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TOWARD A THEORY OF RATIONAL INDIVIDUAL CHOICE

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of the Ohio State University

by

Terry Franklin Buss, B.A., M.A.

* * * * *

The Ohio State University

1976

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ACKNOWLEDGEMENTS

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Chapter 1
INTRODUCTION

1.1 Individual Choice

Individuals frequently find themselves in political situations in which they may be required to choose one or more actions from a collection of possible actions. A Congressman might be faced with a vote upon several amendments to a legislative bill before the House of Representatives (Riker, 1958). A voter in a presidential election might find it necessary to select political candidates based upon their issue stances on various policy positions (Downs, 1957). Or members of a policy planning committee in a federal agency might be required to decide which policy best represents the manifest goals of their bureaucratic organization (March and Simon, 1958). These so called "individual choice situations," for purposes of this investigation, may be conceived of as instances wherein an individual, when faced with a set of mutually exclusive actions, selects, chooses or performs one or more of these actions to the exclusion of the others (Siegel, 1964, p. 1; Richter, 1971, p. 30).

1.2 Choice Under Certainty, Risk, Uncertainty

One way to organize a discussion about individual choice is to consider choice situations which include
certainty, risk, and uncertainty (Luce and Raiffa, 1957, p. 13). Individual choice involving "certainty" includes choice situations in which every available alternative for choice leads to a unique, known consequence. A political decision-maker might be required to choose one policy position from a set of three policy positions. He knows that the one he chooses will be implemented; his task is to determine which one to select. Individual choice may also include situations involving "risk," wherein an individual is faced with a set of alternatives whose consequences occur at some known probability. A foreign policy advisor might be faced with proposing three alternative politics to the President. He knows that the President is likely to choose each alternative according to a given probability, since he has recommended the policies several times before. His task is to choose the policy which is acceptable, given his knowledge of the likelihood of the President's individual choice behavior. And individual choice may involve "uncertainty" if the alternatives for choice have consequences whose probabilities are not known. Weather forecasting is very much concerned with choice under uncertainty. Although the three varieties of individual choice are important, the study will concern only individual choice under certainty. This focus on certainty still leaves many interesting political choice situations for analysis, such as: selecting candidates in presidential
elections, answering questions on public opinion survey questionnaires, voting on bills in Congress, evaluating policy alternatives in bureaucratic setting, and so on.

1.3 Formal Theoretic Approach

Although individual choice under certainty may be analyzed in many ways (Lee, 1971, pp. 1-15), the approach chosen for this study is the formal theoretic approach. Rather than offer an ostensive specification of the methodology of the approach, this investigation will illustrate an analysis of individual choice which is consistent with the formal theoretic approach. Elaboration of various aspects of the approach may be found in Dahl (1956), Downs (1957), Riker and Ordeshook (1973), Thorson and Stever (1974) and Fiorina (1975).

Consider a voter in a Presidential election. The voter is faced with a choice situation in which he must vote for one political candidate on a ballot containing three candidates. The voter chooses the candidate he most prefers. How can this act of individual choice be represented?

An initial assumption in the representation of individual choice is that an individual chooser is presented with sets of alternatives from which he must select one or more alternatives. Let \( x \) represent the set of alternatives presented for choice. In our example above these alternatives would consist of all of the candidates in the
election. Some of the alternatives may be presented to an individual chooser for choice. Now, let $\chi$ represent the family of sets presented to the individual and let any particular element in $\chi$ be represented as $\{A_1, ..., A_n\}$ where any arbitrarily designated $A_2$ is a distinct alternative. In our example, the three candidates represented as $A_1, A_2, A_3$, respectively make up the distinct alternatives in $\chi$. The elements of $\chi$, that is $\{A_1, ..., A_n\}$ are the presentation sets from which an individual chooser makes choices (Bush et al. 1963, p. 83).

It is further assumed that an individual chooser has some goal, desire, propensity, standard or preference according to which the alternatives in a presentation set are to be evaluated. Since these concepts are not equivalent (see Von Wright, 1963; Samuelson, 1947), the study will consider individual choice only in the context of preference-based choice. Preference in this context is reviewed in its various appearances by Luce and Suppes (1963). Let $B$ represent the preferences of the individual chooser. In our example, these might include several dimensions according to which candidates might be compared, such as: issue positions, partisanship, voting record, and so on. These preferences may occur in various combinations. Let these combinations be represented by the family of sets $\chi$ and let any particular set within this family be represented as an element in $\{P_1, ..., P_n\}$. Any arbitrarily
designated \( P_i \) may be referred to as a preference set (Luce and Suppes, 1963). In our example, a preference set for a voter might consist of the ordered triple \((A_1, A_2, A_3)\), wherein candidate \( A_2 \) is preferred to \( A_1 \), \( A_1 \) is preferred to \( A_3 \) and \( A_2 \) is preferred to \( A_3 \). Preference sets differ greatly according to the formal properties which may be imposed upon them (see Luce and Suppes, 1963; Coombs, et al., 1970, for many of these properties and their importance). Many analysts require, for example, that alternatives in preference patterns satisfy the property of "connectedness" which requires that given two alternatives, \( A_1 \) and \( A_2 \), and a relation \( R \) defined upon these alternatives, either \( A_1 R A_2 \) or \( A_2 R A_1 \) holds. Analysis of preferences consists of varying the variety and combination of formal properties in order to assess their implications.

Once the presentation set and preference set are given for an individual, the production of choices may be considered. Choices are produced by a "function," say \( \mathcal{F} \), in which the family of presentation sets \( x \) and the family of preference sets \( x \) are mapped into the presentation sets \( X \); or in symbols, \( \mathcal{F}: x \rightarrow X \). This may be referred to as a choice function (see Uzawa, 1960, for a review of the important properties of choice functions). To take a specific case, our voter when faced with the candidates in the presentation set \( \{A_1, A_2, A_3\} \) and given the voter's
preference pattern \((A_1, A_2, A_3)\), then a choice function would yield the ordered triple \((A_2, A_1, A_3)\).

Now the general notion of a choice function suggests that the function will produce alternatives which are at least as good as every element in the presentation set (Pattanaik, 1971, p. 9). So in the case of our voter, the ordered triple \((A_2, A_1, A_3)\) may be interpreted as "\(A_2\) is at least as good as \(A_1\) or \(A_3\)." This set of "equally adequate alternatives" produced by the choice function may be referred to as a choice set (Chernoff, 1954).

1.4 Rational Individual Choice

Thus far the study has focused on preferred-based choice under certainty as viewed from a formal theoretic perspective. Now, it is possible to consider whether or not individual choice is "rational," as opposed to being irrational, non-rational or extra-rational (Richter, 1971; Downs, 1957). Although rationality can be defined in many ways (see Riker and Ordeshook, 1973; Kettler, 1966; Hayek, 1960; Mannheim, 1940; Strand, 1975; Dahl and Lindblom, 1953; Downs, 1957; Bennett, 1966; Berelson, et al., 1954; for a discussion of its many appearances), one of the most interesting is rationality in conjunction with the formal property of transitivity. "Transitivity," as a formal relation, is generally defined as follows (Pfanzagl, 1968, p. 20): given a binary relation \(R\) defined on a set \(A\), for all \(a, b, c \in A\), \(aRb\) and \(bRc\) together imply \(aRc\).
Rationality in association with transitivity in preference-based choice may be formalized in one of two ways. On the one hand, if a preference pattern which manifests transitive relations among alternatives for choice leads to choices which are consistent with this pattern, that is, transitive relations are revealed in the choices; then the preferences are said to "rationalize" the choices (Richter, 1971, p. 30). This perspective associates transitivity with preferences in order to predicate rationality of individual choice (see Arrow, 1963; Riker and Ordeshook, 1973). On the other hand, if one begins with choice data which manifests transitive relations and if one can discover some preference pattern to rationalize them, then choices may be treated as rational (Richter, 1971, p. 30). Regardless of whether the focus of analysis is on rational preferences which rationalize choices or rational choices which can be rationalized by preferences, their association with the formal property of transitivity is the cornerstone of rational individual choice (see Edwards, 1954, 1961; Luce and Suppes, 1965; Samuelson, 1953; Luce and Galanter, 1963; Riker and Ordeshook, 1973).

This central assumption remains the case even though some analysts of rational individual choice have attempted to weaken the assumption of rationality by citing empirical evidence which suggests either that individuals do not manifest transitive relations in many choice situations (May,
1953, 1954; Tversky, 1969, Coombs, 1964, 1968), or that rational individual choice theories which are reasonable yet have no transitivity assumption may be constructed (see Strand, 1975; Richter, 1971).

The assumption of rationality as tied to the property of transitivity is important to rational individual choice theory for at least the following reasons. First, the property of transitivity when it obtains has certain "nice" characteristics which other relations may not have (see Richter, 1971, p. 32). Among these is that it is possible given an ordering of objects to determine which object is most preferred and least preferred in a preference pattern. Riker and Ordeshook (1973, p. 17) state that without this characteristic it is not clear if choice behavior can be meaningfully analyzed. Second, the property allows for the use of choice functions having important characteristics for individual choice (Uzawa, 1960). So for example, if preferences and relations among objects are transitive, it is possible to find choice functions which allow for correspondence between preference and choice. And third, the property is important to social choice theories in that individual transitive behavior suggests interesting possibilities for analysis when aggregating choice data across individuals (Arrow, 1951; Pattanaik, 1971).
1.5 An Apparent Shortcoming

Theories of rational individual choice as presented above assume as "given" presentation sets, preferences patterns, choice functions and choice sets which are unambiguous, well-defined and easily identifiable in some formal language (see Newell and Simon, 1972, p. 54). Analysis of choice under this framework consists of "fixing" or assuming certain kinds of formalisms for some of these givens and then assessing the formal consequences for those not fixed or assumed (Richter, 1971). An analyst might construct a certain preference pattern and by positing different kinds of choice functions determine what kinds of choice sets are produced (Uzawa, 1960).

Now, theories of rational individual choice are most interesting for understanding observed choice behavior to the extent that observed choice behavior approaches or approximates that represented by the formal theory (Downs, 1957, p. 21). But, most theories of rational individual choice do not approach explanations of individual choice behavior manifested by individuals (see May, 1953; Tversky, 1969; Riker, 1958; Smedslund, 1963, 1965; Piaget, 1970). Consequently, many theories of rational individual choice remain true of "some possible world," but may not conform to observed behavior.

One way to deal with the problem of the disparity between the theories of rational individual choice and the
observed behavior of individuals is to conclude that the individual is essentially irrational, non-rational or extra-rational. But this approach suggests that the theories constructed are only of interest "in principle" (see Berelson, et al, 1954).

Another more suitable approach suggests that the domain of theories of rational individual choice could be enlarged from a consideration of "givens" to include a concern for formulating possible structures, components, processes and systems sufficient to represent the possible cognitive dynamics of individual choice behavior (Coombs, Dawes, Tversky, 1970, pp. 163-164; Newell and Simon, 1972). In so doing, rational individual choice might not only be concerned with "givens," but also with selective perception, context effects, perceptual accuracy, memory storage and retrieval, choice processing mechanisms, response set effect, and so on. With a theory of cognitive dynamics imbedded in a theory of rational individual choice, it may be possible to gain a better understanding of individual choice behavior while at the same time preserving many of the important results of formal-analytic theories of choice. Although this approach seems like a reasonable enterprise, it remains at this stage only a goal.

1.6 Purpose of This Study

Thus far the investigation has traversed a considerable amount of theoretical, formal and empirical territory
arriving finally at a problem with theories of rational individual choice that has only a proposed general guideline for solution. The purpose of this study will be to attempt to enlarge the domain of existing rational individual choice theory to include a concern for cognitive dynamic processing with the intent of reducing the disparity between rational individual choice theory and observed individual choice behavior.

1.7 Some Strategic Considerations

The plan of the analysis will consist of the following strategy. First, a framework for representing and analyzing individual choice will be developed. Second, a theory of individual choice which includes some major cognitive processing considerations will be constructed. Third, a theory of rationality will be offered to be used to determine the rationality of individual choice. Fourth, the resulting theory of rational individual choice will be operationalized, that is, it will specify a set of observations for measurement. Fifth, the specific sets of observations for measurement will be performed using experimental research so that an empirical test of the theory may be given. And sixth, the theory and experimental results will be compared with rational models of political behavior in political socialization and public opinion.

These strategic concerns are dealt with specifically in the following chapters. Chapter 1 includes the
individual choice theory founded upon a concern for cognitive dynamics. Chapter 2 provides the preliminaries for a theory of rationality. Chapters 3 and 4 constitute an operationalization of the theory of rational individual choice and a precise methodological statement of the experimental design and procedure conducted in the study. Chapter 5 presents the empirical results of the experiments conducted. And Chapter 6 offers a conclusion and an application of the theory to rational models of political behavior.
Chapter 2

A THEORY OF INDIVIDUAL CHOICE

To conclude, seeing there may be many who will not like this my definition of philosophy, and will say, that from the liberty which a man may take of so defining as seems best to himself, he may conclude any thing from any thing . . . yet, lest in this point there should be any cause of dispute betwixt me and them, I here undertake no more than to deliver the elements of that science by which the effects of anything may be found out from the known generation of the same, or contrarily, the generation from the effects; to the end that they who search after other philosophy, may be admonished to seek it from other principles.

Thomas Hobbes,
De Corpore

2.1 Introduction

In Chapter 1, rational individual choice under certainty was introduced as the major topic for investigation. Previous theories of rational individual choice relying upon formal theoretic analyses were asserted to be somewhat inappropriate for explaining much observed individual choice behavior. One goal of the formal theoretic perspective was to make theories of rational
individual choice more appropriate for explaining individual choice behavior. In this chapter, achievement of this goal is attempted in the following manner. First, the study offers a definition of individual choice, along with a reformulation of the entire individual choice problem presented in the form of an analogy. Second, given the new representation for the problem of individual choice, information processing theory is chosen as a possible theoretical framework for making sense of the choice problem. This framework includes several characteristics which might solve many problems apparent in competing choice theories, as well as many possibilities for satisfying some theoretical desiderata for a theory of individual choice. Although information processing theory as it now stands allows for the above to a certain extent, it does not entirely relate to individual choice. Instead, it refers mostly to representations of more general problem solving activities which may include some aspects of individual choice behavior as defined for purpose of this analysis. This being the case, the analysis attempts to include a more general notion of choice within the domain of problem-solving. This is accomplished by constructing a flow diagram which represents an individual choice mechanism.
And third, the information processing theory perspective is slightly modified along several dimensions in order to better account for choice. Among these include the use of classical experimental design, the interplay between theory, data and formalisms, and some important assumptions which affect the representation and analysis of choice mechanisms.

2.2 An Alternative Representation of the Problem of Individual Choice

The formulation of any theoretical problem determines and limits the possible solutions to the problem under analysis. Since most theoretical problems are subject to a wide variety of formulations, it makes little sense to speak of a "best" formulation of the problem to attain a solution. Instead, it seems to make more sense to ask, given a certain formulation of a theoretical problem, what is the nature and character of the class of solutions which might be generated? Once this question has been answered at least in part, then an analyst may compare one problem formulation and class of solutions to others in order to assess their usefulness vis-a-vis one another. In sum, theoretical problems and solutions only make sense according to a presupposed frame of reference (March and Simon, 1958, pp. 138-9).
In order to provide a frame of reference in which the problem of individual choice may be formulated, this portion of the analysis will offer a definition of individual choice and suggest one way in which the problem might be represented.

2.2.1 Individual Choice Defined

As with most theoretical constructs, there are a multiplicity of ways in which to characterize individual choice (see for example, Luce and Suppes, 1965). For purposes of this analysis, one widely accepted notion of individual choice offered by Bush, et al (1963) will be used. In general, *individual choice* may be defined as: Whenever an organism, either in its natural environment or in the laboratory, is confronted with a set of two or more mutually exclusive courses of action—responses—and it selects or performs one of them, we say that a choice has occurred" (p. 79). The concept of individual choice does not require or even suggest a conscious decision in the process of choosing over a set of actions. This being the case, judgemental choice situations which arise out of individual consciousness such as length, color or sound frequency discrimination experiments (see, for example, Poulton, 1968) are included in a theory of individual choice, as well as unconscious choice situations arising of physiological
peculiarities in the operating logic of the living brain (see, for example, Sommerhoff, 1974).

2.2.2 The Problem of Individual Choice

Imagine yourself standing next to a sealed carton, the insides of which are not visible. On one face of the carton, there are two openings, one labeled "input" and the other labeled "output." You notice that the operator of the carton is feeding presentation set data into the input opening and receiving a subset of this presentation set data from the output opening. The operator of the sealed carton poses the following problem for you to solve. First, under what conditions would you as an observer conclude that the carton was engaging in an act of choice? Second, if the carton may be considered an individual choser, then how would one represent the internal processes which are producing choice data. And third, if the internal processes of one carton can be represented, then can one predict choice behavior given knowledge of the presentation sets input into the carton?

In addition to posing the problem, the operator imposes the following restrictions upon your problem solving activity. First, you may not assume that the carton can input presentation sets in any language, either natural or artificial; but instead must find the "appropriate" languages or languages in which to represent the presentation sets. Second, you may neither view nor change the insides of the
carton at any time. And third, you may assume that the output subsets of the presentation sets have been modified, transformed or mediated in some cases by the internal processes of the carton. The operator mentions in passing that you are permitted to vary the nature of the presentation sets input into the carton and to observe the resulting output.

Having laid out the problem and restrictions, the operator turns to you and asks, "How would you solve the problem?"

The "sealed carton" problem provides a nice analogy with the problem of enlarging individual choice to include a concern for cognitive processing. One way in which it does this is by requiring a theorist not only to include such "givens" as presentations sets, preferences, and the like, but it also requires him to find a way to discover whether or not a choice is made, how the mechanisms which process presentation sets mediate them, and how one can interpret choice behavior which is observed. In short, it requires the theorist to make inferences about choice processing mechanisms.

A theorist is successful in representing individual choice from a "sealed carton perspective" if the following occurs. Consider a situation wherein an observer is asked to distinguish between the observed choice data produced by a chooser represented by a sealed carton and a human individual chooser. The observer is not allowed to observe
either chooser. If the observer cannot determine from the observed choice data produced by both choosers which choice data was produced by which chooser, then the sealed carton constitutes a representation of individual choice. So how might one represent individual choice according to the "sealed carton analogy" framework?

2.3 Information Processing Theory: A Proposed General Framework for Analyzing Individual Choice

Information processing theory as formulated by Newell and Simon (1972), Newell (1973), and Klahr (1973) provides a framework which might make sense of the problem of individual choice as represented by the "sealed carton analogy" and the subsequent questions generated in the previous section. To begin with, information processing theory is appropriate since it manifests certain desirable ways of formulating theories which are relevant to the sealed carton analogy. These can be summarized initially in the first section below. Information processing theory is not explicitly relevant to individual choice as it is now formulated. Instead it concerns primarily task-specific problem-solving activities. This being the case, it must be made compatible with the concept of individual choice. The focus of information processing theory on individual choice is dealt with in the final section.
2.3.1 Information Processing Systems

The first concept to be considered is that of "symbol." A symbol is an expression or token which designates or references something. In rational individual choice, symbols will reference objects over which choices are made. Symbols may be combined into sets of symbols with relations defined upon them. Symbols and relations defined upon them may be referred to as symbol structures, or simply as structures. Preference orders are symbol structures since they consist of objects of choice with relations defined upon them (see Brunner and Brewer, p. 89).

The basis of information processing theory centers around the use of information processing systems. An information processing system (IPS) is a system consisting of a memory, processor, effector and receptor (Newell and Simon, 1972, p. 20). These "components" of the IPS are characterized in the following figure.

PLACE FIGURE 1 ABOUT HERE

Taking each of these components in turn, memory may be characterized as a component for storing and retaining symbols and structures in the IPS. Memory is of two varieties, short term (STM) and long term (LTM). Short term memory stores the input and output symbols and structures of individual production statements. Long term memory is a source of additional information from within the IPS which is interfaced with the STM (Newell, 1973, p. 467). The STM
Figure 1. An Information Processing System.\textsuperscript{a}

\textsuperscript{a}Adapted from Newell and Simon (1972, p. 20).
is an integral component of the processor which operates upon the data structure. The receptors are linkages with the external environment of the IPS, where environment is conceptualized as an external memory (EM). The IPS may also manipulate its external environment by means of effectors which act directly upon the external environment (Newell and Simon, 1972, pp. 20-21). By specifying these components which constitute many recognizable processes, that is, its memory, encoding and operations, it is possible to construct an information processing system.

**Productions and production systems.** The way in which an information processing system is constructed depends upon the use of production statements which when taken together form a production system. A production is an independent rule consisting of a "condition" and an "action" in the following form: \( C \rightarrow A \). The condition portion of the rule consists of symbols which are capable of being true or false of a given set of data structures. These data structures are expressions that encode information on which a production operates. The action portion consists of all those modifications, deletions and additions which are or can be executed upon the data structure (Klahr, 1973, p. 528; Newell, 1973, p. 463). Each production may be collected with others to form a production system. The production system operating upon a given data structure, starts initially by considering a first production which has a
condition that is true for the data structure, then an action is executed which operates upon the data structure. After the consideration of the first production, another production having a true condition becomes operative so that an accompanying action is executed on the data structure. This process continues until all productions having the conditions are executed and no further actions are indicated (Newell, 1973, p. 463).¹

Control structures. In order to specify the actual way in which the IPS processes symbols, it is necessary to have additional knowledge about the "control structure" of the IPS. The control structure of an IPS is the organization of the entire process, that is, control that constitutes a precise specification of the IPS's operation as it passes from one production to another until the entire production system is accounted for (Miller, et al., 1960, pp. 27-28). Control structure and the notion of production system are related in that a production system is one type of control structure (Newell, 1973).

Task environment. The environment external to the individual chooser provides some goal, problem or task which the chooser may perceive as requiring processing to attain some desired end. Let this environment be referred to in general as the task environment (Newell and Simon, 1972, Chapter 3) and when applied to choice situations let it be referred to as the choice task environment. An
example of a task environment would be the presentation of the game of tic-tac-toe so that an individual chooser must "play" the game according to a set of rules against another individual chooser in order to win or tie. An example of a choice task environment would be a survey questionnaire in which several candidate rating scales, or "thermometer scales," are presented two at a time for pairwise comparison so that the choice task requires the individual to choose the candidate out of a pair of candidates he prefers more and the one he prefers less, and then he is required to indicate the degree of preference by placing the choices on the interval level thermometer scale. Both task environments are "objectively" determined—that is, the experimenter or outside observer determines their representation.

2.3.2 The Problem of Representation

Within the IPS framework, one might interpret the "sealed carton analogy" as a "problem of representation." The "problem of representation" is best characterized by asking four related questions (see Klahr and Wallace, 1970, pp. 363-4; Trabasso, et al., 1975, pp. 1-30; Newell and Simon, 1972; and Simon and Newell, 1974, p. 132). First, how is the choice task, that is, the requirements of the choice situation the objects and the relations between objects, formally represented? By represented is meant the symbol structure which is chosen by the analyst which characterizes the choice task to be given to an individual. Representation
in this first question, then, concerns the external or objective characterization or representation of the choice task by an analyst. See, for example, Laughery and Gregg's (1962) analysis of serial patterns in choice task environments involving binary choice.

Second, how does the individual participating in the choice task map the external objects and relations as characterized by the analyst into some "internal representation?" Representation at this stage is best viewed as the transformation of the external objects and relations into some individual internal representation of objects and relations. See, for example, Quillian's (1968) treatment of LTM as a kind of associational net. This transformation may be unique and idiosyncratic or it may be generalizable to many individuals (Klahr and Wallace, 1970, p. 363).

