by the following assumption.

ASSUMPTION 5: The greater the costs of an inaccurate diagnosis associated with a particular subsystem, the greater is the level of excitation required to activate that response.

Our solution to this dilemma of contradictory pressures was to try various combinations of pressure for accuracy and for an early diagnosis in a series of pretest experiments. We devised a combination in which most persons made their choices within about 10 trials and at the same time gave some indications in their post experimental interviews that accuracy of diagnosis was of concern to them.

In addition, we programmed the computer to print out:

> "YOU HAVE GIVEN THE WRONG DIAGNOSIS
> - YOUR PATIENT HAD DIED"

if the subject made a diagnosis on the first or second trial. This was done in an attempt to increase pressure on him or her to refrain from making a diagnosis on these trials since we were unable to differentiate the choice models used on the basis of one or two trials.

CHAPTER 6 - RESULTS AND ANALYSIS

This chapter involves the use of three main types of analysis. The first type has been outlined in Chapter 5 as the "first mode for analysis" (p. 58). This mode (or strategy) involves the assumption that the threshold (k) values for each subject are equal for all patients diagnosed by that subject. (cf. Assumption 3, p. 87). In the course of our investigation it became clear that this assumption was unreasonable and a second mode of analysis was devised. This mode does not require the assumption that the threshold values are constant, but uses instead, the geometric probability distribution as a basis for generating expected values for the outcome of the experiment. After the utilization of this second mode of analysis, it was apparent that the influence of time pressure to diagnosis was very strong on the subjects. As a result, a third type of analysis was devised which allows for this effect. Since each mode of analysis has provided some insight into the factors involved in this type of choice situation, it was decided to include each of them in a discussion of the results.

Before we begin an analysis of the data with respect to our central hypothesis, we will outline some of the more general characteristics of our data. This should provide some indication of the range of behavior we found.

Subjects were run using the design outlined in Appendix A. Each subject was requested to diagnose five patients. We assumed that the diagnosis of the first patient was unsuitable for analysis since it involved a certain amount of learning, particularly in the operation of the teletype console. Our analysis, therefore, was done on the last four patients which each subject diagnosed. The range of trials to diagnose for these four patients is given in Table 6.1 along with the mean number of trials to diagnose.

Table 6.1

Minimum, maximum and mean number
of trials to diagnosis
for the last four patients.

	Patient 2	Patient 3	Patient 4	Patient 5
Minimum	1	1	2	1
Maximum	11	24	20	19
Mean	5.9	9.7	8.6	9.7

The sequence of symptoms for patients three and five are identical except for the reversal of the type of symptoms (i.e., for patient five, 'High BP' occurred at those points where 'Low BP' occurred in patient three, and 'Low BP' occurred at those points where 'High BP' occurred.) (cf. Appendix Ca for the schedule of symptoms). This similarity is reflected in the similarity of mean trials to decision for patients three and five. Patient four includes a shorter sequence of alternating symptom types than patients three and five. This has the effect of reducing the mean trials to decision. Patient two has the lowest mean value because the sequence of symptoms moves to a continual sequence of 'High BP' very early in the experiment.

Thirty-five subjects were run in total.[64] The trials to diagnosis for these subjects along with the schedule of symptoms presented to the subjects can be found in Appendix C. In spite of the fact that our theory made no suggestion that sex, or awareness of the "artificial" nature of the choice would affect the use of certain choice models, we kept information on both of these factors. The reason for this was simply that these variables have had an effect in many other choice situations and might have to be controlled in this one as well. As it turned out, patterns emerged independent of them.

Test of Assumption 3 and the Second Mode of Analysis

Our design permitted a test of our assumption that the value of k is constant over each subject (cf. Assumption

Table 6.2

Values of k for 5 subjects
by patient number.

	Patient number				
Subject number	2	3	4	5	range
1	-	2	3	2	2-3
2	3 ,4*	-	4 ,3	2	2-4
3	1	-	2	-	1-2
4	6,7	5	5	3	3-7
5	4,5	4,3	-	3	3-5

'-' indicates no k value could be identified by the choice point
* both k values are given where two models are implied.

3). It was important to check this out since the strategy of analysis we originally planned was dependent on its support. However, it soon became clear that this was an unreasonable assumption to make. (cf. Table 6.2). Of the first five pretest subjects run, none made their choices with the same value of k for all patients. The range of values in one case was as high as five (cf. subject no. 4). We either had to revise the experiment or develop an alternate mode of analysis.

As it turned out, another technique of analysis was possible, and since this saved a great deal of work in re-doing the design of the experiment, we chose to use it. This method used the notion of mathematical expectation in order to construct a standard for the evaluation of choices.

A subject's choice might fall on one of four different types of trials if we classify the trials of choice by the type of choice model they imply. The possibilities are:

<u>Type 1</u>. The difference model alone

<u>Type 2</u>. The runs model alone.

<u>Type 3</u>. The difference and/or the runs model.

<u>Type 4</u>. No model.

These categories are mutually exclusive and each trial can be identified by one of them. For example, if a subject made his diagnosis on trial 1 of the sequence of symptoms in Table 5.1, it would support the difference and/or the runs model (type 3 outcome), if he made his diagnosis on trial 2, it would support no model (type 4 outcome), if he made his choice on trial 3 it would support the runs model alone (type 2 outcome), and so on. Within the eleven trials shown in Table 5.1 there is one opportunity for a type 1 outcome, two opportunities for type 2, one opportunity for type 3, and seven opportunities for type 4.

The chance of a random choice falling on one or the other of these types is not equal, so if we find a difference in the number of times one type of model is used over the others, it will be very difficult to establish whether this is a function of biases in the opportunities for each model being used, or of subjects' preference of one model over the others. It will therefore be necessary to set up a standard for comparison which reflects the different opportunities which each model has by virtue of the symptom sequence, but does not reflect individual preferences.

To do this we begin by asking the question: "If the subjects always diagnosed randomly, what kind of distribution of outcome types would we expect?" In order to attain such a distribution, we can treat the making of a decision as the occurrence of a success in a binomial trial. At each decision point then, the subject has some probability (p) of making a decision. If the process is a random one, then we would expect the probability to be the same for each trial. This assumes that in random choice behavior there is nothing to differentiate a choice at one point from a choice at another point.

Using this framework, we can then calculate the theoretical probability for a choice being made at each trial in the following way. If the probability of a choice on each trial is the same (e.g., p) then the probability of a final decision on the first trial is p, the probability of a final decision on the second trial is the product of no choice on the first and a choice on the second [i.e. $(1-p)p$]. The same procedure can be repeated for the probability of a final decision on the third [i.e., $(1-p)(1-p)\,p$], fourth, [i.e.: $(1-p)(1-p)(1-p)p$] and n^{th} [$(1-p)^{n-1}\,p$] trials. The resulting distribution over trials 1 to n is a <u>geometric distribution</u> with parameter p.