Third, given a particular external and internal representation of the objects and relations, how does the individual operate on or process the encoded information contained in the internal representation? This question amounts to asking what sorts of components and processes can be posited in the choice processing mechanism of the individual which would be sufficient to represent a possible mechanism for manipulating the encoded symbols in the representation. At this stage, there are two kinds of representation internal for individual choice: one is the representation of the objects and relations encoded internally as symbols and the
other is the representation of components and processes which act upon or manipulate these internal symbols.

And fourth, how can an analyst represent observed individual choice behavior, given the external mapping into internal representation and the internal processing mechanism which could have produced the observed behavior? This question refers to the opposite kind of problem given in the first question above in that above, the problem concerned finding a mapping from the external to the internal, and the latter question concerns finding a mapping into some representation from the internal to the external or observed behavior.

In addition to the four problems of representation above, there is a fifth which is slightly different in nature than the other four. This involves the notion that not only are the problems of internal and external representation which are related to a particular choice task relevant, but also, an analysis must account for additional modes of processing which influence the fundamental representations being considered. In other words, it may be possible to represent symbol structures, components and processes in the four problems above, but one must also be aware of other possible processing mechanisms which influence those only concerned with choice behavior. So, for example, a person may perform an act of choice in one set of representations, but some long term memory component may affect the various
mappings and processes to yield slightly different results. This notion, labeled "depth of processing" (Craik and Lockhart, 1972) is an important consideration in building representations of individual choice.

The problem of representation along the above dimensions may be solvable in part by the manner in which the various remaining subsections in this analysis are employed. The analysis will now turn to a discussion of these possibilities.

**Languages and formalisms.** A major assumption of information processing theory is that humans viewed as information processing systems may have their problem-solving processes represented using formal languages or formalisms such as Turing machines, recursive functions, automaton theory and programming languages for production systems (Hopcroft and Ullman, 1969; Simon and Newell, 1974, p. 101). This is significant not only because formalisms are employed as representations of internal and external symbol structures, but also because these formalisms are assumed to capture and represent one "possible" interpretation of the cognitive dynamics or processes which might have initiated and produced observed behavior for an individual. In other words, representations using formalisms are thought to relate directly to actual choice behavior, problem-solving, perception, thinking, learning and memory in the sense of capturing some flavor of some possible interpretation of the structure
and dynamics of these processes sufficient in nature to explain observed individual behavior (Simon and Newell, 1974, p. 104).

**Production systems as explanations.** Information processing systems represented by production systems are not simply "descriptions" of the cognitive processes in individual behavior. They are assumed to constitute, in addition, an "explanation" for the structure, components and processes which in a given environment produce observable kinds of behavior (Newell and Simon, 1972, p. 9). In short, an IPS constitutes a theory of at least some aspect of human behavior in problem solving. This explanatory assumption with regard to individual behavior is evidenced in at least the following characteristics identifiable in the approach: first, the IPS approach not only allows an analyst to posit structures and processes which represent individual choice, but also allows an analyst to make inferences about the properties of the posited system and cognitive dynamics which it represents. Or, in other words, the posited structures and processes imply or limit additional structures and processes in the system and in the cognitive dynamics of thinking, learning, memory and so on as well.

Inference and implication with regard to explanation refers not only to deductive and inductive derivations via formalisms, but also to less formal inferences and implications about how individual choice works or might work.
Second, the IPS approach is designed or formulated in such a manner that a production system for a given choice task is sufficient to represent and produce the observed behavior of an individual. Since the production system is sufficient, it does in fact represent one possible way in which the human individual processor could have manifested an observed behavior. Therefore, although the production system may not be related to any actual process, it still accounts for the behavior observed. In terms of explanation, one can in the absence of more complex models or additional information, always explain a task given a production system which is sufficient to represent behavior. An important restriction is, however, that the system cannot violate what is assumed to be true about the actual physiological functioning of the brain (Simon and Newell, 1974).

Third, the approach allows an analyst to generalize from task-specific representations of individual choice to more general problem-solving systems. For example, Ernst and Newell (1974) combine several closely related programs into a "General Problem Solver" which will explain several types of problem-solving behavior. This characteristic of the approach, although admittedly in its seminal stage is important since explanation is most powerful when it transcends isolated cases to more general families of problems.
And fourth, the approach is a powerful framework for explanation since it allows for the use of empirical evidence to confirm or disconfirm the theoretical and formal foundations implicit or explicit in a given system. This facet of the approach allows one to modify a system based upon empirical results generated by the theory. Of course, it is also the case that the theory may be used to modify and generate data which may be empirically relevant to system-building activities. In short, the approach admits of a kind of "leapfrog" effect and interplay between theory, data, and formal structure (Newell, 1974).

Theory-ladeness of Language. In theory building activities which use formalisms, an analyst has two choices with respect to neutrality in the language. One involves the notion that languages and formalisms may be considered neutral, irrelevant, or tangential with respect to the phenomenon being modeled. The other involves the notion that because languages and formalisms exist which are not neutral, these languages and formalisms may be chosen to build a theory which is based in a favorable way with regard to representing some phenomenon. Since the former choice is rarely attainable in most political theory enterprises, even when some formal language is employed, it makes sense for the human information processing theory approach to make use of formalisms which may represent one possible structure and process in human problem solving (Newell, 1973, pp. 516-517).
Theory-ladeness in the information processing approach is manifested in various ways. One way would be the architecture of the production system when converted into a set of formalisms in some language. In the previous discussion of basic IPS concepts, for example, it was noted that productions in short term memory are processed hierarchically (or serially) one after another as long as the $C \rightarrow A$ implication holds for each statement given the data structure. Now, this hierarchical processing of productions is analogous to an implied serial processing mechanism in cognitive dynamics which is sufficient in the sense of representing the performance of an individual in a given task environment. This being the case, it is clear that formalisms are not neutral affairs, but do in fact address a possible representation in cognitive dynamics.

The advantage of non-neutral formalisms, then, is that (1) an analyst need not eliminate non-neutral characteristics, but can instead make good use of them in the theory as part of the representative structure of the system, (2) an analyst may marshal an infinite set of formalisms to vary the kinds of models used to represent problem solving, and (3) an analyst may utilize formal models which are not content specific, and by converting them into representations relevant to a particular choice task an analyst can increase the number of formalisms which might apply to the problem.
The idea that theory-ladeness is an important consideration is of course necessitated since many formal/analytic enterprises employ formal languages without due consideration for their neutrality or observe of neutrality with respect to the modeled phenomenon. The IPS approach, then, attempts to ameliorate in part this particular problem in explanation.

Completeness. "Completeness" with regard to the information processing theory perspective has both a technical and non-technical connotation. The "technical" connotation of completeness suggests that since productions are very much theories in a formal/mathematic sense, or can be made to be theories in a formal/mathematical sense, the productions of the production system are sufficient for generating all logical truths expressible in the system. Or states in a slightly different way, every logical implication in a production system is a tautology in that system and can be expressed within that system (Nagel and Newman, 1958, p. 55; Margaris, 1967). This is important since it is desirable to be able to deduce the all of the logical conclusions in the production systems from the initial posited production statements used to construct the system. If this completeness were not a property, then there would exist tautological statements about a system which could not be deduced from the initial set of propositions of the system.
The "non-technical" connotation of completeness is of equal importance, but of a very different genre than the technical. Completeness of this sort concerns the notion of "sufficiency," where sufficiency asks of a system, is it rich enough in representations of components and processes to effectively "model" the phenomenon—that is, individual choice behavior—it is supposed to be modeling. (Newell, 1973, p. 517). If the model is not sufficient, then it might be so general so as to say nothing or it may be so specific so as to be too narrow in scope to be useful, or it may be entirely irrelevant to the theoretical problem at hand. A complete model, which is sufficient, may be best described as one which actually performs what it is intended to model. This notion of completeness is important to the approach since it is not simply the case that components and processes are being analyzed per se, but instead, these entities are "representations" of cognitive psychological dynamics which actually are thought to operate within a human problem solver given a certain task environment. Therefore, if actual psychological processing is important in a theoretical enterprise, then non-technical completeness must also be important.

Testability. A final assumption and characteristic of the information processing approach which has been implicit in much of the above is the notion that the formal representation of structures and processes which are sufficient
to represent actual cognitive processing is the idea that statements about these formal representations may be empirically tested by designing experiments (or other data generating enterprises) which will support or confirm the architecture and process of the production system. More specifically, performance indicators such as rate or response, accuracy, and amounts of information processed have implications for the kinds of production system models which will be sufficient to represent a cognitive process. If the model is incompatible with the data, then this suggests that either the model, the data or both are somehow not consistent with one another. Clearly this is an important assumption in that it motivated the idea that the symbols of a production system represent a psychological process. If they do, then testability must be assumed. Notice that pure mathematical individual choice theories with no reference to psychological processes do not require this assumption, and indeed oftentimes reject the notion. But, in so doing, the question of relevance of these pure theories is invoked.

2.3.3 From Problem-Solving to Individual Choice.

The initial treatment of information processing theory as an approach based upon the construction of production system suggested that the approach has focused mostly upon task-specific human problem-solving activities. Klahr (1973), for example, constructed a production system for
counting and adding. Newell and Simon (1972) and Newell (1973) developed a production system for solving problems in crypt-arithmetic. And Baylor and Gascon (1974) conducted a simulation given as production systems in order to represent the development of the ability of children to perform the weight seriation task. The approach has not explicitly, however, encompassed individual choice behavior; although this remains an explicit goal of the approach (Newell, 1973, p. 465).

An examination of the kinds of theoretical, formal, and empirical analyses generated by the information processing theoretical framework and methodology suggests that the approach may lend itself to the representation of more general kinds of individual choice behavior in addition to task-specific human problem-solving. This being the case, it seems that the approach might be used to construct a representation of the cognitive process in individual choice, where individual choice is broadly defined to include judgmental and preferential choice. In so doing, a general model of individual choice behavior may be able to be constructed.

Under the assumptions that the information processing theory approach is a fruitful one in terms of generating important results and that the approach lends itself to an analysis of individual choice, the analysis will attempt to provide the initial foundation for a theory of individual
choice along with an experimental analysis of choice (see Chapters 3, 4 and 5) both of which are couched in the IPS approach. The general plan of this portion of the analysis is to include within an IPS framework an opportunity for analyzing and representing individual choice, and then develop the choice framework into a more general theory of choice which is not task-specific.

2.4 The Individual Choice Mechanism

Having formulated the problem of individual choice in the sealed carton analogy and having proposed information processing theory as a possible theoretical framework for making sense of the problem, a very general representation of an individual choice mechanism can be constructed. In order to accomplish this, a flow diagram of the major components and processes of a representation of individual choice is offered. Each component and process is discussed separately and then related one to another. The theoretical components and processes of a possible representation of an individual choice producing mechanism are captured in the following flow diagram.

PLACE FIGURE 2 ABOUT HERE

The blocks in the flow diagram in Figure 2 indicate considerations and relationships which might increase our understanding of the general flow of input symbols from the choice task environment represented by a "choice stimulus" given as a structure into the processes of the
Figure 2. Flow Diagram Representation for an Individual Choice Mechanism.
individual choice mechanism whereby they are operated upon to produce choice in the form of responses observed in the environment.

2.4.1 Stimulus Block

Figure 2 represents the choice task environment for the individual choice mechanism. In general, this includes some goal, problem or task which an individual might perceive as necessitating or affording the opportunity to perform an act or acts of choice. The specific cue, collection of cues, signals, or some related terms which may induce choice behavior are referred to as stimuli (Bush, et al., 1963, p. 82). Varieties of stimuli relevant to individual choice might include a perceived image monitored on television, a statement uttered about politics, reading a question on a survey questionnaire, and so on.

Every stimulus is not perceived in identical fashion by every individual exposed to it (Bower, 1972, p. 35). Instead, each individual interprets and evaluates the stimulus according to a kind of perceptual screen in which only certain facets of the stimulus are viewed and according to which these perceived facets are altered by the individual to yield an idiosyncratic version of the stimulus. An example of an altered perception of a stimulus might be "selective perception" in which an individual only sees things as being pleasant to him (Festinger, 1957; Nimmo, 1970, pp. 179-192). The idiosyncratic version of the
stimulus from the external environment may be referred to as the **perceived stimulus**.²

The object of research involving stimulus perception is twofold. First, an analyst must attempt as much as possible to reduce the variation between the stimulus as "objectively" presented from the task environment and the results of the change in the stimulus due to perception. And second, since there is variation between the external and perceived stimulus, an analyst must attempt to control the manipulation and variation of the difference between the two in order to discover the possible patterned or functional relationship between the two.

By accomplishing the first goal above, an analyst may make statements about the external and perceived structures as if they were equivalent and from this equivalence, an analyst might then attempt to generalize findings across individuals. By accomplishing the second, an analyst might discover the nature and characteristics of the various possible stimuli and in so doing suggest means for manipulation and control. At any rate, the transformation of the external stimulus into an idiosyncratic perceived version is the focus of the first problem of representation discussed above—that is, the discovery of a mapping from an external representation into an internal one.

In terms of the notion of individual choice, the concepts of external and perceived stimulus are useful since
the study must insure that the model is in fact measuring what it is supposed to so that when a stimulus from the task environment is presented, the individual’s behavior is an understandable resultant of the way in which the external stimulus was conceived, and not the resultant of some unknowable perceived version of the stimulus, and

(2) the study requires manipulation and control in order to better understand and delimit the possible models which are sufficient to represent choice—that is, by variation, certain models are seen as appropriate while others are eliminated as contenders. Both points above then allow the analyst to address questions concerning possible representations of cognitive processes rather than simply their consequences as manifested in choice data.

2.4.2 Choice Mechanism Block

The perceived stimulus block provides input for the next block in the flow diagram of the choice process, the choice mechanism. The choice mechanism includes at least four components: strategy, decision-rule, preferences and judgmental valuations.

A strategy may be defined as a kind of meta-decision rule, that is, it is used to select a decision-rule out of the set of possible decision-rules available to the individual. A strategy might consist of employing initially a rule wherein decisions are made which yield alternatives which are "good enough" or satisfactory. This might be
referred to as "satisficing" (Simon, 1957). Once the satisficing rule is used to a certain extent the individual may decide to switch to a "value maximizing" rule which permits one to choose a rule according to whether or not it yields some maximum expected value (Coombs, et al., 1970). This might arise since an individual may have gained additional information in the process of satisficing which would allow him to maximize expected value. Strategies arise from at least three considerations: (1) "availability," that is, are they known to and usable for an individual?, (2) "success," are they or have they been successful in past choice situations?, and (3) "level of information," are they invoked where the choice situation is risky, certain or uncertain for the individual? (Luce and Raiffa, 1957; Axelrod, 1974).

A decision-rule may be defined as a rule which converts an individual's preferences or judgments over a set of alternatives into a choice set given a certain task environment. With regard to preferences, for example, an individual may want to vote in a presidential election. He is faced with five possible choices, two of which are undesirable. The time for voting is near at hand so he must quickly choose. He chooses one of the three candidates who is desirable, but does not compare them one with the other to ascertain which one is best. The decision-rule being used is "satisficing" which amounts to choosing a candidate
who is good enough, but may not be optimal with respect to his preference ordering. With regard to judgments, for example, an individual might be required to choose colored sticks in paired comparisons according to length (see Trabasso, et al, 1975). Suppose that the individual forgets the actual standard or pattern to be used in choosing. Now, in order to compensate, the individual judges the sticks according to their left-right position in a presentation set. If the lengths were associated with colors in this way, an individual could chose correctly even though the previous judgmental standard in the task was forgetting or unlearned, assuming of course that the longest stick in a pair always appeared on the left or on the right.

As implied by the strategy and decision-rule discussion above, the choice mechanism contains "preferences" and "judgmental valuations." Preference may be understood as some form of subjective notion of betterness for one state of affairs over and against another (von Wright, 1963, p. 12). By "subjective" is meant that an individual decides what standard he will use to decide the "betterness" of one state of affairs has some value, goodness, or worth associated with it so that when compared with another state of affairs one is of a higher value, more good, or more worth than other. An example of a preference, then, might be an individual believes or perceives that one automobile
is better than another. A typology and review of the various interpretations of preference may be found in von Wright (1963).

Judgmental valuations may be understood as some form of "objective" standard of comparison according to which one alternative is chosen over another (see Hull, et al, 1947, pp. 238-9; Campione, 1969, p. 387; Hurwick, 1965). By "objective" is meant that there exists intersubjective agreement as to the standard to be used for comparing one alternative to another. So, for example, an individual might use a standard of length, say, "inches" to judge whether one wooden stick is longer than another. By choosing inches as a unit of measure, all can agree on the definition of what is means to have a unit inches. It does not necessarily mean that inter-subjective agreement may be gained as to the actual application of the standard of measure or comparison to a set of objects. For example, a group of individuals might decide to measure the "distance" between two objects using inches as a measure—all could then agree upon what an inch is. But, several individuals using a ruler to measure the distance may in fact attain different measurements.

The choice mechanism block is important because it attempts to account for the representation problem which relates to positing some process which can manipulate the symbol structures input from the perceived stimulus block.
In essence then the choice mechanism is one internal representation which acts upon, converts or transforms the internal representation of the external stimulus. It does this by either processing input by strategy and decision-rules, or preferences and judgments, or a combination of both.

2.4.3 Choice Set Block

After the choice mechanism operates upon the internal representation of the stimulus, the next block encountered in the process is the choice set block. Choice may be defined as the selection made by an individual who when faced with a set of possible alternatives acts so as to carry out one of them. If there is only one alternative in the set of all possible alternatives which is preferred by an individual to all others in the set, then the individual is said to choose that alternative. If there is more than one alternative in the set of all possible alternatives which are preferred by an individual to all others in the set, then this subset of alternatives constitutes a choice set from which one or more alternatives may be selected. The cardinality of the choice, then, will always be less than or equal to that of the choice set.

The choice block, which is within the process, is linked to the external environment given as the response block. A response is simply some observable behavior resulting from a change in the environment, that is, the
introduction of a stimulus. The response may or may not be in one-to-one correspondence with the elements in the choice set, but somehow marks a different answer or selection on a survey questionnaire, then choice and response are not the same. Clearly, this is an important problem in analyzing choice behavior since the response is observable by an analyst, but the choice set is only inferred. Therefore, if the response and choice set are not equivalent, then erroneous inferences will be made concerning the rationality of the information processor. One goal of an analysis would be, then, to find ways of insuring that choice and response are equivalent.

2.4.4 Memory Block

Thus far, the flow diagram has considered the introduction of a stimulus, the conversion of a stimulus by perception, the operation on the perceived stimulus information by the choice mechanism to produce a choice set and the output of the choice set as an observable response for an individual. A final block to be considered is that of memory. Memory for purposes of this analysis interfaces only with the choice mechanism. This interface is two-fold, since memory receives input from the choice mechanism and transmits output also to the choice mechanism. Memory as a receptor of input stores or retains symbol structures which have been internally or externally input into the system by means of the choice mechanism. Memory as a
transmitter of output calls-up or retrieves symbol structures from storage areas. This output is then input back into the choice mechanism for use in processing. Klatsky (1975) provides a very detailed review of the current state of knowledge about memory in the above context.

Memory is an important consideration in representing individual choice behavior in an IPS framework since it is important to account for the following. First, does the memory block have certain characteristics which determine the type, amount, variety and so on of symbol structures which can be stored and retrieved by the choice mechanism? Miller (1956) and Waugh and Norman (1965) suggest that primary memory or short term memory is limited to storage of small chunks of information. Second, under what conditions will symbol structures in memory be forgotten (or lost) so that retrieval of the information by the choice mechanism is obviated? Trabasso, et al (1975), find, for example, that children can process complex choice tasks once the confounding effects of forgetting in memory are eliminated by extensive pre-training, training and testing.

2.5 How the Theory of Individual Choice Works

2.5.1 Capacity

It goes almost without saying that an individual choice mechanism is limited to a certain extent with regard to the amount, rate and accuracy of information processed from a task environment. So, for example, an individual choice
mechanism may be able to process 10 symbol structures from
the task environment per minute at 100 percent accuracy, but
it may not be able to process 11 symbol structures per
minute at 100 percent accuracy. When information processing
in an individual choice mechanism is limited by amount, rate
or accuracy taken singly or in concert with one another,
then this limit constitutes the capacity of the mechanism
to process information.

The capacity of an individual choice mechanism has an
"upper" and a "lower" bound which provide limits in which
the mechanism can operate. An upper bound refers to the
maximum combination of values for the amount, rate and ac­
ccuracy of information which can be processed by a choice
mechanism. Hence forth, the analysis will refer to this
upper bound as the maximum capacity of an individual choice
mechanism to process information. A lower bound refers to
the minimum combination of values for the amount, rate and
accuracy of information which can be processed by a choice
mechanism. This will be referred to as the minimum capacity
to the individual choice mechanism.

The capacity of a choice mechanism as delimited by a
maximum and minimum capacity is not the same for every task
environment encountered by the choice mechanism. For
example, capacity will vary according to whether or not
alternatives being processed have attributes which occur in
bundles or as only a single attribute (see Tversky, 1972).
A choice over an alternative which is a bundle of attributes would occur in a presidential election where candidates are judged according to ability, experience, party affiliation, image, etc; while a single attribute might consist of an alternative represented by a physical standard of length, say inches for instance. Bundles of alternatives appear to be less able to be processed at high capacity values vis-à-vis single attribute alternatives since individuals are sometimes unable to find a standard for evaluation, store and retrieve information in memory, and so on in the case of the former, but may not have these difficulties in the case of the latter. Of course, the opposite effect might occur if the bundles are small in attribute number while the single attribute is large in value on its only attribute. The point, then, is that this capacity indicator is variable across task environments.

2.5.2 Performance Versus Capacity

It was stated above that capacity was task-specific having a maximum and minimum bound. This assumption as evidenced in many empirical studies seems to be incorrect. For example, survey researchers have found that individuals interviewed in panel studies— that is, before, during and after elections, tend to respond differently on the same task requirements of the survey across time (see for example, V. O. Key, 1966). This would seem to indicate that some facet of the choice mechanism is changing so that different
observed behavior is produced. This common explanation may not refer to capacity at all. Is there then, some other explanation which can account for these empirical results yet at the same time preserve the notion of capacity?

One way that capacity as a maximum and minimum bound which is task-specific can be rescued is that when one measures amount, rate and accuracy, one is not necessarily indicative of capacity. What one might be measuring could best be viewed as a kind of "performance rating" for the choice mechanism. Now, by performance rating, or performance, is meant a measure of the amount, rate and accuracy of information processed by a choice mechanism without certain identifiable confounding effects upon these measures controlled for and/or eliminated. Capacity, then, is a measure of amount, rate and accuracy of the choice mechanism as a processor without any confounding effects.3

These confounding effects which make performance measure much less indicative of capacity may be briefly discussed below.

Perception and context effects. It was noted above that there exists or could exist a substantial difference between the way in which an analyst "objectively" identifies a task environment for choice behavior and the way in which an individual choice mechanism perceives this task. As a result, performance varies directly with the extent to which the task environment diverges from the perceived task with
the choice mechanism. Only when the task environment and perceived task are equivalent, and only when an analyst is aware that they are roughly equivalent, can an analyst be sure that capacity and not performance is being measured. Of course, if an analyst understands an individual's perception of a task even though it may diverge greatly from that of the analysts, then this will produce results which are of some value since they can be linked up to some task even if it is not the intended, objective one. The task environment and perceived task when divergent is only a problem in an analysis when either the divergence is unknown or the extent of divergence is unknown. Of course, this could be and is a frequent occurrence.

Although there are many perceptual factors which could lead to a divergence between the task environment and perceived task, this analysis will only, for the sake of brevity, consider one generic strain, the "effects of context." Some of the major literature reviews touching on the concept in general are found in Berg (1967), Sudman and Bradburn (1974), Parducci (1968) and Klatzky (1974). For purposes of this analysis context effects which affect performance are perhaps best illustrated by means of an example and then a definition. Suppose an analyst presents an individual with three real numbers, say 5, 3, and 1. He asks the individual to order the numbers from greatest to smallest. The individual responds 5 > 3 > 1, where ">"
refers to the relation "greater than." The individual also responds that 5 > 1 by a rule of inference. In this case the individuals judgmental comparisons are "transitive" and there is evidence of "transitive inference." If the same choice task is presented over and over for the same numbers, then the individual responds equivalently to the above.

Now suppose that the same numbers 5, 3, and 1 are given some semantic interpretation so that 5 becomes the response "agree," 3 becomes "don't know" and 1 becomes "disagree." Suppose in addition, that the numbers are imbedded in a situation requiring a choice. As an example, a survey question might ask an individual which person he would prefer to obey given a certain state of affairs so that the individual would respond either agree, disagree, or don't know. The choice task is subsequently repeated and varied and presented to the individual. As is well known in public opinion research, the responses over the set of questions may not be transitive. Further, it may be the case that no transitive inference rule was employed.

Why does this second portion of the example lead to intransitive results and the first to transitive results? What can account for the difference?

In answer to these questions the concept of context effect is offered. In the first portion of the example, the choice task and alternatives were relatively context free or context minimized. That is, the choice task and
alternatives were familiar to the individual; they were
dissimilar enough to manipulate; the number of aspects
involved was not beyond the individual's capacity to process
them; and so on. In the second, the choice task and alter­
natives were subject to the effects of context--that is,
they were unfamiliar to the individual, contained too many
aspects to process, and so on.

Context effects, then are identifiable characteristics
of alternatives in the perceived task or stimulus which
occur when one or more alternatives are placed in a set so
that processing the set is impeded or inhibited for an
individual choice mechanism.

In this analysis, two context effects constitute the
primary theoretical focus, although the variety of context
effects in general are perhaps infinite in number. One con­
text effect may be identified as the effect of "similarity"
among a set of alternatives in a choice task (Simon and
Feigenbaum, 1964, pp. 388-389; Underwood, 1953; Bruce, 1933).
Similarity, for purposes of this analysis, refers to the
relative discriminability of one alternative to another in
a pairwise comparison. Suppose, for example, that a set of
alternatives \{a, b, c\} forms a complete ordering, say
(a,b,c). Now suppose that an individual, when presented
the unordered pair \{a,c\}, always chooses "a" as most pre­
ferred and "c" as less preferred; but when faced with the
pairs \{a,b\} and \{b,c\} cannot choose a more preferred
alternative from either pair. This example, developed by Luce (1959) is referred to as the case of "just noticeable differences," or j.n.d. It leads to the formal notion of a semi-order in which the end points "a" and "c" are ordered, but the adjacent pairs (a, b) and (b, c) are indifferent in the sense that no preferred element can be selected. Clearly, in terms of identifying some minimal capacity for producing orderings in choice data, it would be inappropriate to expect orderings when the choice mechanism cannot perceive or discriminate. As a result, similarity as an effect is directly related to performance: as similarity increases, performance decreases.

The other context effect might be referred to as the "familiarity" of the task environment to an individual (Underwood and Shulz, 1960; Simon and Feigenbaum, 1964, p. 391; Chapanis and Overby, 1971). Familiarity for purposes of this analysis refers to an individual's experience with elements in a set of alternatives than singly and elements when placed in a context with others. So for example, when an individual perceives an alternative, he has or has not some experience with the meaning of that alternative. If an individual's "father" was an alternative, then an individual might be highly familiar with this person. Now suppose the alternative "father" is placed in the context of which person the individual might obey as a citizen of the United States. Suppose that two additional alternatives, the
"President" and "Vice President" are presented. Will the individual be as "familiar" with the notion of father taken in concert with the other alternatives as he would be with father taken singly? Well perhaps we would be familiar with all three, but he might not. In setting up a task environment to get at the notion of capacity, then, it is necessary not only to examine alternatives for choice singly, but also in concert with others—both examinations may not yield the same results. In terms of performance, then, performance tends to increase as an individual becomes more familiar with alternatives taken singly and in concert.

Performance and context effect may be related so that performance varies inversely as a function of context effects (Moyer, 1973; p. 120; Welford, 1960; Smith, 1968; Egeth, et al, 1972; Atkinson, et al, 1969); while capacity for a given task manifests some stable maximum/minimum bounds.

The notion that performance varies inversely with the effects of context is perhaps trivially obvious as it now stands. But if context effects can be experimentally controlled and manipulated to produce identifiable effects in choice data produced by an individual choice mechanism and if these effects can be mathematically modeled as symbol structures internal and external to the choice mechanism; then, by knowing the context effects generated in the task environment as a result of perception, it might be possible
to predict individual choice behavior (see Rabinowitz and Robe, 1968; Bower, 1972, p. 92-94; Estes, 1955). It might even more importantly lead to a solution to the problem of representation.

**Memory:** the effect of storage and retrieval. In Figure 2 and the subsequent explanation of this flow diagram, it was suggested that memory is important in that it interfaces with the choice mechanism block. This means that the effects of memory are felt in every portion of the IPS. These effects involve the storage of information to be used in processing throughout the entire flow of information through the system and retrieval of information for use by the choice mechanism. Since the effects of memory are important to the production of certain kinds of choice behavior or even the production of any choice behavior, it is not surprising to discover that information cannot be "properly" processed according to the specifications of the task environment unless memory can be controlled (see Craik and Lockhart, 1972; Miller, 1956; Broadbent, 1958; Wauch and Norman, 1965; Peterson, 1966; Atkinson and Shiffren, 1968).

So, for example, if an individual forgets what the requirements of the task environment are, then performance will be low; and conversely, all other things being equal, if he remembers then performance will be high.

Again, for purposes of building a theory of individual choice, it is necessary to be able to say whether or
not performance or capacity is being measured. To do this, memory effects must be controlled. Of course, the control and manipulation of these effects and their subsequent possibilities for mathematical modeling may lead to a solution to the problem of representation.

Effects of the choice producing mechanism: standards for comparison and decision-rule selection. It is clear that in many cases that objective and/or subjective standards for comparison—that is, judgmental valuations and/or preferences, contained as symbol structures in the choice mechanism may produce choices which may be observed as responses in the environment of the individual choice mechanism. The symbol structures in the choice mechanism, although not the actual processes contained in the mechanism may undergo change in structure from time to time. Among the identifiable changes possible, one might find the following. First, the standard for comparison may be entirely random so that given a certain task environment different choices are produced over time. An example of this might occur on a survey questionnaire on which a respondent must indicate his preference over political issue positions. If the respondent has no preference, then he may still choose by selecting alternatives at random. Second, the standard may be probabilistic for an individual. An example of this would occur when an individual has several preference orderings which may be imposed over a set
of alternatives such that one ordering is sometimes preferred to another according to some probability. As a result, an individual might prefer one alternative over another at one time and the latter over the former at another. And third, a standard may change over time as a function of preference or judgmental valuation over time. In public opinion research it is not uncommon for an individual to change his initial preferences on some positions after completing only part of a survey questionnaire.

Suppose that an analyst intended to measure some minimum capacity for a given task environment. Suppose in addition that he had not taken into account that symbol structures were constantly changing in the structure of the choice mechanism. It would not be surprising to discover, then, that choice behavior for the same task environment varied radically. This might lead to a notion that the minimal capacity for the process also varied radically or will. But, however, if the change of standard is expected, controlled for and manipulated it would suggest that performance varies according to the particular standard chosen, while the minimal processing capacity remains the same.

It is also clear that not all choice data can be claimed to be generated exclusively by preference patterns or judgmental valuations operating on symbol structures from the choice task environment (Richardson, 1972, p. 50). Choices might be generated in other ways, namely by the choice of
decision-rules used in processing information. For example, suppose that a set of alternatives each element of which is a bundle of attributes consisting of length and color. Next suppose that an individual is required by the choice task to associate a particular length with a particular color, so that choices over pairwise presentations would yield an ordering from longest to shortest based upon seeing a color and remembering its length. One way to accomplish this is to place the objects in a "linear array" as they are learned so that ordinal spatial differences on length are maintained (see Huttenlocher, 1968; Potts, 1972). This would, of course, be an instance of choice produced by some judgmental valuation, that is the spatial notion of length. Another way might consist of always choosing the element in a pair that is to the right as the greatest in length. So if an individual is presented with the unordered pairs {ab}, {bc}, {cd}, respectively, he would choose b, c and d respectively. Clearly, this decision-rule could yield correct choices if the ordering were $b > c > d$. But they could as well produced the opposite of the desired ordering, that is, shortest to longest; or they could have lead to nonsense choice data. At any rate the choice of decision-rules is here considered to be related to performance. If the task is complex in the sense that using decision-rules rather than a judgmental valuation leads to confounding effects,
then performance decreases as the effects of incorrect
decision-rule choices increase.

Effects of feedback: the need for adaptive behavior.
The individual choice mechanism as conceived of in this
analysis is one which can modify its choice behavior
according to its success of failure in a given task pre­
presented several times or based upon a set of similar tasks.
In short, it is adaptive (Newell and Simon, 1972, p. 53).
Explicit in the notion of adaptation is the assumption that
an individual choice mechanism will attempt to accomplish,
perform, or choose in accordance with the requirements of
the choice task. This does not assume that this movement
toward accomplishment and so on is in any sense optimal or
of maximum efficiency but only that it is moving positively
toward task accomplishment.

If this assumption is correct, then choice mechanisms
which become aware of their past performances or the "cor­
rectness" of their past performances will attempt when
afforded the opportunity to increase their movement in a
positive way toward task accomplishment. So, if a choice
task is intended to produce consistency, that is, an ordering
among objects of choice, then a choice mechanism will either
maintain consistency if it is at a maximum or increase con­
sistency if it is suboptimal.

The notion of feedback to an adaptive individual choice
mechanism has important implications for performance
vis-a-vis capacity. Since feedback may provide a choice mechanism with additional or modified information, performance may be increased since the effects of perception, choice, memory and so on may be ameliorated to a certain extent (Riley and Trabasso, 1974, p. 189). For example, if an individual chooses an alternative from a set, but physically indicates the wrong choice, then perhaps, when the individual becomes aware of this he will attempt to make the correct choice if afforded the opportunity or at least he will be aware of his error. Of course, the modification of behavior is in fact performance related since it does not affect in any way the existing processes which determine the capacity of the system.

Effect of error making. Most, if not all, information processing models do not contain a concept of error in accounting for problem-solving behavior. This is evident in that production systems are constructed which are sufficient to represent a problem solving task. Of course, they might also reveal the impossibility of such a problem solving representation. At least one reason for the omission is that no theory of error has been proposed or incorporated (Newell, 1973).

In this analysis, an error made by a choice mechanism given a specific choice task will be defined as any deviation from an appropriate or acceptable kind of choice behavior for that choice task such that the potentially
confounding effects of perception, memory, etc. are controlled and the mechanism will, if made aware of the deviation would attempt to correct it in light of the requirements of the choice task.

In defining error in this fashion, the following points must be elaborated.

(1) The concept requires that error is only visible or manifested when the capacity for a given choice task and individual choice mechanism are known. Error, then, is characteristic of the structures and processes when revealed for some minimal capacity. Error, therefore, is not as defined, indicative of performance.

(2) Error fits well with the notions of adaptation and feedback, since assuming that performance is controlled or minimized with regard to its confounding effects vis-a-vis capacity, a choice mechanism would attempt to identify and correct errors which arise.

(3) Error, as characteristic of the structures and processes of the choice mechanism when operating at minimum capacity, is assumed to result from some identifiable function which can be represented in the individual choice model.
2.6 Information Processing Theory: Some Caveats

2.6.1 Role of Classical Experimental Design and Execution

Not only has the inclusion of individual choice within the IPS framework changed some of the basic characteristics of the approach, but it has also necessitated different experimental techniques. Newell and Simon (1972, pp. 12-13) have viewed experimentation in the problem-solving context as a technique to be applied to single individuals with the idea of finding an IPS sufficient for the representation of one possible problem-solving mechanism. In so doing, they do not require an experimental design with experimental and control groups. Indeed, experimentation based upon this design are thought to be of little use.

In this investigation, the use of classical experimental design will not be rejected as an inviable technique. At least three reasons for this deviation from the accepted practice in the IPS framework can be marshalled. First, the theoretical and experimental analyses conducted in this investigation treated each subject in the same way as if there had only been one subject. So each subject contributes data to the construction of an individual choice mechanism for a particular choice task. In this way, the experimental approach herein is compatible with its competitors in the IPS framework. Where this analysis differs is that it is seeking not only representations for single individual choice mechanisms, but also some general mechanism
which can subsume these individual mechanisms into a consistent general model for individual choice. Or in other words, it seeks to go beyond a single representation to a representation which can account for many single or possible representations. Second, since individual choice as defined for purposes of this analysis has not been an explicit focus for IPS theory, it is not clear prior to extensive empirical analysis how some portions of the individual choice theory might work. Therefore, some portions of the theory can be operationalized and tested immediately, but other portions require further elaboration by looking at data contributed by many subjects. Hence, the "leapfrog" approach (see section 2.6.3 below) which requires a continual interplay between theory and data. And third, the data generated is not only of interest in the construction of an IPS, but in addition, it is very relevant to theoretical/empirical enterprises generally found outside the IPS perspective. This being the case, it is useful to be able to generalize across subjects (independent of constructing an IPS) so that results and perspectives based upon data can be more readily shared. So for example, a single subject's data will be of some interest to psychologists, economists and especially political scientists, but data based on larger numbers of subjects is even more interesting. Again, it is important to note that this purpose greatly transcends the data requirements for dealing with IPS theories.
2.6.2 Production Systems and Flow Diagrams

In most of the information processing theories cited above, the analysts were able to construct full-blown, operating production systems which were sufficient to represent the structures and processes of a problem-solver in a given task environment. These were made possible because of the narrow focus and comparative simplicity of the problems utilized. This is not to say by any means that the models themselves are not complex or unimportant. Now individual choice as a kind of problem-solving activity is not well understood in the information processing theory framework. Therefore, it is not possible at this stage given the state of the knowledge about choice to construct a production system model which would be sufficient to represent individual choice behavior.

Instead of presenting a production system, this analysis makes use of flow diagrams. A flow diagram expresses the independent and ordering stages derived experimentally by design of the operation of the individual choice mechanism (see Newell, 1973, p. 519). Therefore, although the flow diagram is undisciplined and informal in the sense that they are not specific productions; they are important nevertheless since it parcels out and delimits portions of the choice mechanism wherein sets of unspecified productions interact and interface with one another. It is important to proceed in such a fashion since flow diagrams are a necessary first
step in the generation of data and construction of subsequent production systems.

2.6.3 The Leapfrog Approach

Thus far in this portion of the analysis the notions of classical experimental design, flow diagrams, and production systems have been dealt with. These separate activities combine in a unique fashion to produce what might be referred to as the "leapfrog" approach to analyzing individual choice. The leapfrog approach is seen as follows: initially, a theory of individual choice was proposed. This proposal amounted to the construction and explication of a flow diagram representing an individual choice mechanism. Once the flow diagram is given, a classical experimental design is required in order to empirically test the model and to generalize the results across individuals. Once this stage is reached, then it may be possible to construct a production system sufficient to represent many kinds of choice behavior. The term leapfrog, then, refers to the alternating interplay between theory, experimentation and symbolic representation.

The leapfrog approach does not culminate in a production system representation, however. Instead, the production system may and will serve these additional purposes and functions. First, the production system may point up new possibilities for more elaborate flow diagrams. This results in the continual execution of the leapfrog approach
moving from theory to data to representation and back again. Second, the production system requires an analyst to be explicit about the precise structure of the choice mechanism. In those cases where precision is not possible, production systems suggest areas for further analysis. Therefore, the leapfrog approach may be undertaken within subsections of the model. And third, production systems when constructed constitute complete units which might be plugged into other models. For example, a model of choice might well fit into a more general model for individual behavior. In this way the leapfrog approach may be applied across modeling enterprises.

The above explication of the general nature of the approach is important since individual choice is not a one shot affair. Instead, it requires an ongoing approach which can generate increasingly "better" models and important results. In general, then, it is undesirable to have an approach which ends without implying subsequent research possibilities.

2.6.4 Manipulation, Control and Stability

The IPS perspective when expanded to include a notion of individual choice relies upon a mix between theory, formalisms and data. And indeed, this is perhaps its strong point. Now, it is clear that the entire analysis based upon this interplay is founded upon the assumptions that (1) the structures which reflect internal representations of the
choice task environment can be manipulated and controlled empirically as well as formally, but that (2) the processes of the choice mechanism remain stable throughout this manipulation and control.

The above assumptions, which hopefully are or can be answerable, empirical questions are necessary it would seem at this stage of theoretical development since if all of the "actual" empirical objects and relations which are being formally modeled are constantly in flux, then a kind of social science Heisenberg indeterminancy principle is perhaps operative—this is, when one accounts for one set of objects and relations at one instance, he is unable to account for equally important objects and relations elsewhere. If this is the case, then it seems reasonable to fix one set of structures and processes at least by assumption and analyze as many of the rest as possible.

In so doing, the theory of individual choice suggests that the individual choice mechanism is stable through time. 2.6.5 The Importance of the Framework

The analysis thus far has offered an innovative theory of individual choice albeit in its seminal stages. The entire approach to individual choice theorizing has only been hinted at in the literature on the topic, but it is considered important. Coombs, Dawes, and Tversky (1970, pp. 163-4) suggest, for example, that eventually, theories of choice ought to include less restrictive experimentation
and a wide range of "information-processing variables." For these analysts, individual choice theory should contain experimental designs which determine the adequacy of a wide range of models. The choice models themselves ought to be collapsed into a more complete, general model of choice based upon experimental data. These adequate, complete, general models must also include cognitive/perceptual factors if they are to mirror "human choice mechanisms." Hopefully, this portion of the analysis will suggest how these criterion might be included in an individual choice theory paradigm.

Of course, individual choice is not the only concern of this analysis. Another more important concern is the concept of rationality as related to individual choice. So, although the analysis offers a different way to view individual choice theory, it is not an end in itself, but instead will be important in formulating an innovative theory of rational individual choice. It is to this theory of rationality that the analysis will now turn.
Notes to Chapter 2

1The production system in general follows the following operating rules (Klahr, 1973, pp. 528-529):
   (1) Productions are considered in sequence, starting with the first.
   (2) Each condition is compared with the encoded data structure of the system as represented by symbols; if all symbols in the condition match all symbols in the data structure, then the condition is satisfied;
   (3) If a condition is not satisfied, then the system moves on to consider the next production and so on, through the system.
   (4) When a condition is satisfied, the system requires that the symbols in the data structure be compared again with all of the previous productions considered.
   (5) Conditions are stored in a short-term memory (STM) within the system.
   (6) Actions initiated by conditions can replace elements, apply operators or add symbols within the STM, and
   (7) A STM is a stack in which a new symbol on the top of a hierarchy of symbols to be lost because of its limited storage capacity.

Production systems of the above form may be used to "specify" an "information processing system." Production systems are treated in much greater detail in the following analyses: Newell and Simon (1972), Newell (1972), Klahr and Wallace (1972), Klahr (1972), and Klahr and Wallace (1973).

2The perceived stimulus component when processing input structures will yield internal representations similar, although not identical to what Newell and Simon (1972, p. 59) refer to as a "problem space."

3The distinction between performance and capacity is related to Chomsky's (1965, pp. 10-15) distinction between "performance" and "competence." At any rate see Chomsky (1965) for an extensive treatment of performance as a concept.
Chapter 3

TOWARD A THEORY OF INDIVIDUAL RATIONALITY

For first we are to observe what effect a body moved produceth, when we consider nothing in its motion . . . next, what the motion of a long body produces, which we find to be superficies; and so forwards, till we see that the effects of simple motion are; and then, in like manner, we are to observe what proceeds from the addition, multiplication, subtraction, and division, of these motions, and what effects, what figures, and what properties, they produce . . .

Thomas Hobbes

De Corpore

3.1 Introduction

The investigation will attempt to accomplish four things in this chapter. First, a framework for assessing the rationality of an individual choice mechanism will be developed. This is achieved by predicating rationality of an individual choice mechanism only if it can produce transitive relations among objects of choice subject to a variety of important restrictions imposed upon both the choice task environment and the individual choice mechanism. Second, the investigation will present a theoretically oriented discussion concerning types of transitive relations
which might be used to represent choice data and a companion discussion concerning the types of mechanisms which might account for the various types of transitive relations. Third, the investigation will present several hypotheses which capture the major expectations of a theory of rational individual choice. These include a concern for: (1) some minimal rational capacity, (2) the developmental occurrence of this rational capacity, (3) the stability of this rational capacity and (4) rational capacity and its relation to gender. And fourth, the investigation will suggest a way to distinguish the concepts of rationality, irrationality, and extra-rationality and error from one another.

3.2 A Concept of Individual Rationality

A theory of individual choice was constructed in Chapter 2 above by posing the problem in representing a human information processing system in a choice task environment and by attempting to solve the problem of individual choice by proposing an individual choice mechanism. In this section, the analysis will offer a concept of individual rationality which should allow one to determine whether or not an individual choice mechanism is rational.
The concept of individual rationality may be viewed as follows: an individual choice mechanism will be considered rational if it can be formulated as a process which provides a representation of one possible cognitive process such that given a choice task environment that requires the mechanism to produce transitive relations among objects of choice, the mechanism produces transitive relations among objects of choice.

The concept of individual rationality requires the following:

(1) The choice task environment, that is, the stimulus requiring the production of transitive relations among choices, must be "objectively" definable in the sense of attaining intersubjective agreement on its attributes.

(2) The objective interpretation of the choice task environment must be equivalent, or nearly so, to the perceived task environment formulated by the individual choice mechanism.

(3) The individual choice mechanism must store and retrieve all relevant information in the choice task form memory.
without the occurrence of extensive forgetting or memory loss.

(4) The individual choice mechanism must be permitted the possibility for error or mistake making the processing of choice task information.

3.3 Predicting Rationality


In almost every case these attempts to predicate rationality of some aspect of individual choice are intended not as prescriptions which classify, but instead are attempts to "predict" or "explain" individual choice. This remains the case even through the focus of prediction or explanation is entirely different across theories.

This theory of rational individual choice predicates rationality of the "choice mechanism" which processes structures from a choice task environment. The purpose of
formulating the theory in this way is two-fold. First, it is entirely consistent with the formal theoretic approach to rational individual choice since it is intended to predict and explain individual choice behavior. Second, it offers an alternative to existing theories of rational individual choice in that it subsumes those aspects of choice, such as preference, judgment, choice function, into various components and processes which represent cognition. These representations, then, if postulated to be rational, allows one to predict and explain individual choice behavior in terms of cognition.

3.4 Transitivity and the Representation of Individual Choice Mechanisms

3.4.1 Exhibiting Transitive Relations in Choice Data

An important characteristic of individual choice mechanisms which are considered rational is their capacity for producing choice data which can be represented in part by transitive relations. Although transitivity in general may refer to a logical relation, say R, such that when three elements, say x, y, z ∈ A, are related so that xRy and yRz, then by logical implication xRz (Tarski, 1965, p. 94; Margaris, 1967, p. 2); there exists a great deal of ambiguity as to how the property is to be represented and interpreted. This ambiguity in meaning apparently arises for the following reasons: (1) the concept is very complex with many subtle nuances of meaning, yet it tends to be
treated simply when referenced in an analysis, (2) most analysts have some concept of transitivity used only in a particular field, enterprise or approach, but most analysts have not attempted to ferret out the commonality and diversity across disciplines in order to better understand the concept, (3) the concept as understood theoretically and/or formally is rarely understood sufficiently when interpreted empirically, or rarely understood empirically when interpreted theoretically and/or formally with the result that it becomes unclear as to how theory and data ought to be interpreted with respect to the concept, and (4) the concept enjoys a wide variety of labels which all stand for the same thing, yet the underlying concept rarely emerges as a result of these labels which tend to mask its meaning.