In order to calculate the probability of a certain outcome type under this random process, one can then simply add the probabilities for each trial on which a certain outcome type occurs. For example, in Table 5.1, if we were to calculate the probability for outcome type 2 to occur (the runs model alone) under the particular symptom sequence shown, we need only to add the probability of a choice occurring on trials 3, 11 and any other further trials at which a decision would imply the runs model. Theoretically, this should be carried on for an infinite number of trials, but the probabilities become so small after 20 or so trials that there is no advantage to extending the process. We will adopt the policy of calculating such values only to a total of 50 trials. By that time the probabilities of choice were smaller than .0005 for all "patients".

The value of p can be estimated from the mean number of trials to criterion for a particular patient. In this way, the actual data and the probabilities under the geometric distribution are made similar and we can make a reasonable judgement of the differences between expected and actual frequencies.[65] The means and values of p for the last four "patients" are given in Table 6.3.

Primary Analysis

Table 6.4 shows the values of expected and actual frequencies for each outcome type and for each patient presented to the subjects. These were calculated in the following manner. Using the values of p as estimated from the mean number of trials to criterion, the probabilities of choice predicted by the geometric distribution were generated. From this distribution the probability for each choice type to occur was calculated and used as a basis for calculating the expected number of persons under the geometric distribution. A more detailed example of the way in which this was done for patient number 4 can be found in Appendix D.

If we look at the first three columns of Table 6.4 the following interpretation can be made. For patient 2, the difference model alone was never used by subjects in making their choices. This was because a trial which implies the difference model alone never occurs in the sequence of symptoms for patient 2. The frequency of choice predicted by the random model reflects this.

For patient number 3, we can infer that the difference model alone was utilized 9 times over the 35 subjects. The random model predicts that this should occur

Table 6.3

Mean trials to diagnose and associated values of p for patients 2 to 5. (number of subjects = 35)

Patient No.	Mean no. of trials	$p = \frac{1}{\text{mean}}$
2	5.9	.169
3	9.7	.103
4	8.6	.116
5	9.7	.103
Total	8.5	

Table 6.4

Actual frequencies for
4 types of outcomes and expected frequencies
under the geometric distribution
(number of subjects = 35)

Patient Number	Outcome types							
	1. Difference model alone		2. Runs model alone		3. Difference and/or runs model		4. No. model	
	Exp.	Actual	Exp.	Actual	Exp.	Actual	Exp.	Actual
2	0	0	4.08	6	19.78	25	11.13	4
3	3.85	9	1.88	5	4.30	5	24.98	16
4	5.59	14	3.17	4	5.10	3	21.13	14
5	3.83	12	1.88	5	4.32	2	24.98	16
Total	13.27	35	11.01	20	33.50	35	82.22	50
Total Actual -Total Exp	21.73		8.99		1.50		-32.22	

X^2 (calculated on totals for columns) = 55.62

$X^2_{.01,\ 3df} = 11.34$

only 3.85 times. Similar results are found for patients numbers 4 and 5. In comparison with the random distribution over all patients, the actual data show an increase in the number of times the difference model alone was used (21.73 more times). This is shown in the bottom row of the table. We can continue this process for each of the patients and each of the choice model types. By comparing the extent to which the various types account for more or less of the data than the random distribution, we can establish the relative explanatory power of each outcome type over the random distribution. Through this comparison, we can also establish the relative explanatory power between outcome types (cf. "Total of Actual - Total of Expected" row). The chi square measure provides an indication that the differences we find between the random distribution and the actual distribution of choice types are statistically significant.

If we look at the total figure for each of the four choice models some rather striking patterns are evident. For the type 4 outcome, we see that the actual number of times a subject chose at a choice point suggesting no model was far below the expected number of times under a random choice assumption. The difference model alone and the runs model alone were both above the expected number of times predicted by the random choice assumption. The difference model shows a greater variation from the random model, however, accounting for almost three times as many choice points, whereas the runs model accounts for only about two times as many points over the random model.

The type of choice which may indicate either a runs or difference model was not significantly different from the outcome predicted by the random model.

On the basis of these results, the importance of the difference model is clearly identified. Controlling for the different opportunities which each choice type has (through the random distribution) we find that the difference model makes the greatest improvement in prediction over that random distribution. As a predictive statement, however, it falls rather short of a powerful claim. Only 25% of the choices (35 out of the possible 140)[66.] were clearly made on the basis of a difference model, and even if we add to that figure the number of choices made where the model may be a difference model (i.e., type 3) it still only accounts for 50% of the choices (i.e., $\frac{35 + 35}{140} \times 100$).

By turning to the subjects' responses in the interviews we might get some idea of why there was a sizeable amount of variation in the theoretical and predictive significance of these results.

The Interviews

Upon completing the experiment, each subject was asked to give an account of the way in which the choices were made (cf. Appendix E). The usual type of response given to this question was a rather vague statement such as:

> "I asked for readings until I got more of one type than the other."

On probing for what they looked, there was a wide range of accounts. Some mentioned the occurrence of two highs or more in a row, some spoke of the overall preponderance of one type of reading over the other, and a number referred to the consideration of both of these factors in their judgement. Often, we found that a subject said that the choice was made not at the point where he or she made a decision, but a trial or two after that "decision" was made. Such behavior would probably be a major source of error in our method if we identified the subjective accounts of a decision with the reaching of a threshold, since we had assumed that the subjects would make their choice as soon as one or another of the models predicted a change.

Such accounts were somewhat misleading, however, for in going over the actual choices made, subjects often would indicate that they had made up their minds but tried one more reading to check. If the next trial was consistent with their decision they would most likely choose. If it were inconsistent, they would go on to the next trial. A response from the machine which was at that point consistent would often produce a response, in spite of the fact that the difference between one type of symptom and the other had not changed between the first and last trial of that sequence. In such circumstances the subject often justified the choice at that point by comments such as "it went back to what I thought". This seemed to be sufficient evidence for a choice. Choices made on this basis might be seen as similar to those which Peterson and DuCharme deal with in their examination of the "primary effect".[67]

This factor was apparently also compounded by the pressure for making one's decision promptly as specified by the experimental design. A number of subjects indicated that they had had a hunch about the proper diagnosis, were in the middle of checking this out when they got a single piece of evidence which contradicted their hunch. Rather than continue, they said, they chose to diagnose their original hunch, almost as an attempt to prevent the occurrence of further disconfirming evidence and prolong the process.

A third aspect which was often expressed was the problem of memory. Some subjects asked if they could write down the symptoms as they occurred, because they had forgotten the sequence. Since we were concerned with this experiment insofar as it related to interpersonal interaction, they were not permitted to write them down. This was done since most interpersonal interaction does not permit the maintenance of records and would therefore be subject to problems of memory. We were concerned that these features of interaction be maintained, and we hoped that the use of any particular choice model would still be apparent in the data.