Since transitivity is the cornerstone of this theory of rational individual choice (and other theories of choice as well, see section 1.4) and since the study must provide a clear explication of the kinds of transitive relations and associated formal properties which might be used to represent choice data; it is important to sort out the various interpretations of the concept.

Varieties of transitive relations. The general form of the transitive relation above may be interpreted in many ways depending upon the kind of individual choice enterprise being considered. Two of the major generic types of individual choice, "probabilistic" and "algebraic," lead to the
following interpretations of transitivity (see Luce and Suppes, 1965, p. 256). For probabilistic theories of choice: probabilistic transitivity refers to transitive relations in choice data which are probabilistic since the choice mechanism which generated them was itself probabilistic. Probabilistic transitivity is defined as follows. Given alternatives x, y, z and some binary probability defined all possible pairs p(x,y), p(y,z) and p(x,z), where p is the probability of choosing one element of the pair over another such that when

\[ p(x,y) \geq 1/2 \text{ and } p(y,z) \geq 1/2 + p(x,z) > 1/2 \] (Luce, 1959, Campione, 1968)

(1) weak probabilistic transitivity exists when

\[ p(x,z) \geq 1/2 \] (see Valavanis-Vail, 1957)

(2) moderate probabilistic transitivity exists

when \[ p(x,z) \geq \min\{p(x,y), p(y,z)\}; \] (see Georgescu-Roegen, 1958; Chipman, 1958) and,

(3) strong probabilistic transitivity exists when

\[ p(x,z) \geq \max\{p(x,y), p(y,z)\}; \] (see Valavanis-Vail, 1957)

For algebraic theories of choice, transitivity is defined as in the general definition, that is, given three elements x, y, z \in A, a relation R is transitive if xRy and yRz, implies xRz. It is useful to include within the "algebraic" framework the concepts of "weak" and "strong" orderings. This can be done by adding two additional axioms:
(1) reflexivity: \( xRx \); and

(2) connectedness: \( xRy \) or \( yRx \).

A weak ordering, given the above axioms is one in which the alternatives ordered include the notion of indifference, that is, \( xRy \) and \( yRx \). This relation may be interpreted as "greater than or equal to," symbolized \( \geq \). So for example, \( x \geq y \geq z \) constitutes a weak order. A strong ordering has no indifference assumption. This relation may be interpreted as "greater than," symbolized \( > \). For example, \( x > y > z \) is a strong order.

3.4.2 Transitive Inference and Individual Choice

The exhibition of transitive relations in choice data is assumed to originate as a result of the operation of some process upon symbol structures input into an individual choice mechanism from a choice task environment. It is possible, of course, to construct a great variety of mechanisms which could produce transitive relations, or for that matter intransitive ones. Although it is virtually impossible to innumerate all of the mechanisms which might account for choice data, it is possible to briefly catalog some important characteristics of several important mechanisms.

Varieties of transitive inference mechanisms. An initial dichotomy in theorizing about choice mechanisms might include a concern for those that might be referred to as "transitive inference mechanisms" and mechanisms which
have no relation to transitive inference whatsoever. For purposes of this analysis, only transitive inference mechanisms will be considered. One major type of transitive inference mechanism might be referred to as "syllogistic inference" of the following form. An individual is presented with several alternatives which can be objectively ordered according to some standard. The presentation set consists of all possible pairs of alternatives. The representation of the choice mechanism which produces transitive relations among alternatives chosen is as follows. The individual stores each adjacent pair separately in his memory; so for example, given the three unordered alternatives \{A, B, C\} might be stored as the ordered pairs \{(A, B)\} and \{(B, C)\} in memory. Next, the individual would be required to choose over the unordered pair \{AC\}. The individual's choice under this representation requires that the ordered pair \{(A, B)\} be recalled in memory; then the ordered pair \{(B, C)\} is recalled. The individual then "reverses" the relation on B from A > B to B < C.

Since B is distributed in both pairs, \{(A, B)\} and \{(B, C)\}, the individual derives the conclusion that \{(A, C)\}. This kind of inference has been known since at least the advent of Aristotelian logic and has been as a possible representation of individual choice until analyzed by Piaget, (1921, 1928, 1970), Piaget, et al, (1960), Braine (1959) and Smedslund (1960).
Another major type of transitive inference might be referred to as "inference by linear array," conceptualized as follows. An individual is presented with all of the adjacent pairs possible for a set of ordered alternatives. In three alternatives, the individual again is presented with pairs \{A,B\} and \{B,C\}. Instead of storing this information as ordered pairs \(A,B\) and \(B,C\) the individual's choice mechanism is represented by an ordered triple \((A,B,C)\). This results because the pairs are coordinated and integrated in the linear array as soon as enough information is available to place them in the ordering. Once a linear array exists, then the individual when presented with the pair \(A,C\) need not recall each adjacent pair from memory; but instead the individual will enter the linear array at some point in the ordering \((A,B,C)\) and chose \((A,C)\).

Inference by linear array is a recent theoretical construct for representing choice mechanisms. Huttenlocker (1968) and Potts (1972) provided the initial theoretical basis and subsequent empirical analyses. The most recent studies applying this approach are Barclay (1972), Trabasso and Riley (1973), Trabasso, et al., (1975), Lutkus and Trabasso (1974), and Riley and Trabasso (1974).

Still another type of transitive inference mechanism might be characterized as a serial processor. A serial processing mechanism is one in which alternatives or pairs of alternatives are processed one at a time, completing
one element before beginning the next (Townsend, 1974, p. 139). So for example, a set of ordered pairs (A, B) and (B, C) are stored in memory. Next, suppose that the unordered presentation pair {A, C} is presented to an individual chooser. A serial processing mechanism might recall the pair (A, B) initially at time₁ and terminate processing at time₂. Then, (B, C) might be called up at time₃ and terminate processing at time₄. At time₅, the pairwise comparison over {A, C} is produced as the ordered pair (A, C).

Yet another type of transitive inference mechanism might be characterized as a parallel processor. A parallel processing mechanism is one in which alternatives or pairs of alternatives are processed simultaneously, although there may be limits upon the number of simultaneous ongoing processes (Townsend, 1974, p. 139). So for example, the ordered pairs (A, B) and (B, C) are stored in memory. Now suppose that (A, B) and (B, C) are called up in memory simultaneously at time₁, and processing is terminated for (A, B) at time₂ and for (B, C) at time₃. Then (A, B) and (B, C) are concatenated at time₄ to yield the ordered pair (A, C).

A final type of transitive inference mechanism might be characterized as a hybrid processor. A hybrid processing mechanism is one which cannot be classified as either serial or parallel. An example of a hybrid processing mechanism would be one which combined the serial and parallel processing mechanisms just mentioned above so that both serial
and parallel processing was ongoing concurrently in order to produce some result.


3.4.3 Relationships Between Transitive Relations and Inference

The analysis has thus far treated the transitivity relation and the transitive inference mechanisms as separate considerations. In this portion of the analysis, the two will be related to one another.

For the sake of argument, assume that there exists some choice task environment which has as a characteristic an objective, agreed upon standard according to which choices are to be made. This standard is equivalent to the concept of judgmental valuation defined in Chapter 2. Next, allow
an individual choice mechanism the option of employing any transitive inference rule mentioned above, or allow the mechanism the option of using no rule of inference at all. Two possibilities might result in actual choice behavior given the above. One possibility is that the mechanism will use a rule of inference, say the syllogistic inference rule, to produce a set of transitive relations in the response set observed by an analyst. For example, a mechanism might learn that in the alphabet, the letter A comes before B and the letter B comes before C. Then by syllogistic inference, the mechanism might deduce that A comes before C. Now when presented with a set of unordered pairs \{A,B\}, \{C,B\} and \{C,A\}, the mechanism chooses to as to produce an ordered triple \((A,B,C)\).

The other possibility is that the mechanism will produce transitive relations in the response set observed by an analyst without using a transitive inference rule. For example, a mechanism might learn that when two objects for choice are presented, the longer of the two will always appear on the left. Now, if the pairs \{A,B\}, \{B,C\} and \{A,C\} are presented and the mechanism always chooses the element on the left, then the choice data will reveal the ordered pairs \((A,B)\), \((B,C)\) and \((A,C)\). This, of course, yields a complete ordered triple \((A,B,C)\) and transitivity among choices is exhibited, while no inference rule was employed.
Now for the sake of argument, assume that no objective, agreed upon standard exists. Again allow the mechanism the object of employing some transitive inference rule. Two possibilities again may arise in this situation. Consider a situation in which baseball teams are compared as follows:

Cincinnati beats Pittsburgh
Pittsburgh beats Dodgers
Dodgers beat Cincinnati

Clearly, the pairs do not yield an ordering since no teams beats the other two. Two possibilities result from this situation: one is that a mechanism may employ a transitive inference rule and when the last paired comparison is given, the mechanism realizes that no objective standard exists and no ordering is possible. As a result, the mechanism uses a rule of inference, but cannot produce transitive relations in choices. The other possibility is that the mechanism uses no rule of inference and exhibits no transitive relations. This might result when a mechanism chooses randomly in this particular choice task.

The four possibilities above may be represented for the judgmental valuations choice task as follows:

PLACE FIGURE 3 ABOUT HERE

The analysis used choice tasks based upon some objective standard to generate the four possible relations between transitive inference and the exhibition of transitive relations. The same principle also applies to each possibility
<table>
<thead>
<tr>
<th>I.</th>
<th>II.</th>
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<tbody>
<tr>
<td>transitive inference</td>
<td>transitive inference</td>
</tr>
<tr>
<td>rule used</td>
<td>rule not used</td>
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<tr>
<td>transitive relations</td>
<td>transitive relations</td>
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<tr>
<td>exhibited</td>
<td>exhibited</td>
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<table>
<thead>
<tr>
<th>III.</th>
<th>IV</th>
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<tbody>
<tr>
<td>transitive inference</td>
<td>transitive inference</td>
</tr>
<tr>
<td>rule used</td>
<td>rule not used</td>
</tr>
<tr>
<td>no transitive relations</td>
<td>no transitive relations</td>
</tr>
<tr>
<td>exhibited</td>
<td>exhibited</td>
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</table>

Figure 3. Transitive Inference and Transitive Relations Related.
when the choice task environment concerns preference-based choices. The only difference, of course, being that the mechanism determines for itself whether or not an ordering is possible. So for example, the team comparisons:

Cincinnati beats Pittsburgh
Pittsburgh beats Dodgers
Dodgers beat Cincinnati
do not yield a transitive relation when objectively considered, but a mechanism might "prefer"

Cincinnati to Pittsburgh
Pittsburgh to Dodgers
Cincinnati to Dodgers
when placing bets on the teams involved.

3.4.4 A Theoretical Position

Rationality as predicated of an individual choice mechanism requires that the mechanism produce or exhibit transitive relations in choice data. When the choice task environment is objectively defined as a judgmental valuation task in which objects of choice can be ordered and when the individual choice mechanism perceives this task correctly, then the mechanism is rational if it can produce transitive relations among choices according to the objective standard. And when the choice task environment is subjectively defined, that is, choice is preference-based, and the task is such that objects of choice can be ordered, then the mechanism
is rational if it can produce transitive relations among choices according to a preference ordering.

Now, the analysis has pointed out above that there are several ways in which an individual choice mechanism might produce transitive relations. One of these involves the use of transitive inference rules—that is, syllogistic or linear array inference; while the other involves non-transitive inference mechanisms.

The theoretical position taken here is that the exhibition of transitive relations is of paramount importance in building a theory of rational individual choice. But the exhibition of transitive relations, even though important and interesting in and of itself, is but one representation in a virtually infinite set of representations whereby an individual choice mechanism might produce transitive relations among objects of choice. This means that individuals in an experimental situation involving a choice task might all produce transitive relations among choices, but, they may arrive at these relations in a variety of ways. It would not seem appropriate, then, to characterize any experimental group as rational or irrational because of their choice of decision-rules or rules of inference, since all were able to perform the required choice task. Therefore, the choice of strategy and inference rules must be taken into account only when constructing a model sufficient to produce transitive relations so that a mechanism
characterized by one set of structures and processes is just as rational as another if it completes a choice task.

3.5 Minimum Rational Capacity

In a previous section, the theory of rational individual choice required that an individual choice mechanism produce transitive relations among objects of choice. The production of these transitive relations for a given choice task is an indicator of capacity in that transitive relations may be produced at some minimum level and some maximum level for an individual choice mechanism. The identification of this rational capacity—as a minimum and maximum—is, of course, an empirical question in that extensive experimentation is required to significantly narrow the class of mechanisms or processes which could have produced the transitive behavior.

Since this rational capacity is an empirical question, it is not surprising that subjects in experiments will manifest varying capacity levels. The most interesting questions, then, concern capacity measures which bracket all individuals at both a minimum and maximum level. This theory of rational individual choice suggests that as a first step, the minimum capacity ought to be identified. A major proposition of the theory, then, suggests that

Hypothesis 1. Many individuals in choice situations can be represented by an individual choice mechanism which has the minimum rational capacity to
produce transitive relations in choice data.

The "minimum rational capacity hypothesis" is supported in a wide variety of empirical enterprises. Braine (1969), Bryant and Trabasso (1971), Trabasso and Riley (1973), Lutkus and Trabasso (1974), Riley and Trabasso (1974), Trabasso, Riley, Wilson (1975) have all found that individuals under various kinds of choice situations under certainty do manifest high levels, that is, with respect to some minimum level which most individuals attain, of transitivity in choice data. Tversky (1972) finds that even when individuals behave intransitively given certain choice situations they manifest a propensity for transitive behavior.

Of course, the hypothesis is well-established in many theoretical or formal-theoretical enterprises. Samuelson (1947) motivates many economic analyses by considering the concept of some rational economic man, or *homo economicus*, who makes mistakes yet remains rational to a certain high degree, especially when information and decision costs are low. And Downs (1957), Arrow (1963), Olson (1965) extend the concept of *homo economicus* to include a much broader concept of rational political man, or *homo politicus*.

3.5.5 Minimum Rational Capacity and Performance

Thus far the analysis has suggested several propositions about the rationality of an individual choice mechanism, namely that (1) there is some minimum rational capacity
which represents the choice process for most individuals, (2) this capacity is developmental only in the sense of being manifested sometime before age eight and (3) this capacity is stable in the sense that the minimum capacity remains unchanged for the most part, while upper bounds may be subject to increases. These propositions, of course, all depend upon the possibility, at least in principle, of isolating, controlling, manipulating and analyzing the choice mechanism under conditions where confounding effects are minimal and/or control and manipulation are effective. This means in effect that the rationality of an individual choice mechanism must not be predicated on the basis of performance as defined in Chapter 2, but instead must refer entirely to capacity.

Now, the capacity for the production of transitive relations among objects of choice is only revealed as rational when: (1) Perception and context effects are controlled; (2) Memory permits the proper storage and retrieval of information; (3) The choice mechanism is permitted to choose any strategy and decision rule mechanism for operating on choice task information structures; (4) Feedback is permitted in the choice task; (5) Errors are allowed, but are not considered indications of irrationality, and (6) Individuals supplying empirical data are properly motivated.
3.5.2 Developmental Aspects

Two important hypothetical questions arise when one represents much of rational individual choice by a general individual choice mechanism which is intended to "account for" the choice behavior of many individual choosers. First, at what cognitive-developmental stage does this minimum rational capacity occur? Piaget (1921, 1928) and Piaget, Inhelder, Szeminska (1960), for example, suggest that children up to the age of eight, the "pre-cooperative stage," cannot perform the transitivity choice task. But, after age eight, the "concrete-operational stage," cognitive development is sufficient for most children to perform the transitivity task. This question is important since it is necessary to know whether or not the individual choice mechanism accounts for older elementary school children up through and including adults, but is inappropriate for many younger children. If it is the case that the transitivity task cannot be performed by young children, then the mechanism excludes a large segment of the population.

Second, given that the minimum rational capacity has been observed for everyone beginning at some cognitive-developmental stage and included in subsequent developmental stages, are there differences in the minimum level of rationality across various stages? Trabasso, Riley and Wilson (1975) suggest that the minimum capacity to perform the
transitivity task occurs quite early developmentally and that from these early stages, individuals tend to increase in transitive ability up to some threshold point reached during adulthood. This question is important to answer since the representation of an individual choice mechanism depends upon including many individuals above a certain minimum level of rationality. Or in other words, the representation is based upon performance at some minimum level which is low enough to include many individual choosers.

These two hypothetical considerations may be combined in the following hypothesis.

Hypothesis 2. Rational capacity occurs very early in the cognitive development of an individual at some minimum level. This minimum level tends to increase as cognitive capacity continued to develop.

This "developmental hypothesis" is supported by mixed empirical findings regarding the initial occurrence of the capacity. Some analysts find that the transitive capacity only occurs at the age of eight or older (see Piaget, 1921, 1928; Piaget, et al., 1960; Smedslund, 1960, 1963, 1965; Flavell, 1971; Flavell and Wohlvail, 1969). Other analysts have identified the capacity at much earlier ages including four, five and six (see Braine 1959, 1964; Coon and Odams 1968; Bryant and Trabasso, 1971; Luktus and Trabasso, 1974; Riley and Trabasso, 1974; Trabasso, Riley and Wilson, 1975).
They hypothesize in addition that the capacity might occur even earlier, although they have not yet to demonstrate this empirically.

One way of reconciling this mixed evidence is to examine the underlying methodological techniques of both enterprises. Trabasso, Riley, Wilson (1975) suggest that those who were unable to identify the earlier occurrence of transitive capacity failed to do so because of methodological problems. Among this included experimenter/subject interaction bias, failure to account for the effects of memory, use of inappropriate language in conceptualizing the choice situation, problems with context effects, and so on. Since the critics of the Piagetian approach have sought to improve their methodological foundation based upon the problems with the Piagetian analyses, this investigation will suggest that the occurrence of transitive capacity is at least evidenced at age four or five, and perhaps even earlier.

The second portion of the hypothesis which suggests that the level of performance on the transitivity task increases across developmental stages is not seriously questioned. Both Piaget (1921, 1928) and Trabasso, et al. (1975), find such cognitive-developmental differences. In this theory, a similar developmental hypothesis is proposed.

3.5.3 Stability Aspects

Another interesting hypothesis concerns whether or not this minimum rational capacity changes across time for an
individual. Or in other words, does the minimum rational capacity increase or decrease during an individual's lifetime? This hypothetical consideration is important since the theory must be able to account for many individuals engaged in acts of choice. If individuals gain and lose this minimum rational capacity, then it may be possible that a given individual choice mechanism is not always appropriate even for the same individual.

One interesting indicator of stability might be the intelligence level of the individual. This may be the case since: (1) many intelligence tests require individuals to perform transitive inference tasks, ordering and sequencing, and so on and (2) intelligence tends to remain constant or nearly so for many individuals across time, although changes may occur due to life experiences, physiological change, emotional change, or learning (Piaget, 1960). Intelligence, then, appears to be related to transitivity tasks on the one hand, and is in general, stable across time for the individual on the other.

This expectation may be stated in the form of a hypothesis:

Hypothesis 3. Minimum rational capacity, once established for an individual, remains stable for that individual across time.

The "stability hypothesis," being related in this case to intelligence level, also has some further hypothetical
implications. One of these is that individuals of high intelligence may have "higher" minimum levels of rationality than those of "lower" minimum level (see for example, Piaget, 1960). This expectation is supported in many ways in empirical studies related to intelligence. White (1968, pp. 722-23) found that the higher the capacity for learning an individual possessed, the more intelligent he appeared to be. Hess and Torney (1967, pp. 147-57) found that reasoning ability with regard to abstraction, generalization, association and so on where directly related to intelligence level. The hypothetical expectation of this investigation is that individuals of high and low intelligence will fall on or above some level of minimum rational capacity, but that the more intelligent will always manifest a higher minimum than the lower.

By relating minimum rational capacity to intelligence, it becomes possible to examine individuals who have equivalent intelligence levels, but may be of different ages. So, for example, one may examine individuals of high intelligence in various age groups from infancy to adulthood. One advantage of this kind of comparison is that one can speculate about "stability" throughout an individual's lifetime, even though one may be compelled to measure that capacity at one point in time. It is possible to speculate in this fashion by discovering whether or not individuals who have equivalent intelligence levels also have equivalent minimum
rational capacities. If they are in fact equivalent, then one might have reason for accepting the "stability hypothesis." Of course, the best measure of stability would be a time study which would be undertaken at periodic intervals in an individual's life.

3.5.4 Effect of Gender

And yet another interesting hypothetical question is whether or not males and females differ in some systematic fashion in their capacity for producing transitive relations among objects in choice data. It is well-known that males and females tend to differ upon a wide variety of interesting dimensions. Females, for example, tend to be less interested in politics, less efficacious in political beliefs and less concerned about ideological beliefs about politics (Lane, 1959, pp. 209-16; Campbell, et al, 1964, pp. 483-93; Greenstein, 1965). Gender differences in minimum rational capacity are important in representing individual choice, since the individual choice mechanism must account for acts of choice on the part of both males and females if it is to be completely general.

Unfortunately, there do not seem to be any systematic studies of transitive capacity and sex differences in performance. As a result, no firm theoretical and empirical foundation from which to marshal support exists to support any particular hypothesis. For purposes of empirically
testing this theory of rational individual choice, the investigation will hypothesize:

Hypothesis 4. Minimum rational capacity will be different for males and females, depending upon the choice task environment.

3.6 Transitivity and the Choice Mechanism: Some Empirical Considerations

Thus far the investigation has (1) constructed a flow diagram which represents an individual choice mechanism (see Figure 2), (2) predicated rationality of this mechanism if the observed choice data produced can be represented by transitive relations (see sections 3.2 and 3.3), (3) presented a catalog of the kinds of transitive relations and transitive inference mechanisms which might account for individual choice, and (4) suggested some hypotheses concerning the capacity of a choice mechanism to produce transitive relations.

In this section, the investigation will offer a framework which might be used to empirically identify and analyze these formal-theoretic choice mechanisms based upon observed individual choice data. This involves two considerations. First, how can one represent transitive relations so that they can be empirically distinguished from one another? And second, once these transitive relations are distinguished, how can one make inferences about the choice mechanisms which could have produced them? Both of these questions
require a different framework for analysis depending upon whether judgmental valuation or preference-based choice tasks are being considered. The investigation will now turn to an examination of each of these choice tasks.

3.6.1 A Framework for Analyzing Judgmental Valuations

A series of recent studies,\textsuperscript{1} Bryant and Trabasso (1971), Lutkus and Trabasso (1974), Trabasso and Riley (1975), Trabasso, Riley, Wilson (1975), provide a framework which allows one to represent (1) the objects and relations in a presentation set, (2) the objects and relations in choice data, and (3) based upon the representations of the presentation set and choice data allows one to make inferences about choice mechanisms which might have processed them. Specifically, the approach distinguishes between transitive inference involving the use of the syllogism or linear array and serial or parallel processing.

Transitive and non-transitive inference distinguished. The approach requires that the number of alternatives in a presentation set to at least six in number. Each alternative is paired with every other to yield fifteen possible paired combinations. Given at least fifteen unique pairs, an individual must or can make multiple transitive inferences. For example, a set of alternatives ordered according to an objective standing yielding at least an interval scale (1, 2, 3, 4, 5, 6), two possibilities for making a transitive inference might be defined over the adjacent
pairs $3 > 2$, $4 > 3$ implies the non-adjacent pair inference. $4 > 2$ and $5 > 4$, $4 > 3$ implies $5 > 3$. These inferences only require the reversing of one relation on two adjacent pairs. But, if an analysis adds in a second level inference which requires additional reversals of relations, then it may become evident as to whether or not transitive inference is occurring rather than non-transitive inference or some other rule. For example, the pairs $3 > 2$, $4 > 3$ imply $4 > 2$ and $3 > 4$, $4 > 3$ implies $5 > 3$. Then, the pairs $4 > 2$, $5 > 3$ provide a second level inference which would imply that $5 > 2$.