All of these effects may account for the occurrence of variation in our results, and would have to be taken into account should one want to use the difference model for purposes of prediction or simulation. Our strategy then, was to use the comments of the subjects as a guide for refining our model. As it turned out, it was possible to examine some effects of the time pressure and the associated strategy of delaying the choice, but since the factor of memory loss would require a change in experimental design, it was not possible to examine its effect at this time.

The Third Mode of Analysis

In order to examine the effect of time pressure, there are a couple of strategies possible. The first would be to assume that all persons utilize the delaying strategy for 1 or 2 trials after they have made their decision, and that they all do it for the same number of trials. This is a very demanding assumption. An analysis of the data revealed it was also a very poor one, for it reduced the predictability of the models to virtually nothing. The second strategy requires that we assume that one of the models does operate, but that we have been too severe in our criterion for the identification of that model.

If there were no pressure on the subjects to make an early diagnosis, under the difference model, we would expect that they would make their choice only on those trials in which the k value increased for the first time.[68] For example, if we turn once again to our example in Table 5.1 we can see that the difference model alone is implied by a diagnosis on trial 6 only (at least up to the 11 trials). This is identified by the fact that it is the first time that a k value of 2 has occurred (cf. column 3). This is the basis upon which our test of the models was originally made. As we have seen, this expectation will only account for 50% of the choices made.

A slightly weaker prediction, yet one which is consistent with our model can be made if we introduce the effect of pressure for an early diagnosis. Under this pressure persons might be expected to reduce the threshold value, (i.e.: the value of k) which they find acceptable as time passes. Thus we might expect that <u>after</u> the first occurrence of k = 2, a subject whose threshold has been greater than 2 up to that point might reduce his threshold to k = 2 and make a choice on the <u>second</u> occurrence of this threshold. In Table 5.1 this would mean that a diagnosis on trial 8 would imply the utilization of the difference model, as well as a diagnosis on trial 6. In general then, this would suggest that choices made on <u>any</u> increase in k (identified under some particular model) might indicate utilization of that choice model. This is represented under the difference model in Table 5.1 by diagnosis on trials 1, 3, 5, 6, 8, or 11. On each of these trials there has been an increase in the k value associated with the difference model.

Our third strategy for analysis, therefore, consists of the following procedure. We can identify the k values for the difference and the runs model by looking at the schedule of symptoms for each patient (cf. Appendix C.a). The procedure is directly analagous to the procedure outlined in our second mode of analysis. The only difference is that we consider any increase in the value of k for a particular model, as support for that model.

Using this new criterion we find that 84% (118 out of 140) of the diagnoses were made on trials in which there was an increase of k under the difference model. As a basis for establishing the significance of this value, we can compare it with the percentage of choices accounted for by the runs model. For the <u>first time</u> occurrences, the runs model can be used to account for 35% of the total diagnosis. For any increase in k (identified under the runs model) it can be used to account for 66% of the total diagnoses (92 out of 140). The difference model is still superior.

Since the difference model can be used to account for all but 16% of the diagnoses, we are now faced with the problem of deciding whether the unexplained diagnoses are to be considered as error or whether they are also to be integrated into our conceptual framework. An examination of the responses to the post experimental interview reveals very little regarding different strategies with respect to those persons who were in 16%. There are some indications of relationships, but they are either too sparse or else they are unconnected to any theoretical interpretations.[69]

Shifts in Models Used

Up to now we have concentrated on the identification of choice models under the assumption that persons do not shift the models over time or for different sets of problems. Since we have not specified any theoretical basis for deciding what types of shifts might be expected, it is necessary to proceed on an ad hoc basis for exploring this possibility.

The first possibility we might examine is that persons shift from one model to the other only once and that this is linked to the length of time in interaction. If, for example, a difference model is being used and the threshold is not reached, one might shift in the models used in order to find a solution to the problem.

This reasoning would suggest that we compare the predictability of the models between the beginning and the end of the interaction sequences. This was accomplished by dividing the trials by patient number in such a way as to keep the number of subjects approximately equal for each half of the interaction. For each half, the predictability of each model was calculated using our <u>second</u> mode of analysis (i.e., looking at the <u>first</u> increase in a k value).[70] The results for this analysis are given in Table 6.5. By comparing the proportions for the first and second half of the trials under each type of model, it is possible to see if there are any differences over trials. In addition, by comparing the proportions across the columns, we can compare the differences which might exist between the difference or runs models.

There is one rather striking result shown in this table. For patient 2, there is virtually no difference in predictability between the two models within the first and the second sections of the interactions. For patient 4, the two models are the same for the first half, but the difference model is superior for the second half. For the patients 3 and 5, the difference model is only superior for the second half of the interaction, and in the first half the runs model is a superior predictor of trials of diagnosis. In general then, the difference model appears to be superior in the latter parts of the interaction, and under certain conditions, the runs model is superior during the early parts of an interaction sequence.

If we look at the sequence of symptoms for the various patients, we can see what conditions might produce these results (cf. Appendix C.a). The schedule of symptoms for patients 3 and 5 are simply reversed in value (i.e., high blood pressure for low and vice versa). This would account for the similarity of results for these two-patient sequences. There is an additional aspect of these two-patient sequences which separates them from the sequences for patients 2 and 4. Up to the sixth trial for patients 3 and 5 the two types of symptoms are simply alternated. This would produce a long sequence in which there is no bias for one disease or the other from the point of view of the subject. On the seventh trial there is a repetition of a symptom (i.e., a run with k = 2). Several of the diagnoses were made at that point. For patients 2 and 4, on the other hand, the first run with k = 2 occurs on trial 3. The number of diagnoses at this point is not as proportionately high. It appears from these results that the long sequence of alternating symptoms is an important factor in producing the use of the runs model for choice.

There are two possible explanations for this phenomenon. First, it may be that the subjects change their model of choice simply because the first model does not "permit" a diagnosis to be made. This explanation assumes that there is a priority in choice models (the difference model being favored) and that only when the costs are high (i.e., a diagnosis is delayed) will the less preferable model be utilized. A second explanation is that the subjects lose track of the

Table 6.5

Proportion of trials to decision which were accurately predicted by difference and runs model, for two halves of sequence*

(Proportions represent the proportion of choices in each cell which are accounted for by the model alone)

	Patient 2		Patient 3		Patient 4		Patient 5	
	diff model	runs model	diff model	runs model	diff model	runs model	diff model	runs model
First half	.50 (20)	.40 (20)	.06 (17)	.35 (17)	.35 (17)	.35 (17)	.06 (18)	.33 (18)
Second half	1.0 (15)	1.0 (15)	.72 (18)	.22 (18)	.61 (18)	.17 (18)	.71 (17)	.05 (17)

* trials to decision identified by first increase in k values. Total number of subjects in parentheses

difference between the two types of symptoms over the alternating sequence. Rather than make a guess at what the difference might be, they switch to use the runs model which requires only that they keep track of the events since the last change in symptom type.