The theoretical basis of this approach is that if an individual is not only required to make transitive inferences over three alternatives but also must use the logical conclusions from these inferences as premises for additional inferences; then, although non-transitive inference possibilities are not eliminated entirely, they are more clearly revealed in the choice data. So, for example, individuals who would ordinarily "guess" correctly upon a set of three alternatives are being reduced in number since the probability of guessing correctly as the number of alternatives increases may be much less than for three alternatives.

The Concept of Stepsize. Specific pairs in a presentation set as in the example above may be conceptualized in terms of "stepsize." Stepsize is determined by assigning an integer value to the longest (or shortest) scale value measurement in an ordering of alternatives and then assigning
to each additional scale value successive integers of increasing or decreasing quantity. For example the alternatives ordered \( x > y > z \) would yield integer values \((1,2,3)\) or \((3,2,1)\). Once this is accomplished, \textit{stepsizes} is calculated as the integer value of the greater element in a pair minus the integer value of the lesser element in a pair and this quantity minus 1, \([(\text{greater-lesser}) - 1] = \text{stepsize.}\) So for example, for a pair \((2,1)\), the stepsize would be \((2-1) - 1\) = 0.

The concept of stepsize may be further described by the following classification scheme. If a pair has a value of 0 stepsize, then it refers to an \textit{adjacent pair}—that is, any two alternatives as positioned on the scale so that no other alternative value can be placed between them. Pairs having a stepsize greater than 0 are referred to as \textit{non-adjacent pairs}. When a set of alternatives has three or more numbers, then, there must exist an alternative that has a greatest scale value and one that has a least scale value. Alternatives located on the endpoints of a scale are referred to as \textit{anchor points}. If a pair contains one anchor point or the other or both, then the pair is referred to as an \textit{anchored pair}. A final terminology describing stepsize has to do with the inferences made in performing the transitivity inference task. When a pair is adjacent and necessary to infer the relationship between a non-adjacent pair, then this is referred to as a \textit{premise pair}. For example, if
3 > 2 and 2 > 1, then (3,2) and (2,1) would be premise pairs used in inferring the conclusion 3 > 1 or the relation over the pair (3,1). When a non-adjacent pair is used to infer the relation over another non-adjacent pair, then this is referred to as an inference pair. For example, if 3 < 5 and 2 < 4, and given that 5 > 4 and 4 > 3 and 3 > 2, then the pairs (3,5) and (2,4) are inference pairs when used to conclude that 5 > 2.

Choice reaction time and pairwise choice. In addition to analyzing the actual choices made by individuals in a choice situation, it is also possible and as will be shown important to consider time as a dimension of choice. For purposes of this analysis, time in making pairwise choices will be conceptualized as choice reaction time as follows. Each element in a presentation set presented for paired comparison is considered a separate stimulus. The presentation of a pair begins the reaction time measure for the individual. The response to the stimuli as referenced by the physical, motor response of the individual chooser completes the reaction time measure. This definition is equivalent to Donders (1898) simple reaction time paradigm "c".

It makes a difference in an analysis of choice which paradigm for choice reaction time is chosen to represent individual choice. These paradigms and some of their implications are reviewed by Smith (1968).
Judgmental Levels of Transitivity: The Concept of Error.

Judgmental comparisons which yield transitive relations over sets of objects are considered to be much less problematic in an applied measurement sense than that of preferential valuations. This is because judgmental comparisons have an objective standard upon which everyone can argue, it becomes possible to assess the correctness of an individual's judgments over a set of objects. In other words, it is possible in many cases to state whether or not a judgment concerning a relation is in fact characteristic of the set of objects. Transitivity, indexed as a "level of correctness" in judgments about relations defined over a set of objects, may be viewed as the number of correct or incorrect responses by an individual for a given protocol or the percentage correct or incorrect for a given protocol.

Error, Stepsize and Reaction Time as Indicators of Transitive Inference Mechanisms. Thus far, the study has suggested that transitive inference ability and the exhibition of transitive relations in choice data may be related to stepsize, reaction time and accuracy of judgments. Further, the study has suggested that the transitive inference task which generates transitive relations in choice behavior may be represented in a wide variety of ways, such as linear arrays or syllogistic operations, or serial or parallel processing. In this section the analysis will suggest how both of the above are related one to the other.
in order to represent the transitive inference mechanism. Or in other words, how can choice data manifesting step-size, reaction time and accuracy be used to decide among alternative models of transitive processes such as the linear array or syllogistic processing.

1. Implications of stepsize and RT. Syllogistic processing requires that ordered pairs be stored separately in memory, and also retrieved separately from memory during the choice task. If syllogistic processing is assumed to be serial, then the RT for the pair (2,5) should be slower than the RT for the inference pairs (3,5) and (2,4) since these inference pairs must be concatenated to yield the relation over pair (2,5). Similarly, premise pairs (2,3), (3,4) and (4,5) will yield faster RTs than (3,5) and (2,4) since they do not require concatenation of any other pairs, but are required to infer (3,5) and (2,4).

If the linear array processing represents the choice act by an individual, then ordered pairs are not stored separately in memory, but instead are mapped onto a continuum either spatial or otherwise in such a way that transitive relations between objects are stored, while the separate pairs are eliminated. The linear array, then, suggests that ordered pairs of the greatest stepsize, say (2,5) will manifest the fastest RT; inference pairs of lesser stepsize (3,5) and (2,4) will manifest immediate RT; and premise pairs (2,3), (3,4) and (4,5) will manifest the longest.
Note that stepsize and RT for the linear array do not in themselves suggest serial or parallel processing implications.

2. Implication of stepsize and error. Stepsize when related to error leads to several conclusions about the use of syllogistic processing. Generally, if a process is syllogistic, then errors occurring at the premise pairs will be increased as the number of inference pairs increases since correct information (or choice) are necessary to attain correct information (or choices) at a later inference level. Therefore, syllogistic processing is evidenced if there are more errors on inference pairs (2,5), slightly fewer errors on (2,4) and (3,5), and fewest errors on (2,3), (3,4) and (4,5). A judgmental choice situation with no errors in judgment, of course, cannot support the syllogistic processing representation.

Linear array processing when serially processed, is evidenced when the "serial position effect" is observed (Bower, 1971; Murdock, 1960; Feigenbaum and Simon, 1962). The serial position effect occurs when the pairs of the greatest stepsize have fewer errors associated with them than the pairs of smaller stepsize. So, for example, the anchored pair (1,2) should manifest fewer errors than the inference pair (2,5). Adjacent pairs under this model should show the most errors, since they are of 0-stepsize.
3. **Implications of error and RT.** When error and RT are considered, syllogistic processing predicts that those pairs having the fewest errors will be the premise pairs and that these pairs will show the fastest RTs. Conversely, the higher the inference level of a pair, the greater the error and the slower the RT. Measures of error and RT imply no conclusions about serial and parallel processing effects.

Linear array processing which is serially processed suggests that the pairs of the least stepsize will manifest the most errors, while at the same time being associated with the slowest times. Pairs of greater stepsize which are derived from higher inference levels will show fewer errors and faster RTs.

4. **Parallel Processing, Stepsize, RT and Error.** The analysis so far has suggested how syllogistic, linear array, and serial processing might be represented by considering stepsize, RT and error. A further possibility is to consider parallel processing as it is related to stepsize, RT, and error. Representations involving parallel processing seem to be most useful in this approach when the following situations arise in choice data: (1) when RT's are identical or equal regardless of the stepsize of the presentation pair, (2) when error is consistent across presentation pairs of all stepsizes, and (3) when some combination of points (1) and (2) occur. For example, parallel processing is considered when each presentation pair yields the same measure
for all RT's and errors, respectively. Since parallel processing may be interpreted in many ways depending upon the nature of the choice data, this analysis will simply direct the reader to the following studies which contain elaborate treatments of the models. What is important to note for now is that once the measures of RT become similar and error becomes uniformly distributed, parallel processing may be one possible explanation. Otherwise the preceding discussion on linear array, syllogistic and serial processing are more appropriate.

An important caveat. The investigation of transitivity has concentrated upon syllogistic, linear array and serial processing. In so doing, other theoretical-empirical concerns such as non-transitive inference, parallel and hybrid processing, and so on have been offered as possible explanations to be examined only if the major concerns in the analyses fail to represent the individual choice behavior observed. There are perhaps three reasons for this strategy. First, the possible representations not dealt with are great in number thereby defying any simple review. Second, even if a review of these representations was possible, the diversity, complexity and uniqueness of the available models defies any systematic presentation. And third, the theoretical expectation of this analysis is that the models covered will explain many important judgmental valuation choice

3.6.2 Preference and Transitivity

Preference based choice behavior is generally considered more complex to analyze than judgmental valuations since preference is founded upon some subjective standard, while judgmental valuations are founded upon an objective standard. This is the case since (1) preference patterns may be undiscoverable in the choice data gathered either because they do not exist or because the precise pattern is not clearly revealed, and (2) preferences may suggest only an ordinal interpretation or representation rather than a cardinal one so that more complex, higher order measurement and representations are precluded. Both problems in analyzing preference-based choice data have not been entirely resolved in the literature on the topic. For example, since this paucity of empirical evidence and technique for analysis exists, it seems important to attempt to construct a technique whereby preference data can be analyzed for purposes of comparison with judgmental valuations.

In order to formulate a technique for analysis of preference data, the analysis will assume that judgmental valuations are similar from a processing standpoint as that of preference-based choice. This permits several important things. First, it becomes possible to examine data in a new way—that is, using judgmental valuation kinds of techniques.
Second, if the empirical analyses of both preference and judgment are similar, then theoretically one could develop techniques in judgmental data and if they work attempt to employ them on preference data.

The next section of the analysis, then, attempts to construct a method whereby the level of transitivity, the upper and lower bounds of transitive behavior, and the inference mechanism for preference-based choice can be discovered.

3.6.3 A Framework for Analyzing Preference Based Choice

One approach, which constitutes the underlying methodological basis of this analysis, provides what might be a partial solution to interpreting choice data. The approach in general consists of the following criteria.

Search for general choice generating mechanism. An initial methodological assumption is that choices made by subjects over objects in presentation sets mirror only to a certain extent the preferences and/or decision-rules which could have generated them. In other words, preferences are in part, but only in part, assumed to be revealed. Since preferences are only revealed in part in choice data, the method rejects the notion of a unique mapping of the objects and relations of the choice data into some unique preference pattern. Instead, the approach is searching for a model or class of models which will be general enough to contain the wide variety of possible mappings from the choice data into
a preference pattern. The focus of the approach, then, consists of a search for models which are "sufficient" to capture the way in which individuals choose.

**A Procedure for Assessing the "Level of Transitivity" in Preferential Choice Data.** The following procedure adopted from Harary, Norman, and Cartwright (1965, Chapter 11) constitutes a partial solution to the problem of discovering the subjective standard of individual preference profile "possibly" used by an individual in making pairwise comparisons. (See Koo, 1963, for an alternative method used primarily in studying consumer behavior.)

**Discovering possible preference profiles.** Initially, it will be assumed that choices are somehow related to one another in a kind of "directed graph," where a directed graph or digraph is simply taken to be an irreflexive relation. For example, a choice over the unordered presentation pair \( (x,y) \) so that \( x \) is preferred to \( y \)--that is, \( (x,y) \), would yield the digraph:

\[
G_1: x \rightarrow y \quad (1)
\]

If two additional unordered pairs are included in the presentation set, say \( (x,z) \) and \( (y,z) \), so that \( (x,z) \) and \( (y,z) \); then the digraph would resemble the following:

\[
G_2: x \rightarrow y \rightarrow z \quad (2)
\]

The objects (that is, alternatives \( \{x,y,z\} \)) and relations (that is, "more preferred") specified in the digraph
G₂ may be converted into algebraic symbols by constructing an "adjacency matrix"—which is, the result of a mapping of the points of a digraph into a square matrix with one column and one row for each object—as follows:

\[
\begin{array}{ccc}
\text{SUM} & x & y & z \\
- & 1 & 1 & 2 \\
0 & - & 1 & 1 \\
0 & 0 & - & 0 \\
\end{array}
\]

The rows x, y, and z, when compared to the columns x, y, and z represent the relations "more preferred" so that x in the first row, when compared with y in the second column will be interpreted as (x,y) if the digit "1" is given and (y,x) if the digit "0" is given. If the matrix is converted into right echelon form as above in (3)—that is, the values "1" are in the upper right hand corner, the labels x, y, and z for the rows and columns represent an ordinal preference scale. In the example, this would be (x,y,z). This suggests a kind of standard which represents to a certain extent an individual's preference pattern over the alternatives \{x,y,z\}.

Sometimes the conversion of a matrix does not yield a matrix in an ideal right echelon form. For example, it might be the case that an individual's preference profile over four alternatives \{x,y,z,a\} might result in the partial ordering:
\[ x > y \sim z > a, \quad (4) \]

where \( \sim \) represents a case where it is not known whether an individual prefers \( y > z \) or \( z > y \). This ordering yields two possibilities:

\[ x > y > z > a \quad (5) \]

or

\[ x > z > y > z \quad (6) \]

Since this possibility often arises, the approach will assume that the general preference model is captured by the ordering in (4) and that two specific orderings might be possible in (5) and (6).

Finding possible individual preference profiles is only part of the problem. The other would involve a consideration for finding the extent to which any set of choice data some maximum level of transitivity for a set of alternatives. The analysis will now turn to a consideration of this second question.

**Maximum and observed levels of transitivity.** The labels for the rows and columns only give a rough estimate of the possible individual preference profiles over a set of alternatives, but two additional considerations are indicated. (1) what is the maximum level or degree of transitivity possible for a given standard expressed over a set of alternatives? and (2) what is the observed or actual level or degree of transitivity for a given individual?
In order to accomplish the above, a column is placed to the right of the matrix in (3) which is the sum of the respective rows. This column may be interpreted as the number of times one alternative is preferred to the other alternatives in the presentation set.

Next, the number of possible combinations of triples is computed using the algebraic formula:

\[
\frac{p}{3} = \frac{p(p-1)(p-2)}{6},
\]

where \( p \) is the number of alternatives in the presentation set. In the example in matrix (3), the total number of possible unordered triples would be:

\[
\frac{p}{3} = \frac{3(3-1)(3-2)}{6} = 1
\]

The value 1 above in (8) refers to the unordered triple \( \{x,y\}, \{y,z\}, \{x,z\} \).

In the next phase of the analysis, the calculation of the number of transitive triples (or acyclic triples) observed for an individual in the choice data. This numerical value may be calculated using the following algebraic formula:

\[
\frac{\sum_{i=1}^{p} s_i (s_i - 1)}{2}
\]

where \( s_i \) is equal to any arbitrary row in the adjacency matrix and \( p \) is the number of alternatives in the presentation set. In example (3), the number of transitive triples in the presentation set \( \{x,y,z\} \) is given as:
\[ 2(2-1)/2 + 1 (1-1)2 + 0(0-1)/2 = 1 \quad (10) \]

If the total number of transitive triples (9) observed is subtracted from the total number of possible triples (7); then a measure of the number of intransitive triples \( c \) may be calculated as follows:

\[ c = \frac{p(p-1)(p-2)}{6} \sum_{i=1}^{p} i(i - 1)/2 \quad (11) \]

It is now possible to state how many triples there are and how many are transitive and intransitive. It is also desirable to know how many intransitive triples are possible for a given presentation set. This is desirable since one would like to know the "degree" of inconsistency any individual can be in a given choice situation. To calculate the maximum possible number of transitive triples (Kendall, 1958), \( c_{\text{max}}(p) \), the following equation may be utilized:

\[ c_{\text{max}}(p) = \begin{cases} \frac{p^3-p}{24} & \text{if } p \text{ is odd, and} \\ \frac{p^3-4p}{24} & \text{if } p \text{ is even.} \end{cases} \quad (12) \]

By combining equations (11) and (12), Kendall and Smith (1940, pp. 324-345) were able to construct a coefficient which measures the "degree of inconsistency" or intransitivity (see LaBerge, 1958, for an alternative method to that of Kendall and Smith, 1940; and Edwards, 1957, for a complete treatment of this procedure) given as \( \zeta \):

\[ \zeta = 1 - c/c_{\text{max}}(p) \quad (13) \]
There are at least two major advantages in viewing the level or degree of inconsistency or intransitivity in this way. First, the coefficient $\xi$ norms at 1.0 for maximum inconsistency and 0 for maximum consistency. The coefficient in the interval $0 \leq \xi \leq 1$ allows for an accurate and meaningful interpretation. Second, the coefficient is insensitive to the particular kind of ordering being dealt with as in (4), (5), and (6) above. In other words, the partial ordering $x > y \sim z > a$, when decomposed into its possible constituent parts $x > y > z > a$ and $x > z > y > a$, does not affect the coefficient. Both constituents yield the same value. In one sense, one can talk meaningfully about the level of transitivity without being able to specify the precise standard—that is, individual preference profile from whence it came.

At this point in the analysis, it is possible (1) to roughly identify possible individual preference profiles in choice data, (2) to specify the maximum inconsistency possible for a given presentation set in a specific choice task, and (3) to express the degree of inconsistency observed for an individual, given a set of choice data.

**Minimum levels of transitivity.** In this portion of the analysis, an absolute minimum level of intransitivity or inconsistency among choice data observations may be considered. The purpose of this information would be to consider a case wherein a chooser attempts to choose so
as to maximize his intransitive triples or minimize his transitive triples.

The formula for assessing the maximum level of inconsistency may be derived simply by dividing the maximum number of intransitive triples (12), \( c_{\text{max}}(p) \), by the maximum number of possible triples (7), \( \binom{p}{3} \), yielding \( c_{\text{max}}(p)/(\binom{p}{3}) \). Next, if \( c_{\text{max}}(p) \) is converted into a formula sensitive to odd (12) or even (12) numbers of alternatives in a presentation set, then one attains if \( p \) is odd:

\[
\frac{c_{\text{max}}(p)}{\binom{p}{3}} = \frac{p^3-p/24}{p(p-1)(p-2)/6} = \frac{1}{4} + \frac{3}{4p-8} \quad (14)
\]

and, if \( p \) is even:

\[
\frac{c_{\text{max}}(p)}{\binom{p}{3}} = \frac{3-p/24}{p(p-1)(p-2)/6} = \frac{1}{4} + \frac{3}{4p-4} \quad (15)
\]

Notice that in both formulae (14) and (15) the value of \( c_{\text{max}}(p)/(\binom{p}{3}) \) approaches the limit 1/4 as \( p \) goes to infinity. This suggests that for a large number of alternatives, a deviant chooser can do no better (or worse) than chance in selecting alternatives. In other words, with a large number of alternatives, it is impossible to determine from the choice data whether or not a chooser chose randomly or tried to maximize his inconsistency. In the case of six alternatives—which is the nature of the protocol for the accompanying experiment,

\[
\frac{c_{\text{max}}(p)}{\binom{p}{3}} = \frac{1}{4} + \frac{3}{4(6) - 8} = \frac{1}{4} + \frac{3}{16}
\]
suggesting that at a maximum, a deviant chooser may only depart from chance at a fraction of \(\frac{3}{16}\) — so that total inconsistency is given as \(\frac{7}{16}(\frac{1}{4} + \frac{3}{16})\) which is somewhat more than 50 percent correct.

4.3.3 A Methodological Overview of the Approach

An overview of the general approach to the analysis of transitive inference and transitive relations in choice data might be capsulized as follows. First, judgmental choice data is analyzed in order to understand transitivity in choice behavior. This is possible given the assumption that transitivity is revealed in the choice data for an individual. This serves as (1) a way to gain a somewhat more lucid picture of choice behavior than preferential choice ordinarily permits and (2) a means for validating techniques and insuring reliability which might be appropriate to the analysis of preference, that is, if many analyses of judgment are similarly conducted and equivalent results are obtained, then this constitutes an important first step in applying similar means to preference analyses with the idea that the results obtained are not varying simply because of unreliable analytic techniques. Of course, the techniques used in judgment assessment may not be valid for preference analyses; but this remains an open question.

Second, judgmental choice data, after analysis, is used to formally model the manifested choice behavior for the given choice tasks. In other words, a formal model is
sought which will represent the choice behavior manifested by an individual.

Third, the formal model of judgmental choice behavior for a given choice task is in turn analyzed using the posited assumptions approach. This amounts to assuming certain formal structures in the model and then (1) drawing out their formal or logical implications and (2) using these formal structures to generate subsequent empirical analyses.

And fourth, the subsequent empirical analyses are used to generate other formal models and the process begins anew. This may be thought of as a kind of leapfrog approach with alternating emphasis upon the empirical and the formal. Of course, both are also concurrent enterprises as well.

Now, as steps one through four above are proceeding for judgmental choice tasks, a concomitant enterprise is also being undertaken for preferential choice behavior. It also begins with a theory of revealed preference in choice which lends to an empirical analysis. The empirical analysis is then formalized to yield models for analytic and empirical testing. The process is also a kind of leapfrog approach.

Both portions of the approach, that is, judgmental and preferential, interface frequently in an overall, general approach to choice behavior. This is especially the case in that problems arising in one portion whether theoretical, empirical or formal, may be solved or at least better understood by examining similarities in the other portion.
Outright comparisons and contrasts between the two portions are also considered. But, most importantly, for purposes of this analysis, judgmental and preferential choice are assumed to be proper subsets of choice behavior in general. As a consequence, the results of either enterprise lend to an understanding of individual choice. Or in other words, both contribute to the formulation of a model of individual choice behavior which is general enough to account for many kinds of choice tasks and at the same time specific enough to be non-trivial in its theoretical, empirical and formal implications.

3.7 Distinguishing Rationality from Other Concepts

Any theory of rational individual choice must be able to conceptually distinguish between four types of individual choice behavior: rational, irrational, extra-rational and erroneous choice (Richter, 1971; Downs, 1957). This is apparent in many theories of rational individual choice. Riker and Ordeshook (1973, pp. 23-33), for example, draw a distinction between rational behavior which conforms to some maximizing principle and irrationality which is based upon the frequency of error-making in choice behavior. Bennett (1964) draws the distinction between rational behavior which is "rule-guided" and "regular" and extra-rational behavior which is simply regular. Richter (1971, pp. 30-31) distinguishes rationality in choice behavior from irrationality according to whether individual choices can or cannot be
"rationalized" by the kind of preference pattern which produced them.

Clearly, the four concepts, rationality, irrationality, extra-rationality and error cut across one another when various definitions are examined. But, it does seem possible to organize the concepts into categories which allow one to distinguish between them: one way to organize them and still maintain some compatibility with many theories of rational individual choice is given as follows.

PLACE FIGURE 4 ABOUT HERE

The block diagram does not require that any particular approach to rational individual choice theory be assumed. Instead, it represents one means whereby the four concepts might be sorted out for theoretical, formal and empirical evaluation.

The decision tree in Figure 4 initially requires an analyst of human choice behavior to answer the question: "Does the choice task require the production of transitive relations?" with regard to an individual choice mechanism. A situation wherein no choice is involved will yield a "no" in the first node of the decision tree. This indicates that the observed behavior being evaluated is not rational or irrational, but instead is non-rational. An example of behavior which is extra-rational for this theory would be a situation where an individual responds "I like this picture." The behavior here is extra-rational since the
Is behavior rational or irrational?

If yes
- Is behavior appropriate?
  - If yes
    - Assumption of rational behavior holds.
  - If no
    - Is evaluation or feedback allowed?
      - If yes
        - Is behavior appropriate?
          - If yes
            - Assumption of rational behavior holds.
          - If no
            - Assumption of rational behavior indeterminant.
      - If no
        - Assumption of rational behavior does not hold.

If no
- Behavior is extra-rational.

Assumption of rational behavior holds; but an error was made.

Is cost of performance (motivation) considered?

If yes
- Assumption of rational behavior does not hold.
If no
- Assumption of rational behavior indeterminant.

Figure 4. A Block Diagram for Defining Rationality and Some Related Concepts.
individual is not "choosing" over a set of alternatives or objects. Instead the individual is simply making an assertion which is not comparative. The concept of extra-rationality contained in this theory admittedly accounts for much of human behavior. It is included since it does not seem appropriate *prima facie* at least for all behavior to be either rational or irrational.

A situation where behavior is determined to be either rational or irrational leads immediately to another branch of the decision tree which asks the question: "Is the observed choice behavior appropriate to the choice task?" By "appropriate" is meant, are transitive relations produced in choice data which are compatible with some given judgmental standard or preference ordering? If the observed behavior is appropriate, then one branch of the decision tree terminates in the conclusion: "The individual choice mechanism is rational."

Now, if the observed choice behavior is inappropriate to the choice task—i.e., the behavior does not yield transitive relations in the choice data, then another node on the decision tree is encountered. The question the analyst must ask here is: "Is feedback to correct errors allowed?" The purpose of the feedback criterion is to determine whether or not the choice data produced was a function of erroneous behavior or the result of irrationality. This situation might arise when an individual has
answered 200 survey questions in succession and inadvertently circles one item when he meant to circle another. If feedback and correction is not allowed the response might appear intransitive on paper, but transitive in the choice set of the mechanism; or, it might be a legitimate intransitivity which would yield an irrationality conclusion. At this portion of the decision tree, no feedback criterion leads to an "indeterminant" conclusion with regard to rationality, irrationality and error.

If feedback is allowed and if the behavior subsequent to the feedback criterion is transitive in choice data, then the decision tree indicates to an analyst that the observed behavior was produced by a rational individual choice mechanism. An analyst might say, then, that an error was made by the choice mechanism; but the mechanism was in fact rational according to the theory. A situation wherein feedback is allowed but behavior is still inappropriate yields another branch: "Is the cost of performance greater than the benefit to the individual?"

In considering whether or not the cost of performance—that is, the psychological investment or outlay the individual makes in performing in a choice task environment—is greater than the benefits, one of two situations might arise. When an individual participates in a choice situation without the confounding, inhibiting influence of cost, yet at the same time produces intransitivities in choice,
the choice mechanism, having failed all of the tests in this decision tree branch must be considered irrational. On the other hand, if the individual's costs exceed his benefits in the choice situation, then, rationality/irrationality become indeterminant.

The final branch of the flow chart to be considered is the only one in which irrationality may be admitted; although irrationality may be present, but unobservable in the indeterminant cases above. According to the flow chart, the only determinant case of irrationality is when an individual's behavior: (1) can be either rational or irrational, (2) is inappropriate for the choice situation and assumption of rationality, (3) remains inappropriate after evaluation, and (4) is not prohibitive because of cost/benefits in performance.

The major considerations in the flow chart represent some initial and preliminary restrictions upon the concepts of rationality, irrationality, extra-rationality, and error. There certainly are more elaborate and important considerations which could be included. But, the ones included seem to create an interesting start in making sense and coming to grips with the major concept involved in discoursing about theories of rationality.
Notes to Chapter 3

1These studies are the most recent attempts at accounting for theoretical methodological problems and controversy which ranges back as far as Piaget (1921, 1928). The problems and resulting controversy are worth tracing for their own sake. The reader is directed to Piaget (1921, 1928, 1960) as a beginning. Next to Braine (1964, 1959), Smedslund (1960, 1963, 1965) and Bailey (1970) for a discussion of the "Braine-Smedslund controversy." And finally to the series of recent articles already cited. This will provide a background for the current state of investigations into the transitivity task.

2Although performance costs in terms of motivation and personality are important as indicated, they are not treated in detail in this theoretical approach. The reason for this is that the theory must deal with first things first. Hence, motivation and personality must be considered after the concern for representing the cognitive dynamics of individual choice. See Newell and Simon (1972, pp. 8, 55) for a more extended treatment of this same consideration.
Chapter 4

METHODOLOGY

What all this comes to is that the experimental method is inseparable from the development and application of hypotheses and theories.

Abraham Kaplan
The Conduct of Inquiry

4.1 Introduction

In this chapter, the theory of rational individual choice developed in Chapters 2 and 3 will be operationalized, that is, the theory will specify sets of observations about the empirical world. These opportunities for observation will focus upon two choice experiments: judgmental choice (Experiment 1) and preference-based choice (Experiment 2).

4.2 Experiment 1: Judgmental Choice

4.2.1 Design

Subjects. The subjects in this experiment were 72 college and elementary school students. Subjects were selected on a volunteer basis. Parental permission was obtained for students to participate in the experiment. Neither payments for participating, nor rewards for performance were given to any subject involved in the experiment.

Apparatus and materials. The stimulus materials for this experiment were thirty-six sticks (dowls) in lengths of 5, 6, 7, 8, 9, and 10 inches respectively in each of
six colors: blue, red, green, white, yellow and orange. The group of thirty-six sticks was broken down into six "presentation sets" of six sticks so that each set contained only one length of a kind and one color of a kind as follows.

Within each set of six sticks, the sticks were labeled 1, 2, 3, 4, 5, and 6 respectively, corresponding to the lengths 5, 6, 7, 8, 9, and 10 inches.

The pairs of sticks, "presentation pairs," were presented from behind a presentation box measuring 12 x 8 x 6 inches. When the pairs of sticks was presented, the sticks appeared to be of equal length, that is, approximately three inches long. The presentation box was designed so that the only way a subject could see the actual length of a stick was by having the experimenter remove the stick from the box and reveal it to the subject. A stopwatch was used to record response latencies for each presentation pair.

Design. The experiment involves a 3 x 2 x 2 factorial design. Subjects were selected according to three criteria. The first was cognitive-developmental stage which was operationalized as grade level including first graders, fifth graders and college undergraduates. The second was intelligence which was operationalized as academic achievement as follows. For first and fifth graders, teacher evaluations of each student which placed him or her into a high or low category were used to identify high or low
<table>
<thead>
<tr>
<th>Stick Length&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Set Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 6 7 8 9 10</td>
<td></td>
</tr>
<tr>
<td>B G W Y O R</td>
<td>1</td>
</tr>
<tr>
<td>R B G W Y O</td>
<td>2</td>
</tr>
<tr>
<td>G W Y O R B</td>
<td>3</td>
</tr>
<tr>
<td>W Y O R B G</td>
<td>4</td>
</tr>
<tr>
<td>Y O R B G W</td>
<td>5</td>
</tr>
<tr>
<td>O R B G W Y</td>
<td>6</td>
</tr>
</tbody>
</table>

<sup>a</sup> Length in inches.

<sup>b</sup> Color code: B = blue, G = green, W = white, Y = yellow, O = orange, R = red

---

Figure 5. Stick Lengths in Inches and Associated Colors for Set Varieties.
achievement levels for each subject. In addition, complete Metropolitan Achievement Test scores were taken for each student and compared with the teacher evaluations to further support the level classification of each student. For college undergraduates, the college accumulative grade point average was used to identify high and low achievers. High achievement was taken as a 3.00 average or better on a 4.00 grading scale, and low achievement consisted of averages less than 3.00. And third was the sex of the subjects, in which both males and females were used.

4.2.2 Procedure

In Training Phase I, subjects were instructed in the use of the stimulus materials and apparatus. Subjects in grades 1 and 5 were presented with a set of six sticks of different sizes and different colors and were asked to name the colors. This phase was omitted for college students. Next, the stimulus task was explained to the subjects using a set of sticks different from those to be used in actual testing. Finally, each subject learned the comparative relations of five adjacent pairs (stepsize 0): (1,2), (2,3), (3,4), (4,5), and (5,6) where Stick 1 was always the shortest. The subjects were counterbalanced according to whether they learned the stick comparisons from the shortest to the longest or the longest to the shortest. Left-right positions of the pairs in the presentation box were randomized.
To start a trial, the subject was asked either "Which stick is longer?" or "Which stick is shorter?" Questions beginning each trial were randomized. Then the pair of sticks was presented from behind the presentation box and the stopwatch was started. Remember that the sticks presented appeared to be equal length. When the subject responded, the stopwatch was stopped.

After the subject made his choice, two types of feedback were given: **linguistic** and **visual**. Linguistic feedback consisted of the experimenter stating either "That is correct; the (red) stick is longer than the (blue) stick." Or "No, that is wrong; the (blue) stick is shorter than the (red) stick. In visual feedback the experimenter placed the pair of sticks on top of the presentation box in full view of the subject. By presenting the pairs of stepsize 0 so that they appeared of equal length and then by showing the subject both sticks as they actually are, one shorter and one longer, in the feedback after the presentation. The experimenter was essentially requiring the subject to associate the color of the sticks in a pair with their respective lengths. Therefore, at the completion of Training Phase I, subjects should be able to judge length by knowing only the colors of any two sticks in a presentation pair. Feedback questions were randomized for presentation. Trials in the training phase were divided into sets of five trials referred to as blocks. Each
trial concerned pairs of stepsize 0 only. After each trial feedback was given as above. Subjects received a maximum of 120 trials or 24 blocks upon which pairwise comparisons were made. Once the subject responded correctly 80% of the time, Training Phase I ended. If the subject had not reached this criterion in 120 trials, he was retrained the next day using the same procedure. If the subject still had not reached the criterion, he was eliminated from the experiment.

In Training Phase II, subjects were again presented with adjacent pairs of sticks. In this phase, the order of presentation and the left-right position of the pairs were randomized. Trials began and ended as in Training Phase I. Feedback, both linguistic and visual, was given to the subject after each trial. The purpose of this phase was to insure that subjects could judge adjacent pairs according to the colors associated with length and not simply using length. Subjects received a maximum of 45 trials upon which pairwise comparisons were made. Once the subject responded correctly to any six pairs consecutively, Training Phase II ended. If the subject did not reach the criterion in 45 trials, then he was eliminated from the experiment.

The Testing Phase was begun immediately after the six in-a-row criterion had been reached. Test trials were administered in the same way as Training Phases I and II, except that no feedback, either visual or linguistic, was given. Each subject was instructed that no feedback would
be given during the test. Each subject was tested three times on each of fifteen possible color pairs, according to the following scheme: (1) five adjacent pairs (equivalent to those in Training Phases I and II) of stepsize 0: (1,2), (2,3), (3,4), (4,5), and (5,6). (2) two pairs of stepsize 1: (2,4), (3,5). (3) one pair of stepsize 2: (2,5). And (4) seven pairs: (1,3) and (4,6) of stepsize 1, (1,4) and (3,6) of stepsize 2, (1,5) and (2,6) of stepsize 3, and (1,6) of stepsize 4. The test phase differs from both training phases in that subjects must judge presentation pairs exclusively on the basis of color and presentation pairs of stepsizes 1 through 4 are now included. Subjects receive no visual feedback in which they could observe which stick was actually longer in a given pair. In addition, they were not told which stick was longer. The 45 resulting test trials were presented in three blocks of fifteen trials, each pair of colors being presented in a block, and the order of presentation of the fifteen pairs was randomized.

4.2.3 Experimenters

The experimenters in Experiment 1 were twelve upper class college psychology majors. Each experimenter was trained in three experimental tasks: presenting, recording and timing. Experimenters were counterbalanced across subjects as much as possible. The author was present during the conduct of each procedure for each subject as both a
participant and supervisor. The entire interaction between experimenter and subject was taperecorded.

4.3 Experiment 2: Preference-based Choice

4.3.1 Design

**Subjects.** The subjects for the experiment were the same as those for Experiment 1.

**Apparatus and materials.** The stimulus materials for the experiment consisted of five identical sets of six wooden blocks. Each block measured 2 x 2 x 1/4 inches. A black and white photograph of a person measuring 1 x 1 1/2 inches was attached to each block. A label naming the person in the photograph was imprinted beneath each picture. The photographs of persons on the blocks and the labels naming them were constructed as follows.

PLACE FIGURE 6 ABOUT HERE.

The photographs as labeled were intended to represent the individuals in the pictures. They were not photographs of particular individuals known to the subjects, except for President Gerald Ford and Vice-President Nelson Rockefeller.

External memory was supplied in the experiment through the use of a wooden board 24 x 24 x 1/4 inches. On the face of the board were outlined thirty black squares arrayed in five rows and six columns. Each square was two inches from any other square. The squares closest to the edge of the board were one inch from the sides. The square in the upper left corner was labeled "MORE" beneath the square and
<table>
<thead>
<tr>
<th>Photograph</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>woman</td>
<td>MOTHER</td>
</tr>
<tr>
<td>man</td>
<td>FATHER</td>
</tr>
<tr>
<td>woman</td>
<td>TEACHER</td>
</tr>
<tr>
<td>woman</td>
<td>PRINCIPAL</td>
</tr>
<tr>
<td>Nelson Rockefeller</td>
<td>VICE PRESIDENT</td>
</tr>
<tr>
<td>Gerald Ford</td>
<td>PRESIDENT</td>
</tr>
</tbody>
</table>

Figure 6. Photograph Types and Accompanying Labels for Stimulus Blocks.
the square immediately to its right was labeled "LESS" beneath the square. The next square to the right was labeled "MORE." This labeling proceeded across the first row alternating from "MORE" to "LESS." The other remaining rows were labeled in the same way. The external memory board, then, contained thirty squares with labels which were used as markers for placing the thirty stimulus blocks above in pairwise comparisons.

In order to provide variation in the stimulus task, one group was shown four different stimulus pictures relating to the several stimulus tasks involved in the experiment. These pictures, clipped from magazines, were of size 8 x 11 inches, and consisted of the following: (1) a picture of a mother supervising a child while working around the home; (2) a picture of a teacher assisting a student while working in the classroom; (3) a picture of several children saluting an American flag, thereby symbolizing "good citizenship;" and (4) a picture of a battle scene from the American Revolutionary War.

The only other apparatus used included a tape recorder and a stopwatch for determining the latencies in making choices over members in a pair.

**Design.** The experiment involved a $3 \times 3 \times 2 \times 2$ factorial design. Subjects were selected according to the three criteria above (see section 4.2.1): grade level, achievement level and sex. In addition, subjects were
assigned to one of three experimental groups. Group 1, the Stimulus Group, consisted of those subjects who would receive linguistic and visual feedback about the stimulus materials and choice task environment, which included the use of the stimulus pictures above. Group 1 represented an attempt to reduce the variation between the objective stimulus in the choice task environment and the received stimulus of the individual chooser. Under no circumstances, however, were subjects instructed to behave transitively. Group 2, the Memory Group, consisted of those subjects who would use the external memory board during the experiment. Group 2 served two purposes in the experiment: (1) they allowed one to assess the effects of one kind of memory upon individual choice processing and (2) they permitted subjects to change their preferences in order to discover whether or not their level of transitivity would change. This group was also not instructed to behave transitively. Group 3, the Control Group, consisted of those subjects who would receive no stimulus feedback and were not permitted to use the external memory board during the experiment. This group was also not instructed to behave transitively.

After the groups were specified, four choice task environments, that is, "contextual situations," requiring the subject to express his preference over a pair of individuals represented by pictures on wooden blocks, were constructed as follows.
Situation #1: "Which person would you prefer to obey when working around the home?"

Situation #2: "Which person would you want to obey when working in the classroom?"

Situation #3: "Being a citizen of the United States, which person would you prefer to obey?"

Situation #4: "Which person would you prefer to obey in a time of war?"

Each contextual situation was chosen in order to insure that the choice tasks varied according to their "familiarity" to the subject. Or in other words, the four situations were expected to be more or less familiar to the subjects, depending upon their life experiments. The order of presentation of these situations, that is, order 1: 1, 2, 3, and 4; order 2: 2, 3, 4, and 1; order 3: 3, 4, 1, and 2; and order 4: 4, 1, 2, and 3; was counterbalanced across subjects.

Each contextual situation was accompanied by the presentation of fifteen pairs of blocks taken at a time as follows. (MOTHER, FATHER), (FATHER, TEACHER), (TEACHER, PRINCIPAL), (PRINCIPAL, VICE PRESIDENT), (VICE PRESIDENT, PRESIDENT), (TEACHER, PRESIDENT), (PRINCIPAL, PRESIDENT), (MOTHER, VICE PRESIDENT), (FATHER, PRINCIPAL), (FATHER, VICE PRESIDENT), (TEACHER, VICE PRESIDENT), (MOTHER, TEACHER), (MOTHER, PRESIDENT), (MOTHER, PRINCIPAL), and (FATHER, PRESIDENT). These presentation pairs were intended as authority figures over which a subject must choose given
a particular contextual situation. They were chosen under the assumption that familiarity of these objects of choice would vary according to the particular choice task environment encountered by the subject. These fifteen pairs were randomized for presentation in each contextual situation. The left-right configuration of each pair, that is, whether or not a block appeared on the right or left when presented to the subject, was also randomized for presentation.

4.3.2 Procedure

In Training Phase I, subjects were instructed in the use of the stimulus apparatus and materials. Initially, subjects were shown one set of blocks which included six individuals: mother, father, teacher, principal, Vice President and President. The subjects were told to pretend that the blocks actually represented the labeled pictures. Subjects in the first and fifth grades (college students were excluded from this procedure) were then asked to name the persons represented on the blocks. Subjects who could not identify all six blocks were eliminated from the experiment. Next, the subjects were told that they would be required to choose the person they would more prefer to obey. Then they were told that two blocks would be presented and that they should select the one they would more prefer to obey. Indifferences over paired comparisons were not
allowed. Subjects were, however, allowed to refuse to choose for any given pair.

In the second phase of the experiment, subjects were actually tested according to procedures designed for their respective groups. Testing for Group 1 began by asking the subject to tell the experimenter something about the person represented on each of the six blocks. If the experimenter was satisfied with the subject's understanding as revealed in his responses, then testing continued by reading the first contextual situation. If the experimenter was not satisfied, then the experimenter explained the persons represented on the blocks.

If the experimenter was satisfied with the subject's responses, then the first contextual situation was read to the subject. The first contextual situation was accompanied by a stimulus picture appropriate for the choice situation. The subjects were again asked to tell the experimenter something about the choice situation. When the subject was able to do this, the experimenter presented the fifteen pairs to the subject. The procedure continued until all four contextual situations were completed. Upon the completion of each contextual situation and accompanying choice behavior of the subject, the subject was again interviewed in the same manner as above to see whether or not any changes had occurred. Essentially, the interview technique for
Group 1 was loosely patterned after the Piagetian interview format (see Piaget, 1959; Piaget, et al., 1960; Flavel, 1963).

Group 2 was told that they were to place each choice for a given pair on the external memory board according to whether the person represented on the block was more preferred or less preferred, given the contextual situation. They were told that the pairs would remain on the board until the next contextual situation was presented. Subjects were told that a block in a pair representing the person they preferred more was placed on the appropriate square on the memory board labeled "MORE" and the block less preferred was to be placed on the square labeled "LESS" according to their preference. They were permitted to change any choices previously made once the last pair for a given choice situation was presented.

Group 3 was told that they would not be allowed to keep a record of their choices or to make any changes in choices once they were made. In addition, they would receive no information about the choice task environment except the general instructions given to every subject.

4.3.3 Experimenters

Experimenters were the same as those in Experiment 1. The same procedures for experimenter training and observation were followed in Experiment 2.
Notes to Chapter 4

1The college student sample was drawn from undergraduates attending Summer Quarter at Ohio State University, Columbus, Ohio. The elementary school student sample was drawn from McGuffey Elementary School, Newark, Ohio.

2Metropolitan Achievement Scores (MAS) were chosen since first and fifth graders are tested annually using this test, while I. Q. scores are not generally taken for first graders at McGuffey Elementary School. The MAS includes a comparison for a particular class and across equivalent classes tested nation-wide. Major information contained in the MAS includes: word knowledge, reading, language, spelling, math comprehension, math concepts and math problem solving. Detailed information on the Metropolitan Achievement Test may be obtained from Harcourt, Brace and World, Inc., publishers, New York.

3Student experimenters were from Denison University, Granville, Ohio. They were all enrolled in a Psychology Seminar, one purpose of which was to perform applied research upon human subjects. The subject matter of the seminar concerned rational individual choice and political socialization.

4The experimental design based upon experimental treatments by group could have yielded more complex analysis possibilities if the treatments were completely counterbalanced, that is, if there were eight groups receiving various combinations of the three experimental treatments. So for example, a group might have a memory and stimulus treatment combined, another group might have a stimulus and control treatment combined and so on. In so doing, one could compare all possible experimental treatment combinations in order to assess main effects and interactions. Unfortunately, however, resources for the experiment would not permit the use of the required additional groups.
Chapter 5

RESULTS

Evidence is to truth, as sap to the tree, which, so far as it creepeth along with the body and branches, keepeth them alive; where it forsaketh them, they die: for this evidence, which is meaning with our words, is the life of truth.

Thomas Hobbes,
De Corpore

5.1 Introduction

In this chapter, the empirical results for both the judgmental experiment (Experiment 1) and the preference experiment (Experiment 2) will be presented. The strategy for analysis will adhere loosely to the following. In the first section, the results of the judgmental experiment will be reported. This will involve two major concerns: (1) the presentation of results for levels of transitivity, given as transitivity scores and (2) the presentation of mean reaction times as indicators of subject response latencies. Once transitivity scores and mean reaction times are reported, the data may be assessed for the significant main effects and interactions arising out of counterbalancing according to grade, achievement level and gender. For those effects which are significant, the analysis will
specify some major results relating to specific presentation pairs.

In the second section, the results of the preference experiment will be presented. This will involve three major concerns: (1) the presentation of results for levels of transitivity given as transitivity scores, (2) an analysis of preference change with accompanying changes in levels of transitivity, and (3) the presentation of mean reaction times as indicators of subject response latencies. The transitivity scores and mean reaction times will be analyzed to determine whether or not the possible main effects and interactions based upon the variable's grade, experimental group, achievement level, gender, and contextual situation were significant. For those effects discovered to be significant, a further analysis of transitivity scores and mean reaction times for several important presentation pairs will be undertaken.

The first two sections should help answer, in part, theoretical questions concerning the minimal level of transitivity and a possible representation for the individual choice mechanism.

In a final section, levels of transitivity for both experiments will be compared in order to determine whether or not there exists a relationship between performance on one choice task and performance on another.
5.2 Judgmental Valuations: Some Empirical Results

5.2.1 Minimum Levels of Transitivity

A major proposition to be tested in this analysis is the minimum rational capacity hypothesis (Hypothesis 1) which suggests that individual choice data may be represented by transitive relations among objects of choice. One indicator of this minimum level for the entire sample would be the percentage of correct responses, that is, the percentage of responses which are consistent with the objective standard of length. Using this indicator, the judgmental experimental results showed that 92.9% of the responses from all subjects on the experimental task were consistent with the standard. This result suggests that the individual minimum capacity for exhibiting transitive relations in choice data by subjects is quite high. Preliminary indications of these experimental results suggest that the minimum rational capacity hypothesis is in part confirmed.

The hypothesized main effects of grade, achievement level and gender upon this minimum level of transitivity were statistically tested using an analysis of variance. The only statistically significant main effect was grade \( F(2,60) = 5.112, p < .01 \). Since the lowest grade tested in this analysis was first grade with children of ages 6 and 7 years, Hypothesis 2 is confirmed in that children do manifest a minimum rational capacity at a very early age. Another portion of the hypothesis is also confirmed: the
level of transitivity increases across grade level. First
graders were 85% correct, fifth graders 95% correct and
college students 98% correct. Hypothesis 3, the effect of
achievement, \( F(1,60) = 0.570, p > .05 \) and Hypothesis 4,
the effect of gender, \( F(1,60) = 0.056, p > .05 \) showed no
significant main effects upon the level of transitivity.