In the post experimental interviews three of the seven persons involved in this particular type of choice indicated that the necessity for an early diagnosis pushed them to make a choice at the first occurrence of a change from the alternation of symptoms. This would suggest some support for the first explanation. For the other subjects involved, there was no clear indication of the process they utilized.

These suggestions regarding shifts in models used must necessarily be tentative for two reasons. First of all, the number of choices involved is very small (10 out of a possible 140). The reason for this is primarily the research design: that is, we were simply not focussing on this problem. Second, since a full analysis of the utility of the difference and runs model alone has not been completed, it is still possible that such an analysis may allow a simpler account of the results shown in Table 6.5.

CHAPTER 7 - CONCLUSIONS

We have now come to the point where we must try to put this specific piece of research into the more general context of our conceptual framework. This will be done with reference to two major areas: those that relate to the results of the specific research undertaken, and those that deal with the more general conceptual framework.

Research Conclusions

Our research was undertaken in order to examine the theoretical reasonableness of two models of choice for IN relations. On the basis of previous research we had assumed that a best guess for changes in relations would be a thresholding type of mechanism, and the models of choice considered were consistent with that type of mechanism. From the perspective of theoretical development, the results seem promising. The difference model of choice seems to account for more data than the runs model in spite of the effects of subjects' delays in response, the pressures of the experimental design, and variations in memory.

One alternative, then, would be to begin an exploration of these effects to see how much of the choice process they do in fact alter. If they account for a significant portion of the variation from the effect of the difference model, our confidence in our conceptualization of interaction would be greatly increased. At the same time, we might be able to improve the predictive power of our model.

This strategy would require the development of new experiments which are similar to the one reported in this dissertation, but with variations in some of the factors which might introduce error. From the research to this point, two of these factors seem to be most critical.

One of these factors is the pressure which we create for an accurate versus an early diagnosis. Through assumptions 4 and 5, the manipulation of these factors allows experimental control over the threshold values which the subjects hold. In our set of experiments, the value of k was kept very low and it may have had the disadvantage of producing a high proportion of choices at the second occurrence of the k values. At present, these choices drastically reduce the predictability of the choice model, and at the same time they do not clarify the reasonableness of the choice model itself. Thus they prevent us from confidently making a claim for or against the utility of the choice models used. To do so would require a variation in the experimental design. For example, if we relaxed the pressure for an early choice and increased the demand for accurate diagnoses, we would expect that the proportion of non-informative choices would drop, particularly at those points where the k value is low. Should we find that we have just as many choices made at the second or third occurrence of a particular k value, we must abandon our assumption that the choice models proposed are reasonable.

The second fator which appears to introduce some error into the choice process is the influence of memory. It is possible that some of the variation from the choice models is due to the fact that subjects lost track of the sequence of acts. In spite of their utilization of one or the other choice models then, they would make diagnoses at points other than those predicted by the models. One other result of memory loss which we have already mentioned is the shifting of choice models from the difference model (which requires constant monitoring) to the runs model (which allows one to begin monitoring the acts at any point).

Two strategies for dealing with the effect of memory are possible. By providing a continual account of the readings to the subject it would be possible to reduce some of the errors due to memory variations. However, by doing so, we will reduce the extent to which it might match more "natural" interaction situations. This would not be such a crucial factor if we were to utilize this strategy to examine the possible shift of models due to memory loss. For example, if we give a subject a long sequence of alternating symptoms and provide him with an inventory of the symptoms as they occur, he would be less likely to utilize the runs model, if the memory loss explanation was correct. An alternative solution to the general problem of memory effects might be to integrate into the analysis of the model a function to account for variation due to memory. The success of this strategy will depend, of course, on the level of theoretical development which theories of memory have achieved. Both strategies reflect our concern with the control of memory influence on sequential choice rather than the development of theory regarding the functioning of memory. This is consistent with our primary concern with interaction.

In both cases where we propose changes in the experimental design, our concern is with the development of a theory of interaction and not primarily with simulation of interaction. By introducing influences on the value of k and by experimentally controlling for the effects of memory, we do not necessarily make the investigation more "natural", but we do provide a more severe test of the theory.

At one point in the development of the conceptualization of interaction, we had hoped that we might also use simulation techniques to provide a basis for theoretical elaboration. The possibilities for using this technique are greatly undermined by the predictive weakness of the difference model in our research. Under this model alone only about 50% of the data seem to be accounted for, which leaves the largest percentage attributable only to unknown factors. If we should adopt the strategy of elaborating the factors mentioned above in our discussion of theoretical development, it might be that the predictive utility of the model might also be increased.

At present, if we know the threshold value which a person might have for any one patient, we can predict his exact trial of choice only 50% of the time. Even if we relax our demand for the exact trial of choice and include all those of a particular k value the accuracy of our prediction will only be 84%. (For example, for $k = 1$, we can predict with 84% accuracy that the choice will be made on trials 1, 3 or 5 for patient 2). There is some chance that these predictions might be improved if we attempted to integrate the variations we have found.

The first thing to deal with would be the variation in the value of k. Originally we had assumed that the k values would be constant for each subject, but it soon became apparent that there was some variation. A preliminary examination of these values indicates that they are generally restricted, with the mode being a range of 1 value over the four patients with which a subject deals. (cf. Table 7.1). This would suggest that estimation techniques for the value of k would be reasonably useful since the values are stable within a limited range. Values of k for one person at one point in time could then be used to estimate future values with considerable accuracy.

The second important factor suggested by our experiments would be the influence of pressure to choose as the number of trials increases. In the development of a prediction model this would suggest the inclusion of an interaction effect between time and the value of k. If we assume that each individual is differentially influenced by the pressure to choose quickly, this might account for the differential choices after the first occurrence of an increase in k values. Both of these factors might be accounted for by the development of a prediction equation using distributions for the value of k and the pressure of time. The likelihood of a choice being made at a particular trial then, would be a function of the k value at that trial and the number of the trial.[71.]

Conceptual Framework and Conclusions

An alternative strategy for future research must

Table 7.1

Range of k Values under Difference Model

maximum possible range = 7

Range	No. of persons
0	4
1	18
2	8
3	4
5	1
Total	35

also be considered, however, especially since our original concern was with the development of a conceptual framework regarding interaction and not an account of choice behavior alone. The experiment reported here represents only a small portion of our general conceptualization. We had considered this research as the first step in the elaboration of the ways in which feedback affects IN and OUT relations. Since we have dealt only with changes in IN relations our strategy would be to now proceed to an examination of changes in OUT relations. To do so we would have to make the assumption that the unexplained variation in the research was the result of the factors that we have mentioned, or at least others which merely mask the effects of the difference model and were not signs that a fundamentally different type of process was operating.