Only two significant statistical interactions among
experimental groups were found in the analysis of variance.
Grade and achievement \( F(2,60) = 5.354, p < .05 \) and
achievement level and gender \( F(1,60) = 5.564, p < .01 \) in-
teracted significantly. Grade and gender \( F(1,60) = 0.121,
p > .05 \) and grade, achievement level and gender \( F(2,60) =
0.191, p > .05 \) were not significant. The significant
interactions are revealed in the following set of graphs.

PLACE FIGURES 7 AND 8 ABOUT HERE

In Figure 7, the data show that for those subjects
with high achievement levels, the mean transitivity scores
decrease across grade. Figure 7 shows, however, that this
is not the case for low achievement subjects. Instead, the
graph levels out for fifth graders and college students at
a high transitivity level with first graders still lower in
transitive capability. This suggests that achievement level
interacts with grade as follows: for high achievers,
transitivity scores will decrease when moving from first
grade through fifth to college; but for low achievers, the
decrease in score will only be apparent when first graders
Figure 7. Interaction Analysis: Mean Number of Errors by Grade Level and High and Low Achievement Levels.

Figure 8. Interaction Analysis: Mean Number of Errors for Achievement Level and Males and Females.
are compared with college students and fifth graders with these latter groups manifesting identical transitivity levels.

In order to get a better understanding of this complex, significant interaction above, an analysis of variance for "simple effects" was completed. This amounted to looking at transitivity scores for first graders, fifth graders and college students respectively, while holding achievement level constant. The results of this statistical manipulation showed that controlling on first grade \( F(1,94) = 0.321, p > .05 \), fifth grade \( F(1,94) = 0.981, p > .05 \) and college students \( F(1,94) = 1.011, p > .05 \) for the effects of achievement level yielded no significant simple effects.

The significant interaction of gender and achievement level is clearly revealed in Figure 8. Notice initially that mean transitivity score, not controlling on achievement level, is decreasing across grade uniformly on both graphs for males and females. When controlling high and low achievement level, however, the graph in Figure 8 shows a complex graph wherein high achievers are higher in transitivity score than low achievers for males. But in Figure 8 the pattern is reversed. Low achievers are higher and high achievers are lower for females. This suggests that gender manifests the same pattern for transitivity scores across grade, that is, one in which the score decreases as grade levels increase. But, when achievement level is introduced,
high achievement males are less transitive than low achievement males and high achievement females are more transitive than low achievement females.

Again, an analysis of simple effects was conducted. In this case, achievement level was controlled and gender was analyzed. The results yielded no significant effects of gender, males \( F(1,94) = 2.910, p > .05 \) and females \( F(1,94) = 1.010, p > .05 \), when controlling on high and low achievement.

5.2.2 Representing the Individual Choice Mechanism

In Chapter 4, it was suggested that the individual choice mechanism might be represented by examining the functional relationships between stepsize and error, and stepsize and response latency. This functional relationship is motivated by the assumption that individual choice may be represented as a linear array.

An analysis of stepsize and error. Three necessary, although not sufficient, conditions for the occurrence of a linear array representation are that stepsize and error will be functionally related by a serial position effect, step-function effect and end-anchored effect. Although there are many statistical procedures for testing these relationships,² frequency distributions offer the best representation of the choice data. By inspection, an apparent serial position effect in that the pairs on the end points, that is (1,2) and (5,6) manifest fewer errors
than pairs (2,3), (3,4) and (4,5); and pair (3,4) manifests the most error.

**TABLE 1**

Adjacent Presentation Pairs by Number of Errors Committed.

<table>
<thead>
<tr>
<th>Presentation Pairs</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(1,2)</td>
<td>19</td>
<td>34</td>
<td>36</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Number of errors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The relationship is somewhat less than perfect, however, since errors on pairs (4,5) at 20 are fewer than those on pairs (5,6) at 21. Even though this is the case, the overall relationship seems to be satisfied for almost all subjects with only a very few subjects contributing errors which deviate from the hypothesized pattern. Apparently, most subjects were able to encode most of the stimulus information from the choice task environment.

Table 2, by inspection, suggests an apparent "step-function effect." This appears to be the case since pairs (2,3) (3,4) and (4,5) have the most error, pairs (3,5) and (2,4) fewer errors and pair (2,5) fewest errors.

The "end-anchored effect" may be tested by examining the mean number of errors on anchored pairs as compared with the mean number of errors on non-anchored pairs. The
results of this test were that anchored pairs accounted for only 5.1% of the errors committed, whereas non-anchored pairs accounted for 25.0% error. This suggests that an end-anchored effect is manifest in the choice data. The occurrence of this effect supports the contention that a linear array is one appropriate representation of the individual choice mechanism.

### TABLE 2

<table>
<thead>
<tr>
<th>Presentation Pairs</th>
<th>Number of errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2,3)</td>
<td>34</td>
</tr>
<tr>
<td>(3,4)</td>
<td>36</td>
</tr>
<tr>
<td>(4,5)</td>
<td>30</td>
</tr>
<tr>
<td>(3,5)</td>
<td>16</td>
</tr>
<tr>
<td>(2,4)</td>
<td>19</td>
</tr>
<tr>
<td>(2,5)</td>
<td>8</td>
</tr>
</tbody>
</table>

Stepsize and error with the effect of grade. If the developmental hypothesis (Hypothesis 2) holds, then stepsize and error should show similar relationships when controlling on grade: error is inversely related to grade level.

Table 3 represents the results of controlling "serial position effect" for grade. Upon examining the choice data in Table 3, an apparent serial position effect which is similar across grade, that is, errors decrease proportionally for each presentation pair when moving across grade, is manifested. The general serial position effect is also
TABLE 3

Adjacent Presentation Pairs by Number of Errors Committed, Controlling for Grade Level.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Presentation Pairs</th>
<th>(1,2)</th>
<th>(2,3)</th>
<th>(3,4)</th>
<th>(4,5)</th>
<th>(5,6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td></td>
<td>12</td>
<td>18</td>
<td>15</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Fifth</td>
<td></td>
<td>6</td>
<td>8</td>
<td>15</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>College</td>
<td></td>
<td>1</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>19</td>
<td>34</td>
<td>36</td>
<td>20</td>
<td>21</td>
</tr>
</tbody>
</table>

apparent for college students according to the hypothesized developmental relationship. Grades first and fifth also manifest the relationship except that pairs (4,5) and (5,6) are slightly deviant. Although the slight deviation is evident, the overall serial position is apparent. An important conclusion to be gleaned from the data is that grade does not imply the use of different representations from that of the serial position effect.

Table 4 reveals the results of controlling step-function effect for grade. Notice initially that number of errors for each presentation pair decrease uniformly when moving across grade. This suggests a high degree of similarity with respect to the effect of grade. Next, looking at the pairs (2,3), (3,4) and (4,5) by grade, one observed that these pairs manifest more error than pairs (3,5) and
TABLE 4

Premise and Inference Pairs by Number of Errors Committed, Controlling for Grade Level.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Presentation Pairs</th>
<th>(2,3)</th>
<th>(3,4)</th>
<th>(4,5)</th>
<th>(3,5)</th>
<th>(2,4)</th>
<th>(2,5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td></td>
<td>18</td>
<td>15</td>
<td>11</td>
<td>14</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Fifth</td>
<td></td>
<td>8</td>
<td>15</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>College</td>
<td></td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>34</td>
<td>36</td>
<td>20</td>
<td>19</td>
<td>16</td>
<td>8</td>
</tr>
</tbody>
</table>

(2,4) by grade, and that pairs (3,5) and (2,4) in turn manifest more errors than the pair (2,5). Table 4 suggests that the step-function is manifest in the choice data for each grade, suggesting the hypothesized developmental relationship.

5.2.3 Comparison with Trabasso, Riley and Wilson (1975) Study

The judgmental experiment upon which the present analysis is based was also conducted by Trabasso, Riley and Wilson (1975) and Trabasso and Riley (1975). It is useful to compare these stepsize/error results to the present analysis for at least the following reasons. First, the present analysis is the only similar analysis available for comparison with those above. Second, it is useful, especially in judgmental experiments of this kind to independently...
replicate other experimental results. Third, if the present analysis can replicate its predecessor, then perhaps this analysis adds an additional indicator of reliability and validity to the procedures undertaken in the preferential experiment to be dealt with later in this chapter.

The study conducted by Trabasso, Riley and Wilson (1975) and the present study may be compared in the following table. Notice that the points of comparison differ only with regard to the age group constituting the middle group—that is, the comparison study analyzed third graders, while the present study analyzed fifth graders so that there exists an age difference between 9 and 11 years.

Now, in examining the Table 5, the following important points are in evidence. First, the comparison study is equivalent to the present study almost to the exact percentage within the third/fifth grade category and adult/college. There is little developmental difference on the transitivity task between third and fifth graders. Developmental changes in transitive capability or capacity are very gradual indeed, since the adult/college level is somewhat higher than the third/fifth grade level.

Second, the first grade transitivity level for the present study ranges from 7 to 15 percent lower than for the Trabasso, Riley and Wilson (1975) study. Although the reason for this variation cannot be unequivocally identified, the most plausible explanation would seem to be the fact
<table>
<thead>
<tr>
<th>Grade</th>
<th>Presentation Pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1,5) (1,4)</td>
</tr>
<tr>
<td>First/First</td>
<td>97%a 89%b</td>
</tr>
<tr>
<td></td>
<td>(72) (288)</td>
</tr>
<tr>
<td>Third/Fifth</td>
<td>95% 96%</td>
</tr>
<tr>
<td></td>
<td>(72) (288)</td>
</tr>
<tr>
<td>Adult/Adult</td>
<td>100% 100%</td>
</tr>
<tr>
<td></td>
<td>(72) (288)</td>
</tr>
</tbody>
</table>


b Frequencies not reported by Trabasso, et al, (1975), but included for present study.
that in Training Phase I (see Chapter 4) of the present study, all subjects were trained in the experimental task over a shorter period with less trials than did the comparison study. This may suggest that a shorter training period does not influence subjects with high levels of cognitive development, but that in children the training may be essential for higher transitivity levels. Of course, this explanation is a conjecture, but one which is in fact empirically testable. If it turns out that length of time and intensity of training are developmentally important, then perhaps the difference in transitivity levels between first graders and adults will be somewhat reduced.

An analysis of stepsize and response latency. One necessary, although not sufficient condition for the occurrence of a linear array representation is that stepsize is related to response latency as follows: response latencies on premise pairs (2,3), (3,4), and (4,5) will manifest the longest mean reaction time, on inference pairs (2,4) and (3,5) will manifest an intermediate mean reaction time, and on inference pairs (2,5) will manifest the shortest mean reaction time. Table 6 suggests that response latency relationship with stepsize is confirmed by the choice data. The presentation pairs (2,3), (3,4) and (4,5) account for the greatest mean reaction time, 1800 msec.; pairs (3,5) and (2,4) slightly less time, 1750 msec.; and pair (2,5) quite substantially less time, 1500 msec. Table 6 suggests the
occurrence of one necessary condition for observing the linear array.

TABLE 6

Premise and Inference Presentation Pairs by Mean Reaction Time (msec.)

<table>
<thead>
<tr>
<th>Presentation Pairs</th>
<th>Mean Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2,3) (3,4) (4,5)</td>
<td>1800</td>
</tr>
<tr>
<td>(3,5) (2,4)</td>
<td>1750</td>
</tr>
<tr>
<td>(2,5)</td>
<td>1500</td>
</tr>
</tbody>
</table>

Stepsize and response latency: effects of grade, achievement and gender. The representation of a linear array based upon the inverse relationship between stepsize and response latency may be further analyzed according to the effects of grade, achievement and gender using an analysis of variance. ³ Grade \( F(2,60) = 10.519, p < .001 \) is the only statistically significant effect in this analysis. Achievement level \( F(1,60) = 1.973, p > .05 \) and gender \( F(1,60) = 0.023, p > .05 \) were not significant. Again, the developmental hypothesis is confirmed. First graders respond slower, fifth graders intermediate and college students fastest.

Grade and gender \( F(2,60) = 4.230, p < .05 \) were found to be significant interactions, while grade and achievement level \( F(2,60) = 0.511, p > .05 \), achievement level and gender \( F(1,60) = 3.737, p > .05 \), and grade, achievement
level and gender \([F(2,60) = 1.828, p > .05]\) were not found to be significant.

Grade and gender as a significant interaction are revealed in the following figure.

PLACE FIGURE 9 ABOUT HERE

In Figure 9 mean reaction times for female subjects, decreased across grade, but for male subjects, first graders are faster respondents than fifth graders, while remaining somewhat slower than college students.

The simple effect of gender can be examined within each grade level. The results of this statistical manipulation suggest that mean reaction time for males and females, controlling on first grade \([F(2,22) = 1.101, p > .05]\), fifth grade \([F(2,22) = 2.089, p > .05]\) and college students \([F(2,22) = 3.001, p > .05]\) was not significant.

Stepsize and response latency with effects of grade.\(^5\)

The developmental hypothesis (Hypothesis 2) states that stepsize and response latency should manifest relationships which are similar across grade with respect to the linear array.

An inspection of Table 7 reveals that stepsize and response latency evidence a linear array representation for fifth graders and college students. Choice data of both fifth graders and college students may be represented such that stepsize is inversely related to mean reaction time.
By contrast, first graders respond less quickly overall
Figure 9. Interaction Analysis: Mean Reaction Time for Grade Level and Gender.
TABLE 7

Premise and Inference Presentation Pairs by Mean Reaction Time (msec.) Controlling for Grade Level.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Presentation Pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2,3) (3,4) (4,5)</td>
</tr>
<tr>
<td></td>
<td>(2,4) (3,5) (2,5)</td>
</tr>
<tr>
<td>First</td>
<td>2200 2450 2000</td>
</tr>
<tr>
<td>Fifth</td>
<td>1800 1650 1400</td>
</tr>
<tr>
<td>College</td>
<td>1400 1200 1100</td>
</tr>
<tr>
<td>Total</td>
<td>1800 1750 1500</td>
</tr>
</tbody>
</table>

that fifth graders or college students, but the exact inverse relationship between stepsize and mean reaction time is not apparent. Instead the data show a lower time for pairs (2,3), (3,4), and (4,5) but a higher time for pairs (3,5) and (2,4). Interestingly, the pair (2,5) is still, as with the other age group data, much lower. This suggests that the linear array is operating on pairs of large stepsize but on pairs of less "discrimination"—that is, smaller stepsize—the first grader has difficulty distinguishing one object in a pairwise choice from another. One interpretation is that the linear array is a possible representation across grade but that it begins to break down as discrimination becomes more difficult. Discrimination may be a function of cognitive-development. Of this conjecture is an empirical question which cannot be answered on the basis of the present study.
5.3 Preferential-Based Choice: Some Empirical Results

5.3.1 Minimum Levels of Transitivity

According to the proposed theory of rational individual choice, an individual choice mechanism is rational if some minimum capacity for exhibiting transitive relations is manifested.

The Kendall-Smith (1970) consistency coefficient, or "transitivity score" constitutes one indicator of this minimum transitivity level. The experimental results show that the grand mean for the sample was 0.96. This score is extremely high since for 6 alternatives and 15 pairwise choices, the lowest transitivity score which can be attained is 8.00 and the highest 0.00. Apparently, then, the minimum level of transitivity is quite high given the choice task environment in this particular experiment.

The grand mean transitivity score may be broken down into its components by controlling upon the four contextual situations which constituted four separate choice task environments. Table 8 reveals that transitivity scores are high for all four contextual situations.

They hypothesized main effects of grade, achievement level, gender experimental group and contextual situation may be statistically tested using an analysis of variance. The results of this analysis of variance for main effects indicated that only grade \( F(2,9) = 22.500, p < .01 \) and experimental group \( F(2,10) = 4.220, p < .01 \) were
significant. Achievement level \([F(1,36) = 0.088, p > .05]\) and gender \([F(1,36) = 0.910, p > .05]\) were not significant.

TABLE 8

Four Contextual Choice Task Situations by Mean Transitivity Scores.

<table>
<thead>
<tr>
<th>Situation Type</th>
<th>Mean Transitivity Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situation 1: &quot;Which person would you prefer to obey in the home?&quot;</td>
<td>0.92</td>
</tr>
<tr>
<td>Situation 2: &quot;Which person would you prefer to obey in school?&quot;</td>
<td>1.22</td>
</tr>
<tr>
<td>Situation 3: &quot;Which person would you prefer to obey as a citizen of the United States?&quot;</td>
<td>1.02</td>
</tr>
<tr>
<td>Situation 4: &quot;Which person would you prefer to obey during a time of war?&quot;</td>
<td>0.67</td>
</tr>
</tbody>
</table>

The effect of grade. The relationship between grade and transitivity score should indicate an increase in transitivity score across grade. Table 9 indicates that the hypothesized relationship is apparent in the transitivity scores. Looking first at the marginals by grade, first graders scored 1.62, fifth 0.73 and college 0.52. This suggests that although the transitivity capacity is developmental, there is a rather high minimum level. If the marginals by grade are examined by contextual situation, the relationship continues to hold in situations involving
### TABLE 9
Mean Transitivity Scores for Four Contextual Situations\(^a\) by Grade Level.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Mean Transitivity Score</th>
<th>Situation 1</th>
<th>Situation 2</th>
<th>Situation 3</th>
<th>Situation 4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>1.75</td>
<td>1.87</td>
<td>1.67</td>
<td>1.17</td>
<td>1.62</td>
<td></td>
</tr>
<tr>
<td>Fifth</td>
<td>0.71</td>
<td>1.00</td>
<td>0.92</td>
<td>0.29</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>College</td>
<td>0.29</td>
<td>0.79</td>
<td>0.46</td>
<td>0.54</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.92</td>
<td>1.22</td>
<td>1.02</td>
<td>0.67</td>
<td>0.96</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)See Chapter 4 for an explanation of these contextual situations.

"the home" (Situation 1), "the school" (Situation 2), and "being a citizen" (Situation 3). In the war context (Situation 4), fifth graders deviate from the developmental pattern, while first graders and college students maintain the appropriate pattern. Although the effect of contextual situation will be dealt with at length later, it is apparent that the developmental hypothesis is not necessarily appropriate for every choice task situation. In other words, it is possible as reflected in the data, for older individuals to score less well than younger on some choice tasks. In terms of the rational choice theory being tested, the overall results suggest that transitivity as some minimum level is quite high for those non-trivial choice situations examined, and this level will at times yield developmental effects.
in some instances but not in others. This developmental effects, furthermore need not be inversely related so that with an increase in grade level, an accompanying decrease in transitivity score is observed. These data support the effects of context assumption in individual choice.

The effect of experimental group. For experimental group, the data show the Stimulus Group manifesting the highest level of transitivity. This is due to an attempt to eliminate the variation between the objective stimulus task and the perceived stimulus task, using the Piagetian interview format (see Chapter 5). The memory group should yield intermediate levels of transitivity. This results from the group's access to an external memory source. They are lower in scores than the Stimulus Group, since their task perception may be divergent from that of the analyst and external memory as a "technique" or aid in choice tends to be something developed over time with practice. And the control group should yield the lowest level of transitivity since they have neither the benefit of stimulus explanation, nor the use of external memory.

An examination of the marginals for Table 10 suggests that the relationship hypothesized is only partially revealed in the choice data. Although the stimulus group showed the highest level of transitivity, the mean transitivity scores across situation for the Memory and Control groups were similar. They were, however, greater than that
TABLE 10
Mean Transitivity Scores for Four Contextual Situations<sup>a</sup> by Experimental Group.

<table>
<thead>
<tr>
<th>Experimental Group</th>
<th>Mean Transitivity Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Situation 1</td>
</tr>
<tr>
<td>Control</td>
<td>1.17</td>
</tr>
<tr>
<td>Memory</td>
<td>1.08</td>
</tr>
<tr>
<td>Stimulus</td>
<td>0.50</td>
</tr>
<tr>
<td>Total</td>
<td>0.92</td>
</tr>
</tbody>
</table>

<sup>a</sup>See Chapter 4 for an explanation of these contextual situations.

for the Stimulus Group. When the marginal totals are controlled for contextual situations, the hypothesized relationship is shown on three of the four contextual situations: Situations 1, 2, and 3 concerning home, school and citizenship all manifest the hypothesized relationship. Situation 4, however, shows Memory lowest, Stimulus intermediate and Control highest with respect to transitivity.

The data reveal in terms of the theory being tested that the experimental groups as main effects are important independent variables in assessing transitivity levels. This means that aggregate data in the marginals is subject to a much different interpretation when one examines the choice task situation. Overall, then, the three groups
behave only in the hypothesized way on certain choice situations but not on others. This result is important to this individual choice theory, since it was suggested input and output structures must be manipulatable if inferences are to be made concerning the choice mechanism.

Although the theory of rational individual choice above hypothesized no interactive effects among the experimental treatments employed in the analysis, several interesting and important statistical interactions were discovered in the choice data. The results of the analysis of variance suggest that grade and experimental group \( F(4,13) = 3.990, \ p < .05 \) and achievement level and contextual situation \( F(3,164) = 4.745, \ p < .003 \) were significant interactions.

Figure 10 represents the statistical interaction between grade and experimental group.

PLACE FIGURE 10 ABOUT HERE

Figure 10 shows that grade and experimental group interact as follows: transitivity scores decrease uniformly across grade for all three experimental groups. In order to better understand this complex relationship, an analysis of variance, controlling on grade for the effect of experimental group was performed. The results show that experimental group for first graders \( F(2,93) = 4.150, \ p < .01 \) and experimental group for college students \( F(2,93) = 6.870, \ p < .01 \) were significant; while for fifth graders experimental group was not significant \( F(2,93) = 2.001, \ p > .05 \).
Figure 10. Interaction Analysis: Mean Transitivity Score for Grade Level and Experimental Group.
These relationships may be summarized as follows: for first graders the Memory Group was less transitive than the Control Group and the Control Group was less transitive than the Stimulus Group. Apparently, first graders do not have the experiential background to deal with the complexity of the "memory board" choice task. But as predicted, the Stimulus Group was the most transitive, thereby leaving the Control Group somewhere between the Memory and Stimulus Groups. College students, by contrast, did behave as predicted: the Control Group was least transitive and the Stimulus Group most transitive, while the Memory Group manifested intermediate transitivity scores. The data suggest that complex interactions do yield important results which are essential in representing individual choice data.

PLACE FIGURE 11 ABOUT HERE

Figure 11 represents the statistical interaction between achievement level and contextual situation. Namely that for Situation 2, concerning "obedience in school," Situation 3, concerning "obedience as a citizen," and Situation 4, concerning "obedience during time of war," high achievers have a higher level of transitive capacity on these three situations than do low achievers. The exact opposite holds for high and low achievement levels on Situation 1, concerning "obedience in the home," high achievers manifest a lower transitivity level than low achievers.
Figure 11. Interaction Analysis: Mean Transitivity Score for Achievement Level and Contextual Situation.
This interaction between achievement level and contextual situation may be analyzed using an analysis of variance for simple effects. This is accomplished by performing an analysis of variance controlling on high achievement and low achievement for the effects of contextual situations.

The results of this analysis showed that the effect of contextual situation in high achievement \( F(3,68) = 0.502, \ p > .05 \) and low achievement \( F(3,68) = 0.315, \ p > .05 \) was not significant.