To adopt this strategy would mean that we would have to settle for a much weaker test of the factors involved in the OUT relation than if we had more precise conclusions regarding the IN relation. If we had a clear idea of how it was that the IN relation changed, then we would be able to experimentally separate the influence on a choice of the two relations. As it now stands, if we were to assume that the IN relation operates under the difference model, for example, we would have to assume that the variation from that model which we found in the data was due to theoretically insignificant factors.

One further area which requires elaboration is the relationship between our conceptualization of the choice process in the experimental design, and other types of situations. We have, in general, made the case that most interaction situations can be conceptualized as choice situations with sequential information. Up to now, we have focussed mostly on the development of an experimental design which is consistent with that view, and have neglected the alternate strategy of elaborating the way in which it might relate to situations in which the information is not sequential. By doing so, we will then be in a better position to test the limitations of our conceptualization.

Our theoretical conceptualization as it now stands is limited in that we have only tested a very minor part of the total structure. In addition we have dealt only with a situation in which cooperation is desired by both persons, where only one interactant is making choices, and where the information he receives is simple and constrained. Each of these conditions keeps us a long way from the type of situation which we hope eventually to account for.

The choice of one or more of these strategies over the other will be made only after an examination of the factors which we have outlined as possible influences on the centrality of the difference model. This includes the influence of memory, pressure for early diagnosis, and the mixing of choice models. If it looks as though a more detailed examination of these factors will not take us too far from our central concern with interaction, we will explore these factors with the hope that we might be able to account for more of the variation in the results. However, if it looks as though a more thorough examination of the contingencies on the research will lead to a movement away from our central concern with interaction, we will most likely adopt the second of the two strategies and move to a consideration of the process of changes in OUT relations. The adoption of such a strategy would mean that we would not use some of the more powerful techniques of theoretical exploration such as simulation. This is primarily due to the lack of strong predictive power of our operationalization of the interpretive process.

One further comment might be made regarding the general strategy for conceptual development which we have used. Throughout this dissertation we have developed and utilized a rather loosely formulated conceptual framework in a number of ways. First of all it has provided a conceptualization of interaction which emphasises particular factors which we felt were important. These factors include such things as the interdependence of persons in interaction, the importance of interpretations in action and the sequential behavior which is characteristic of interaction. Second, it has provided a framework for the identification of particular research problems. This allows problems to be identified for research and it also permits one to be able to specify the way in which separate research issues might be related. Even in an imprecise form such a conceptual framework can generate research which in turn, has the effect of making the framework more precise. This was the expectation with which our research strategy was chosen. It will take some time before it is possible to evaluate the reasonableness of that expectation.

FOOTNOTES

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22. Two examples may be found in Goffman, E., The Presentation of Self in Everyday Life, New York, Doubleday, 1959, and Scheff, T.J. op. cit.

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25. We will assume that such patterns are generated through an association-learning type of process.
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For the purposes of our discussion, we will assume that a basic repertoire of associations has been established by the interactants and we will focus on the changes and adaptations produced in that repertoire by interaction.
Using this assumption it will be apparent that the notion of pattern is very general in this part of the discussion. It may refer to a pattern of action overtime (e.g., repetition, alternation, random), overspace (e.g., square, circle, random) or over some combination of these two (e.g., playing checkers, painting a wall, serving a customer). In social relations roles can be conceived as patterns of action.

26. For references, see footnote 25.

27. An interesting discussion of the way in which teleological and mechanistic views of behavior may be compatable can be found in Ackoff, R.L. and F.E. Emery, On Purposeful Systems, Chicago, Aldine Atherton, 1972. From their discussion it may not be unreasonable to consider even so called "reflex action" from the point of view of purposeful behavior. The utility of doing so with such action is probably very slight but at the level of analysis which we propose we feel that there is great utility in looking at action from a

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47. By using the term 'coding process' in relation to the notion of interpretation we mean only to link the formal term 'code' to the more informal notion of "interpretation". We refer to the same thing with the use of the two terms, but make the link only to facilitate the discussion of the model.

48. This is an assumption shared by a wide range of learning theories and models from paired-associate learning to stimulus sampling. Cf., Atkinson, R.C., et al., op.cit.

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51. This phenomen is dealt with in a number of other studies as well. For a general discussion of research in this area see Edwards, W., "Conservatism in Human Information Processing" in Kleinmuntz, Formal Representation of Human Judgement, John Wiley and Sons, 1968.

52. Lawrence, D.H., op. cit., 1963.

53. We would also like to note that this argument might serve as a basis for a theory of cognitive structure should it be reversed. That is, we would expect to find that a concatenation of a threshold and a simple learning mechanism would produce an associational structure with the form of a hierarchical branching process. In terms of our model, each interpretation would have a number of acts associated with it, but not vice versa.

54. Lawrence, D.H., op. cit., 1963, p.190f.

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62. For a discussion of the theoretical significance of the concept of stimulus elements see Atkinson, R.B., et al., op. cit., pp.346-349.

63. The information given to the subjects with an example of the output of a program is given in Appendices A and B.

64. Ten of these subjects volunteered from classes at the University of B.C. and the other twenty-five volunteered from classes at Sir George Williams University in Montreal. These volunteers were all from undergraduate courses in the faculties of arts and science. Eighteen of the subjects were male and the other seventeen were female.

65. The best estimate of the mean of the geometric distribution is given by $\frac{1}{p}$.

66. This value is calculated from the total number of times the difference model alone could be used to account for the choices made (i.e., 35) and the total number of choices made (i.e., 140) 35/140 x 100 = 25%

67. Peterson, C.R. and W.M. DuCharme, op. cit.

68. Note that the k values are the values as calculated under one or other of the models.

69. For example: a) the one subject who consistently chose at a point not predicted by the Difference model said that she diagnosed the sequence Low-High-High-Low as 'Neurophasia' (Low subsystem) because it "came back to Low".
b) the majority of diagnoses which were made at variance with the Difference model were made by females (77%; f = 16).

70. Under the third strategy for analysis (any increase in k) the differencesfound in Table 6.5 disappear.

71. A preliminary investigation using such a function in which k was assumed to be normally distributed and the probability of choice was assumed to be a linear function of the number of trials has yielded encouraging but inconclusive results. This is one strategy which will be pursued.

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Appendix A

A Description of the Experimental Situation

1. Subjects were seated before a computer terminal. The terminal used for the first 10 subjects was an IBM MED2260 terminal. The terminal used for the last 25 subjects was a CDC terminal. For both machines, the subjects typed their responses on a keyboard similar to a typewriter, and the machine responses were displayed on a screen.
2. Subjects first of all were asked to read a general description of the study (cf. Appendix B.a).
3. They were then asked to type a number on the console. This number was simply used to distinguish the subjects on the record of data. The machine then responded by typing a set of specific operating instructions on the screen. (cf. Appendix B.b).
4. Subjects began the sequence of symptoms by typing 's'. A typical sequence is printed in Appendix B.b. Whereas this typical sequence is printed, the subject saw only one symptom at a time on the screen. After the subject made a response, the symptom was erased and a new one substituted.
5. When a diagnosis was made, a new patient was introduced with the message:

   "I WILL NOW GIVE YOU READING FOR A NEW PATIENT"

   and a new series of symptoms was begun.
6. After 5 patients, the program was terminated.

A record of the subject responses, machine responses, k values under each model and the time of response for each trial was stored by the computer. (A copy of the program with some sample data is given in Appendix E).

7. The post experimental interview was conducted. (cf. Appendix D).

Appendix Ba

Handout to the Subjects

A general description of the study

In this study we are examining the way in which persons make diagnoses of diseases on the basis of a sequence of symptoms. By an examination of this process, we hope to improve the way in which diseases may be diagnosed by medical personnel, and possibly even by machines.

In the following exchange you will be asked to diagnose a disease on the basis of a sequence of blood pressure readings. The readings are a typical sequence of readings for patients who have contacted the two diseases in which we are interested.

The first disease is called ANEUROPHASIA. It is typically associated with HIGH blood pressure levels, although these levels are not constant for each patient, but sometimes will drop drastically for a short period of time. This drop in blood pressure is the result of many complex factors such as the patient's stamina, the presence of associated complications, and the patient's history of illness.

The second disease is like the first in many respects, but it is usually distinguished by the LOW levels of blood pressure which it creates. It is called NEUROPHASIA. Like aneurophasia, the blood pressure readings will sometimes shift due to various factors.

Both of these diseases are reasonably rare, both will result in death if not treated, yet both respond well to the proper treatment. Because of the deterioration of a patient with these diseases, a diagnosis should be made as accurately as possible, but also as soon as possible. It is often the case that a patient may die after only 3 days from the onset of the disease if it is not treated. Inaccurate diagnosis will produce the same result.

The problem for a doctor, then, is to make a relatively quick diagnosis on the basis of unstable symptoms. To this date, the only means of separating the two diseases is through the general difference in blood pressure over time - yet time cannot be wasted.

We are asking you to help us in this dilemma by indicating the way in which you would diagnose aneurophasia or neurophasia for particular patients.

You will be presented with a series of blood pressure readings (either High or Low). Each reading you receive represents the passage of about 30 minutes. At any point you may diagnose the disease. A wrong diagnosis will almost certainly mean the loss of the patient.

REMEMBER: A <u>HIGH</u> blood pressure reading is most typical of <u>ANEUROPHASIA</u>, whereas

A <u>LOW</u> blood pressure reading is most typical of <u>NEUROPHASIA</u>.

Appendix B.b

An Example of an Interaction Sequence

Note: Upper case letters are printed by the machine

Lower case letters are typed by the subject.

Each time the subject types b, n or a, the screen is erased and a new symptom presented.

```
WHAT IS YOUR NUMBER?

200

HELLO,

      I HOPE YOU UNDERSTAND THE IMPORTANCE OF BOTH THE ACCURACY
          OF THE DIAGNOSIS YOU MAKE AND THE SPEED WITH WHICH
          YOU MAKE IT.
      I WILL GIVE YOU ONE OF TWO POSSIBLE BLOOD PRESSURE READINGS:
                          HIGH BP
                             OR
                          LOW BP
          AND THEN ASK FOR YOUR DIAGNOSIS.
      IF YOU NEED MORE BLOOD PRESSURE READINGS BEFORE MAKING
          YOUR DIAGNOSIS, SIMPLY TYPE THE LETTER 'B'.
      YOU MAY TAKE YOUR TIME IN RESPONDING, BUT REMEMBER THAT
          EACH READING YOU REQUEST REPRESENTS THE LOSS OF ABOUT
          30 MINUTES, SO DO NOT LET THE PATIENT'S CONDITION
          DETERIORATE TOO LONG.

      YOUR FINAL DIAGNOSIS CAN BE INDICATED BY TYPING:
                         'A' FOR ANEUROPHASIA
                               OR
                         'N' FOR NEUROPHASIA
      REMEMBER:
          ANEUROPHASIA PRODUCES A PREPONDERANCE OF HIGH BP READINGS
          NEUROPHASIA PRODUCES A PREPONDERANCE OF LOW BP READINGS

      THE READINGS FOR YOUR FIRST PATIENT WILL BEGIN WHEN YOU
          TYPE 'S'.

s

      OKAY

      HIGH BP
DIAGNOSIS? b
      LOW BP
```

```
DIAGNOSIS? b
     HIGH BP
DIAGNOSIS? b
     LOW BP
DIAGNOSIS? b
     HIGH BP
DIAGNOSIS? b
     HIGH BP
DIAGNOSIS? a

     I WILL NOW GIVE YOU READINGS FOR A NEW PATIENT

     HIGH BP
DIAGNOSIS? b
     LOW BP
DIAGNOSIS? b
     LOW BP
DIAGNOSIS? b
     HIGH BP
DIAGNOSIS? b
     LOW BP
DIAGNOSIS? n

     I WILL NOW GIVE YOU READINGS FOR A NEW PATIENT

     HIGH BP
DIAGNOSIS? b
     LOW BP
DIAGNOSIS? b
     HIGH BP
DIAGNOSIS? b
     LOW BP
DIAGNOSIS? b
     HIGH BP
DIAGNOSIS? b
     LOW BP
DIAGNOSIS? n

     I WILL NOW GIVE YOU READINGS FOR A NEW PATIENT

     LOW BP
DIAGNOSIS? b
     HIGH BP
DIAGNOSIS? b
     HIGH BP
DIAGNOSIS? b
     LOW BP
DIAGNOSIS? b
     HIGH BP
DIAGNOSIS? b
     HIGH BP
DIAGNOSIS? b
     LOW BP
DIAGNOSIS? n
```

I WILL NOW GIVE YOU READINGS FOR A NEW PATIENT

```
    LOW BP
DIAGNOSIS? b
    HIGH BP
DIAGNOSIS? b
    LOW BP
DIAGNOSIS? b
    HIGH BP
DIAGNOSIS? b
    LOW BP
DIAGNOSIS? b
    HIGH BP
DIAGNOSIS? a
```

THANK YOU FOR YOUR TIME

Appendix C

a. Schedule for Symptoms for the Last Four Patients

H = high blood pressure
L = low blood pressure

Trial No.	Patient 2	Patient 3	Patient 4	Patient 5
1	H	H	L	L
2	L	L	H	H
3	L	H	H	L
4	H	L	L	H
5	H	H	H	L
6	H	L	H	H
7	H	L	L	H
8	H	H	H	L
9	H	L	L	H
10	H	L	H	H
11	H	H	H	L
12	H	L	H	H
13	H	H	L	L
14	H	L	H	H
15	H	L	H	H
16	H	L	L	H
17	H	H	H	L
18	H	L	H	H
19	H	L	L	H
20	H	H	H	L
21	H	L	H	H
22	H	L	H	H
23	H	H	L	L
24	H	L	H	H

b. Number of Trials to Diagnoses for Thirty-five Subjects

Subject Number	Patient 2	Patient 3	Patient 4	Patient 5	Sex of Subject
1	5	7	11	10	M
2	7	17	12	10	F
3	1	2	3	3	M
4	10	19	15	15	M
5	8	16	14	15	F
6	9	8	9	8	F
7	11	24	20	19	M
8	8	19	15	19	M
9	8	15	10	15	M
10	3	7	6	7	M
11	6	10	5	10	M
12	6	15	11	15	M
13	3	1	6	4	M
14	2	3	4	4	F
15	6	10	5	7	F
16	5	3	3	5	F
17	6	5	7	5	F
18	7	12	13	10	F
19	6	6	6	6	M
20	3	5	6	6	M
21	3	3	3	1	M
22	8	16	12	16	M
23	7	15	10	8	M
24	9	10	12	17	F
25	1	5	2	5	M
26	6	7	6	7	M
27	9	16	18	19	F
28	6	9	10	9	M
29	3	7	2	6	F
30	7	16	11	18	F
31	5	7	3	7	F
32	6	9	6	10	F
33	7	10	11	12	F
34	7	4	11	7	F
35	3	3	4	4	F

Appendix D

Calculation of Expected Frequencies for Patient Number 4.

Steps:

1. Mean number of trials to decision calculated over all subjects. (mean = 8.6 trials)

2. Parameter p of the geometric distribution calculated.

$$p = \frac{1}{\text{mean}} = .116$$

3. Probabilities for a choice on each trial up to trial 50 is calculated, using the geometric distribution.

   Example probabilities for trials 1 - 10. (p = .116)

Trial number	Probability of choice
1	.115
2	.102
3	.090
4	.080
5	.071
6	.063
7	.055
8	.043
9	.038
10	.038

4. Probabilities summed over all trials which imply a given choice type

   e.g., trials 6, 11, 15, 18, 23, 24, 27, 30, 35, 36, 39, 42, 47 and 48 imply type 1 (Difference model only).

   The probability of a choice occurring on each of these trials (under the geometric distribution) is summed over all the trials, to give a probability for the Difference model only occurring by chance.
   (Prob (Diff) = .160)

5. Probabilities for each type of model are multiplied by 35 (the no. of subjects) to give the expected frequencies for each model.

Appendix E

Questions Asked During Post-Experimental Interview

1. Can you tell me anything about the way in which you decided what to diagnose?

2. To what extent were you concerned about making an accurate diagnosis with respect to making a quick one?

3. Go through each choice made -- ask what it was that affected the making of that choice.

4. Have you ever participated in an experiment like this before?

   If so - what kind?

```
          PROGRAM DOCTOR(INPUT,OUTPUT,TAPE4,TAPE5=INPUT,TAPE6=OUTPUT)
C     PROGRAM DOC 4ULY 6/72
C     DOCTOR PROGRAM
C       THIS PROGRAM IS USED TO PRESENT A SERIES OF SYMPTOMS,
C       ASK FOR A DIAGNOSIS, AND TO RECORD SEVERAL FACTORS
C       RELATING TO THE RESPONSE.
C
          DIMENSION NOM(12),NO(5,60),NOUT(2),IN(20),MA(2),JM(3,2),D(2),
+     TM(2)
          DATA NOM/1,2,2,1,2,2,1,2,1,2,2,2/
          DATA NOUT/10HHIGH BP   ,10HLOW BP    /
          DATA MA/10HA         ,10HN         /,NS/10HB         /
           DATA NEND/10HEND       /
           DATA NEXT/10HNEXT      /
           NPAT=0
           MK=1
C
C     SET UP RESPONSE ARRAYS
C
           L3=0
           DO 70 L1=1,5
           DO 70 L2=1,12
           L3=L3+1
   70      NO(1,L3)=NOM(L2)
           L2=0
           DO 71 L1=7,10
           L2=L2+1
           L3=L1-6
           NO(2,L2)=NOM(L3)
   71      NO(3,L2)=NOM(L1)
           DO 72 L1=1,46
           L2=L1+4
           NO(2,L2)=1
   72      NO(3,L2)=NO(1,L1)
C
C     READ IN SUBJECT NUMBER AND ACT APPROPRIATLY
C
   51      WRITE(6,1)
   1       FORMAT(6X,*WHAT IS YOUR NUMBER≥*/)
           READ(5,2) NAME
   2       FORMAT(I3)
           IF(NAME) 56,56,52
C
C     PUT INSTRUCTIONS IN HERE
C
   52      WRITE(6,3)
   3       FORMAT(5X,*HELLO,*/8X,*I HOPE YOU UNDERSTAND THE IMPORTANCE*,
+ * OF BOTH THE ACCURACY OF*/10X,*THE DIAGNOSIS YOU MAKE AND THE*,
+ * SPEED WITH WHICH YOU MAKE IT.*/
+ 8X,*I WILL GIVE YOU ONE OF TWO POSSIBLE BLOOD PRESSURE READINGS:*/
+ 26X,*HIGH BP*/
+  30X,*OR*/26X,*LOW BP*/10X,*AND THEN ASK FOR YOUR DIAGNOSIS.*/
+ 8X,*IF YOU NEED MORE BLOOD PRESSURE READINGS BEFORE MAKING */
```

```
+ 10X,*YOUR DIAGNOSIS, SIMPLY TYPE THE LETTER ≠B≠.*/
+          8X,*YOU MAY TAKE YOUR TIME IN RESPONDING,*,
+ * BUT REMEMBER THAT EACH*/10X,*READING YOU REQUEST REPRESENTS*,
+ * THE LOSS OF ABOUT 30 MINUTES,*/10X,*SO DO NOT LET THE PATIENT≠S*,
+ * CONDITION DETERIORATE TOO LONG.*//8X,*YOUR FINAL DIAGNOSIS*,
+ * CAN BE INDICATED BY TYPING:*/20X,*≠A≠ FOR ANEUROPHASIA*/30X,*OR*/
+ 20X,*≠N≠ FOR NEUROPHASIA*/8X,*REMEMBER:*/10X,*ANEUROPHASIA*,
+ * PRODUCES A PREPONDERANCE OF HIGH BP READINGS*/,10X,*NEUROPHASIA*,
+ * PRODUCES A PREPONDERANCE OF LOW BP READINGS*//8X,*THE READINGS*,
+ * FOR YOUR FIRST PATIENT WILL BEGIN WHEN YOU ENTER ≠S≠.*///)
          READ(5,100) START
  100     FORMAT(1A1)
          WRITE(6,101)
  101     FORMAT(5X,*OKAY*)
C
C    WRITE IN DATE AND TIME ON UNIT 4
C
          DD=DATER(D)
          DTM=CLOCK(TM)
          WRITE(4,18) NAME,D,TM
  18      FORMAT(I4,1X,A10,1X,A10)
C
C    INITIALIZE AND CHECK FOR NUMBER OF PATIENTS
C
  56      NPAT=NPAT+1
          IF(NPAT.EQ.1) GO TO 57
          IF(NPAT.GT.5) GO TO 58
C
C    PUT INTRODUCTION TO NEW PATIENT IN HERE
C
          WRITE(6,16)
  16      FORMAT(6X,*I WILL NOW GIVE YOU READINGS FOR A NEW PATIENT*
+    )
C
C    INITIALIZE FOR RUN
C
  57      DO 54 I=1,3
          DO 54 J=1,2
  54      JM(I,J)=0
          JD=2
C
C    LOOP FOR PATIENT
C
          DO 13 I=1,50
C
C    CHOOSE SYMPTOM AND ACT
C
          NPT=NPAT
          IF(NPAT.LE.3) GO TO 73
           NPT=NPAT-3
           IF(NPAT.EQ.5) NPT=3
  73       MO=NC(NPT,I)
           IF(NPAT.GT.3) MO=2/MO
           IF(NAME.LE.499.AND.NAME.GE.-49) GO TO 64
           TI=(FLOAT(I)*30.)/60.
           WRITE(6,19) NOUT(MO),TI
  19       FORMAT(///////////5X,A10,3X,*(*,F5.1,* HOURS HAVE PASSED)*)
           GO TO 65
  64       WRITE(6,4) NOUT(MO)
```

```
 4    FORMAT(////////////5X,A10)
C
C     MONITOR MODELS AND K VALUES
C
 65   IF(MC.NE.JD) JM(3,JD)=0
 55   JD=MC
      IF(JD.EQ.2) JD=MO-3
      JM(1,1)=JM(1,1)+JD
      JM(2,MO)=JM(2,MO)+1
      JM(3,MC)=JM(3,MO)+1
      JD=MC
C
C     REQUEST AND READ DIAGNOSIS
C
      WRITE(6,5)
 5    FORMAT(3X,*DIAGNOSIS*)
 53   S=RTIME(SD)
      READ(5,6) (IN(I3),I3=1,8)
 6    FORMAT(8A10)
      P=RTIME(SD)
      T=(P-S)/(10.**10.)
C
C     IDENTIFY DIAGNOSIS
C
      DO 7 J=1,2
      IF(IN(1).EQ.NEXT) GO TO 56
      IF(IN(1).EQ.NEND) GO TO 58
      IF(IN(1).EQ.NS) GO TO 59
      IF(IN(1).EQ.MA(J)) GO TO 8
 7    CONTINUE
C
C     WRITE OUT UNRECOGNIZED DIAGNOSIS AND PROMPT
C
      WRITE(4,10) NAME, I,(IN(K),K=1,7)
 10   FORMAT(2I4,7A10)
      WRITE(6,9)
 9    FORMAT(5X,48HI DON≠T UNDERSTAND YOU, PLEASE ENTER REPLACEMENT
+     )
      GO TO 53
C
C     MONITOR S RESPONSE
C
 59   WRITE(4,17) NAME,NPAT,I,MO,T,((JM(I1,J1),J1=1,2),I1=1,3)
 17   FORMAT(I4,2I3,I2,F8.3,6I2)
      GO TO 13
C
C     RECORD DATA
C
 8    WRITE(4,11) NAME,NPAT,I,MO,T,((JM(I1,J1),J1=1,2),I1=1,3),J
 11   FORMAT(I4,2I3,I2,F8.3,7I2)
C
C     MONITOR DIAGNOSIS
C
      IF(I.LE.2) MK=2/MK
C
C     INCREASE K VALUE IF I IS TOO SMALL
C
      IF(I.GT.2) GO TO 56
      WRITE(6,21)
```

```
21     FORMAT(6X,*YOU HAVE GIVEN THE WRONG DIAGNOSIS*/
+ 10X,*-YOUR PATIENT HAS DIED*)
       GO TO 56
13     CONTINUE
       WRITE(6,20)
20     FORMAT(6X,*YOU HAVE TAKEN TOO LONG - THE PATIENT HAS DIED*/)
       GO TO 56
58     WRITE(6,15)
15     FORMAT(6X,*THANK YOU FOR YOUR TIME*)
       REWIND 4
       STOP
       END
```

APPENDIX F.B.
DATA RECORDED BY MACHINE FOR SUBJECT NUMBER 20

```
INFORMATION RECORDED IN THE FOLLOWING FORMAT:
      1. EXPERIMENT NUMBER
      2. PATIENT NUMBER
      3. TRIAL NUMBER
      4. MACHINE RESPONSE (SYMPTOM)
                1 = HIGH BP
                2 = LOW BP
      5. LATENCY OF SUBJECT RESPONSE
      6. K VALUE FOR DIFFERENCE MODEL
      7. NO INFORMATION
      8. AND 9. K VALUES FOR THE TWO SUBSYSTEMS OF THE
                SIMPLE ACCUMULATOR MODEL
     10. AND 11. K VALUES FOR THE TWO SUBSYSTEMS OF THE
                 RUNS MODEL
     12. SUBJECT DIAGNOSIS:
                1 = ANEUROPHASIA
                2 = NEUROPHASIA
```

```
419  73/07/09.
419  1  1 1  35.232 1 0 1 0 1 0
419  1  2 2  28.521 0 0 1 1 0 1
419  1  3 2  26.844-1 0 1 2 0 2 2
419  2  1 1  21.810 1 0 1 0 1 0
419  2  2 2  11.744 0 0 1 1 0 1
419  2  3 2  31.877-1 0 1 2 0 2 2
419  3  1 1  16.777 1 0 1 0 1 0
419  3  2 2  10.066 0 0 1 1 0 1
419  3  3 1  18.455 1 0 2 1 1 0
419  3  4 2  16.777 0 0 2 2 0 1
419  3  5 1  13.422 1 0 3 2 1 0 1
419  4  1 2  13.422-1 0 0 1 0 1
419  4  2 1  11.744 0 0 1 1 1 0
419  4  3 1  16.777 1 0 2 1 2 0
419  4  4 2  10.066 0 0 2 2 0 1
419  4  5 1  15.099 1 0 3 2 1 0
419  4  6 1  11.744 2 0 4 2 2 0 1
419  5  1 2  13.422-1 0 0 1 0 1
419  5  2 1  15.099 0 0 1 1 1 0
419  5  3 2  13.422-1 0 1 2 0 1
419  5  4 1  15.099 0 0 2 2 1 0
419  5  5 2  10.066-1 0 2 3 0 1
419  5  6 1  20.133 0 0 3 3 1 0 1
```