5.3.2 The Propensity to Behave Transitively and the Opportunity for Feedback

The theory of rational-individual choice relies upon the possibility of an individual making choices, discovering errors in these choices and attempting to correct these errors in choices made (see Chapter 3, Figure 4). The Memory Group in this analysis provided an opportunity for examining this portion of the theory by allowing individuals to make choices, to record these choices by preference in relation to other choices, and once all choices were completed it allowed the individual to make changes in previous choices. It was possible to determine whether transitivity levels increased, decreased or remained the same.

In order to measure this effect of change on transitivity level, a table may be constructed wherein no changes in transitivity level and increases and decreases in transitivity levels for the four contextual situations are recorded.
TABLE 11

Changes in Level of Transitivity in Memory Experimental Group Showing Increases, Decreases, and No Change in Transitivity Scores for Four Contextual Situations by Subject.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Changes in Transitivity Score</th>
<th>Subject</th>
<th>Changes in Transitivity Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sit 1</td>
<td>Sit 2</td>
<td>Sit 3</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>+</td>
<td>0</td>
</tr>
</tbody>
</table>

a Scoring codes: "0" indicates no change in preference. "-" indicates a change in preference which is less transitive. "+" indicates a change in preference which is more transitive.
Table 11 is quite interesting with regard to the number of individuals who failed to change their level of transitivity. Fifteen out of twenty-four subjects did not make any changes on any of the four contextual situations. Consequently, only nine subjects made any changes in transitivity level. If one takes each of the four situations and the nine subjects, then there are thirty-six opportunities for change. Of these thirty-six, twenty-one remained unchanged with regard to level. Only fifteen changes occurred for the entire sample. Of this fifteen, seven were increases in level, but eight were decreases.

The immediate conclusion suggested is that most individuals are not inclined to change initial preference patterns. But even more importantly, when they do change, they apparently are just as likely to increase their transitivity level as not.

The data in Table 11 when collapsed over grade suggests some interesting explanations for why and how changes were made in transitivity levels.

PLACE TABLE 12 ABOUT HERE

Table 12 represents the results of the control over grade. Notice that regardless of grade, most levels of transitivity remain unchanged in every situation except Situation 2, concerning "obedience in school." Here, first graders and college students tended to change transitivity levels. Of those subjects changing across situations, first graders
TABLE 12

Percentage of Subjects Changing Transitivity Levels for Contextual Situation by Grade Level.

<table>
<thead>
<tr>
<th>Situation/Transitivity Level</th>
<th>First</th>
<th>Fifth</th>
<th>College</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

**Situation #1**
- increase: 12.5, 0.0, 0.0
- decrease: 12.5, 12.5, 0.0
- no change: 75.0, 87.5, 100.0
- total: 100.0, 100.0, 100.0
- (N): 8, 8, 8

**Situation #2**
- increase: 12.5, 12.5, 50.0
- decrease: 50.0, 0.0, 0.0
- no change: 37.5, 87.5, 50.0
- total: 100.0, 100.0, 100.0
- (N): 8, 8, 8

**Situation #3**
- increase: 0.0, 0.0, 0.0
- decrease: 12.5, 0.0, 0.0
- no change: 87.5, 100.0, 100.0
- total: 100.0, 100.0, 100.0
- (N): 8, 8, 8

**Situation #4**
- increase: 25.5, 12.5, 12.5
- decrease: 12.5, 0.0, 0.0
- no change: 62.5, 87.5, 87.5
- total: 100.0, 100.0, 100.0
- (N): 8, 8, 8
tend to be more prevalent changers. In addition, first 
graders who change tend to decrease their level of transi-
tivity. Fifth graders and college students who change 
levels tend to increase their levels rather than decrease 
them. This is the case for every situation except fifth 
graders in Situation 1, concerning "obedience in the home." 
Apparently, first graders are making random changes, while 
fifth graders and college students are making changes which 
tend to increase their transitivity level. One interpre-
tation of the data, then, especially in view of the overall 
high transitivity levels across grades is that memory, 
especially external memory record-keeping, is learned and 
refined over time. As a result, first graders are simply 
unfamiliar with the uses of memory devices, whereas older 
subjects have a wider range of experience upon which to 
draw. Indeed, this would seem to be the case, since, as 
Trabasso, Riley and Wilson (1975) report, children can in 
fact behave transitively when the effects of memory are 
eliminated or controlled. In terms of the theory of 
rationa choice, it would appear that individuals 
do behave transitively in some choice tasks as a natural 
manifestation of their propensity toward transitivity. But, 
explicit, conscious increase in the capacity to behave 
transitively tends to be learned over time.
5.3.3 Response Latency and Preference

The hypothesized main effects of grade, achievement level, gender and experimental group may be statistically analyzed using an analysis of variance. The results of this analysis showed grade to be the only significant effect \( F(2,54) = 3.265, p < .05 \). The other hypothesized effects: achievement level \( F(1,36) = 0.918, p > .05 \), gender \( F(1,36) = 0.082, p > .05 \), and experimental group \( F(2,54) = 1.121, p > .05 \) were not significant.

The main effect of grade on response latency is revealed in the mean reaction times for each grade: first graders were slowest at 3,050 msec., fifth graders were faster at 2,075 msec., and college students were fastest at 1,850 msec. These data support the hypothesis which suggests that choice data is subject to change based upon comparisons across individuals of varying cognitive-developmental stages. It is important to notice that this same "developmental effect" is manifested in a similar way in the judgmental choice experiment above.

Although the theory of rational individual choice being tested hypothesized no interactive effects among the experimental treatments, several interactions were observed in the choice data. The results of the analysis of variance on these interactions suggest that grade and achievement level \( F(2,60) = 3.700, p < .05 \) and grade and contextual situation \( F(2,162) = 2.510, p < .02 \) were significant interactions.
The effect of grade and situation. Figure 12 shows the interaction between grade and contextual situation.

Grade interacts with contextual situation as follows: for Situation 1, concerning "obedience in the home," Situation 2, concerning "obedience in school," and Situation 3, concerning "obedience as a citizen," mean reaction time decreases across grade. By contrast, for Situation 4, concerning "obedience during time of war," first graders and college students tended to respond in about the same amount of time, but fifth graders were substantially faster.

As before, this complex interaction between grade and contextual situation may be analyzed for simple effects. In this instance, the effect of contextual situation will be analyzed while controlling on grade. The results show that contextual situation is a significant effect when controlling for first grade \( F(3,44) = 750.722, p < .001 \), fifth grade \( F(3,44) = 20.723, p < .001 \) and college \( F(3,44) = 15.660, p < .001 \). The relationships for grade, then may be summarized as follows: first graders are fastest in mean reaction time when responding to obedience during time of war, less fast in the home context, still less in the school context and slowest when considering the context of citizen. Fifth graders increase in time to respond when moving from contexts involving school, war, citizenship and home. And
Figure 12. Interaction Analysis: Mean Reaction Time for Grade Level and Contextual Situation.
college students respond fastest to slowest on situations moving from school to home to citizenship to war.

These data confirm the hypothesis which suggests that the effects of context determine individual choice behavior. More specifically, the data illustrate that familiarity and not capacity is a major explanation for individual choice behavior.

**The effects of grade and achievement level.** Figure 13 shows the significant interaction between grade and achievement level.

*PLACE FIGURE 13 ABOUT HERE*

Figure 13 shows that across grade corresponding high and low achievement levels decrease on mean reaction time so that high achievers in first grade respond slower than those in fifth grade and those in college. The same is true for low achievers. The relationship becomes more complex when high and low achievers are compared. First grade low achievers take longer to respond than first grade high achievers. But, at the college level, the opposite is true: high achievers take longer to respond than low achievers.

This significant interaction over grade and achievement level can be analyzed controlling upon grade and assessing the effects of achievement level. The results of this test were that: for first graders \( F(1,94) = 15.930, p < .001 \) and for fifth graders \( F(1,94) = 13.800, p < .001 \) achievement level was significant. By contrast, achievement level
Figure 13. Interaction Analysis: Mean Reaction Time for Grade Level and High and Low Achievement Level.
was not significant for college students \( F(1, 94) = 2.050, \ p > .05 \).

5.3.4 Representing the Individual Choice Mechanism

In Chapter 2, the analysis suggested that preference-based choice was much more complex than judgmental valuations, even though the complexity of both was quite great. It was also suggested that the analysis of problems in judgmental valuation experiments might lead to solutions of equivalent problems in preference-based choice experiments. One way to accomplish this is to treat the objects and relations of a preference pattern in the same way as stepsize among judgments was treated in a linear array representation with the notion of gaining some insight into the processing mechanism of the preference portion of the individual choice mechanism.

**Stepsize in preference and response latency.** The stimulus materials consisted of six objects of choice presented in fifteen pairwise comparisons. Each presentation pair and subsequent response yielded a response latency for a particular pair. Now, if the results of the pairwise choices are mapped onto a continuum representing some preference pattern and if the response latencies are controlled for each response, then preference data may be analyzed in the same way as the judgmental choice experiment.

Since each contextual situation constituted a choice task in itself, the preference data generates four separate possibilities for analysis. These may be analyzed individually.
Situation 1: Step size and response latency. If the preference data is processed in the same way as judgmental valuations, then one would expect that linear array processing would be operative. Premise pairs (2,3), (3,4), and (4,5) will be greater in mean reaction time than inference pairs (3,5) and (2,4), and these in turn will be greater than inference pair (2,5). Table 13 represents the choice data on stepsize and response latency.

<table>
<thead>
<tr>
<th>Presentation Pairs</th>
<th>Mean Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2,3) (3,4) (4,5)</td>
<td>2600</td>
</tr>
<tr>
<td>(3,5) (2,4)</td>
<td>1980</td>
</tr>
<tr>
<td>(2,5)</td>
<td>1840</td>
</tr>
</tbody>
</table>

Table 13 shows that in Situation 1, "obedience in the home," the relationship between stepsize and response latency may be represented as a linear array. Notice that response latencies associated with premise pairs (2,3), (3,4) and (4,5) at 2,600 msec. are greater than inference pairs (3,5) and (2,4) at 1,980 msec. and are greater than pairs (2,5) at 1840 msec.

This choice data may be controlled for grade level. By inspection, Table 14 shows the inverse relationship between
TABLE 14

Premise and Inference Presentation Pairs
by Mean Reaction Time (msec.) for Situation 1,\textsuperscript{a}
Controlling on Grade Level.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Presentation Pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2,3) (3,4) (4,5)</td>
</tr>
<tr>
<td>First</td>
<td>3630</td>
</tr>
<tr>
<td>Fifth</td>
<td>2090</td>
</tr>
<tr>
<td>College</td>
<td>2090</td>
</tr>
<tr>
<td>Total</td>
<td>2600</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Obedience in the Home.

increase in stepsize and decrease in mean reaction time for each grade. Notice that the general relationship holds across grades, but that first graders take slightly more time to respond, fifth graders are intermediate and college students are fastest. Again the similarity in time relationships is in evidence as a result of controlling on grade.

Situation 2: Steplsize and response latency. Again, a linear array mechanism is hypothesized as a possible representation in Situation 2.

Table 15 shows that in Situation 2, concerning "obedience in the home," the linear array is a possible representation. This is apparent since pairs (2,3), (3,4) and (4,5) are greatest with a mean reaction time of 2,400 msec.,
(3,5) and (2,4) are intermediate at 2,280 msec., and (2,5) lowest at 2,090 msec.

TABLE 15
Premise and Inference Presentation Pairs by Mean Reaction Time (msec.) for Situation 2.

<table>
<thead>
<tr>
<th>Presentation Pairs</th>
<th>Mean Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2,3) (3,4) (4,5)</td>
<td>2400</td>
</tr>
<tr>
<td>(3,5) (2,4)</td>
<td>2280</td>
</tr>
<tr>
<td>(2,5)</td>
<td>2090</td>
</tr>
</tbody>
</table>

Again, the data can be controlled upon for the effects of grade.

TABLE 16
Premise and Inference Presentation Pairs by Mean Reaction Time (msec.) for Grade Level for Situation 2.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Presentation Pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2,3) (3,4) (4,5)</td>
</tr>
<tr>
<td></td>
<td>(3,5) (2,4)</td>
</tr>
<tr>
<td></td>
<td>(2,5)</td>
</tr>
<tr>
<td>First</td>
<td>3680</td>
</tr>
<tr>
<td>Fifth</td>
<td>2060</td>
</tr>
<tr>
<td>College</td>
<td>1460</td>
</tr>
<tr>
<td>Total</td>
<td>2400</td>
</tr>
</tbody>
</table>

aObedience in school.
Table 16 shows that in Situation 2, concerning "obedience in the school," that the linear array representation is a possibility. Notice once more that the inverse pattern between stepsize and mean reaction time holds and in addition the similarity of this relationship across grade, that is mean reaction time decreases as grade increases in level.

**Situation 3: Stepsize and response latency.** Again, the analysis suggests that stepsize and response latency as interpreted for preference patterns can be represented by a linear array.

**TABLE 17**

Premise and Inference Presentation Pairs by Mean Reaction Time (msec.) for Situation 3.\(^{a}\)

<table>
<thead>
<tr>
<th>Presentation Pairs</th>
<th>Mean Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2,3) (3,4) (4,5)</td>
<td>2500</td>
</tr>
<tr>
<td>(3,5) (2,4)</td>
<td>2800</td>
</tr>
<tr>
<td>(2,5)</td>
<td>2400</td>
</tr>
</tbody>
</table>

\(^{a}\)Obedience as a citizen of the United States.

Table 17 for Situation 3, concerning "obedience as a citizen," does not evidence a monotonically decreasing function over the selected presentation pairs and their respective mean reaction times. Instead, the function is one wherein the adjacent pairs (2,3), (3,4), and (4,5) and reference level two pair (2,5) are equivalent in mean reaction time,
but the inference level one pairs (3,5) and (2,4) are greater in mean reaction time.

**TABLE 18**

Premise and Inference Presentation Pairs by Mean Reaction time (msec.) for Situation 3, a Controlling for Grade Level.

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>(2,3)</th>
<th>(3,4)</th>
<th>(4,5)</th>
<th>(3,5)</th>
<th>(2,4)</th>
<th>(2,5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>4100</td>
<td>3700</td>
<td>3800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fifth</td>
<td>1900</td>
<td>1800</td>
<td>2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College</td>
<td>1600</td>
<td>2000</td>
<td>1400</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2500</td>
<td>2800</td>
<td>2400</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*aObedience as a citizen of the United States.*

When the data is controlled for grade, the picture becomes even more confused. For first and fifth graders, the data suggest a "v" shape graph. For college students, the data suggest quite the opposite— that is, an inverted "v".

**Situation 4: Stepsize and response latency.** Again, the analysis hypothesizes that inference by linear array provides a possible representation of the choice process. The data in Table 19 support the linear array representation. Initial adjacent pairs (2,3), (3,4) and (4,5) manifest
the greatest time, pairs (2,4) and (3,5) intermediate time, and pair (2,5) shortest time.

**TABLE 19**

Premise and Inference Presentation Pairs by Mean Reaction Time (msec.) for Situation 4.

<table>
<thead>
<tr>
<th>Presentation Pairs</th>
<th>Mean Reaction Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2,3) (3,4) (4,5)</td>
<td>2100</td>
</tr>
<tr>
<td>(2,4) (3,5)</td>
<td>1900</td>
</tr>
<tr>
<td>(2,5)</td>
<td>1800</td>
</tr>
</tbody>
</table>

*aObedience during a time of war.

The data may also be controlled for grade.

**TABLE 20**

Premise and Inference Presentation Pairs by Mean Reaction Time (msec.) for Situation 4,*

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Presentation Pairs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(2,3) (3,4) (4,5)</td>
</tr>
<tr>
<td></td>
<td>(2,4) (3,5)</td>
</tr>
<tr>
<td></td>
<td>(2,5)</td>
</tr>
<tr>
<td>First</td>
<td>2700</td>
</tr>
<tr>
<td>Fifth</td>
<td>2000</td>
</tr>
<tr>
<td>College</td>
<td>1600</td>
</tr>
<tr>
<td>Total</td>
<td>2100</td>
</tr>
</tbody>
</table>

*aObedience during time of war.
Table 20 reveals that only two grades, fifth and college, manifest the linear array mean reaction time relationship for the transitive inference pairs concerned. First graders, by contrast, reveal a inverted "v" shape relationship with slowest times falling on pairs (2,4) and (3,5).

5.4 Levels of Transitivity: Judgmental and Preferential Choice Compared

One interesting analysis is motivated by a concern for whether or not an individual manifesting a certain transitivity score upon one kind of choice task situation will manifest a similar score on another. A comparison of transitivity scores across individuals participating in the judgmental valuation and preference-based choice experiments constitutes one possibility. One would expect that individual transitivity scores on one experiment will be equivalent on the other, at least relative to the scores of the other participants. This expectation might be interpreted to mean that an individual with high transitivity on one task will be correspondingly high on the other, while low transitivity individuals on one task will be low on the other as well.

One test of this hypothesis would be to rank order the score for individuals on both tasks to see how well one is ordered in comparison with the other. Spearman's rho, a rank order correlation, provides such a measure (see
Blalock, 1972, pp. 416-417). Since Spearman's rho norms between -1.0 and +1.0, a good measure of the relationship between orderings of scores on experiments may be given. The results of this measurement yielded a coefficient -0.14, suggesting no real association between the orderings. Other attempts at collapsing the data yielded similar unassociated results.

Apparently, based upon these results, there is not necessarily a predictable relationship between scoring on one experiment and scoring on another. So for example, a high score on one experiment is not necessarily accompanied by a high score on the other. An alternative explanation should be mentioned, however. It was noted above that most subjects scored high on each experimental task. This occurrence reduced the variation of possible scores. As a result, the lack of association may be attributable to a lack of extensive variation in the data. To measure the association, then, a much wider transitivity score range across subjects would be required.

5.5 Summary of Experimental Results

In this concluding section, a summary of the major experimental results are presented. These results follow closely the organization of the hypothetical framework used to motivate portions of the empirical analysis.
5.5.1 Experiment 1: Judgmental Valuations

Minimum levels of transitivity. The mean transitivity score for choice data in the judgmental experiment was 92.9% correct. This supported the notion that individuals could behave transitively and that the level of this transitive behavior was quite high. Of the possible main effects identified in the analysis, only grade was significant. This suggested that within the overall tendency to behave transitively, there exists a developmental tendency such that first graders behave less transitively than fifth graders, and fifth graders behave less transitively than college students. In addition to the effect of grade, transitivity levels were also a function of the interaction between grade and achievement level and achievement level and gender. The interaction between grade and achievement level is summarized as: for high achiever, transitivity scores will decrease when moving from first grade through fifth to college; but for low achievers, the decrease in score will only be apparent when first graders are compared with college students and fifth graders with first graders and college students manifesting identical transitivity levels. The interaction between achievement and gender was one in which high achievement males are less transitive than low achievement males, and high achievement females are more transitive than low achievement females. No significant simple effects were found in these interactions.
Representing the individual choice mechanism. The results of Experiment 1 suggested with regard to the relationship between stepsize and error that a linear array is a possible representation for individual choice on the judgmental valuation task. This is evidenced by the serial position effect, step-function effect and end-anchored effect which manifested in the choice data. When the data was controlled for the effect of grade, the relationships above were maintained.

The analysis of the relationship between stepsize and error facilitated a comparison of this analysis with a similar study by Trabasso, Riley and Wilson (165). The overall results of this analysis suggest that the comparison study was in fact replicated. This study showed identical results for fifth graders and college students as comparable to the comparison study using third graders and adults. First graders did not compare as high with the comparison study, but this was attributable to the shorter training sessions given to the subjects of this study.

When stepsize and response latency were examined, the results of this experiment also suggested that a linear array was a possible representation. Generally, the study found that the premise pairs showed the greatest time, pairs of one-step inference intermediate time and pairs of two-step inference the shortest time. Grade was the only significant main effect with regard to response latency. Its
effects again suggested a developmental influence: response latency decreased with increase in grade level. One significant interaction between grade and gender was apparent. This relationship was given as: mean reaction times for females decreased as grade level increased, but times for males showed fifth graders to be slowest, first graders intermediate and college students fastest. No simple effects were found to be significant in this interaction.

5.5.2 Experiment 2: Preference-based Choice

**Minimum level of transitivity.** The preferential task in Experiment 2 showed that individuals tend to behave transitively under different choice situations. The overall transitivity level, based upon the Kendall and Smith (1940) consistency coefficient was 0.96. On the four contextual choice task situations, individuals revealed transitivity levels of 0.92, 1.22, 1.02 and 0.67, respectively. Two significant main effects were found: grade and experimental group. The effect of grade was again developmental, that is, level of transitivity increased with increase in grade level. Experimental group showed that levels of transitivity decreased across the Stimulus Group through Memory Group to Control Group for three of the four contextual situations, but on Situation 4 the decrease occurred from Memory to Stimulus to Control.

Two interactions were also found to be significant: grade and experimental group and achievement level and
contextual situation. The first interaction revealed that as grade level increased, Stimulus, Memory and Control groups increased in level of transitivity. And the second interaction showed high achievers to be more transitive than low achievers on Situations 2, 3, and 4, but on Situation 1, the converse was the case.

Memory and the effect of feedback. In this portion of the analysis, subjects in the Memory Group were analyzed to see how levels of transitivity changed when changes in choices previously made were permitted. The overall results showed that most subjects elected not to change their previous choices. Of those who did change, first graders tended to decrease their level of transitivity, while fifth graders and college students tended to increase theirs.

Representing the individual choice mechanism. If choice data is presented by stepsize and mean reaction time, then the preferential choice data suggested that a linear array might be a possible processing mechanism in choice. This remained the case for three out of four contextual situations. When analyzing the choice data for main effects, grade emerged as the only significant effect. Again, grade widened a developmental tendency: mean reaction time decreased across grade level. Two significant interactions were also found: grade and achievement level and grade and contextual situation. The effect of grade and achievement level was that high and low achievers showed decreasing
time with increase in grade level; but high achievers were only faster for first graders but not for fifth or college. The effect of grade and contextual situation was one in which mean reaction times decreased by grade for Situation 1, 2, and 3, but for Situation 4, the pattern reversed to that time increased with an increased grade level.

5.5.3 Judgmental Valuations and Preferential Levels of Transitivity Compared

The transitivity scores for both experiments were rank ordered, then Spearman's rho rank order coefficient was applied to see to what extent the two set of scores were ordered. The result was a -0.14, suggesting that there is not necessarily a predictable relationship between scoring on one experiment and scoring on another.
Notes to Chapter 5

1The analysis of variance used herein was a 3-way analysis with the levels of categories within independent variables considered fixed, where fixed refers to the consideration that the levels be fixed over repeated experiments. The actual program used was supplied by Clyde Computing Service through the Social Psychology Laboratory, the Ohio State University: "Clyde MANOVA."

2Another statistical test conducted was based upon Pearson's product-moment correlation and a linear regression model. The strength of the relationship and goodness of fit to a linear regression line were unimpressive statistically since the data was essentially non-linear. The results, which are available from the author, were therefore not reported.

3See Note 1, above.

4The analysis of variance used herein was a 5-way analysis with independent variable arranged in a mixed-effect model. More specifically, the independent variables: grade, experimental group, gender, achievement level were treated as fixed effects, that is they were considered fixed over repeated experiments; while the independent variable contextual situation was treated as a random effect, that is, it was considered to be random for a larger number of groups. Since a subject contributed a score to each of four situations, the design utilized an analysis of variance program for "repeated measures," instead of treating the four scores on four contextual situations as being contributed by four different subjects even though only one subject was involved. The actual program used was supplied by the Social Psychology Laboratory, the Ohio State University: "SOUPAC: BALANOVA."

5See Note 4, above.
Chapter 6
CONCLUSION

In the study of philosophy, men search after science either simply or definitely; that is, to know as much as they can, without propounding to themselves any limited question; or they inquire into the cause of some determined appearance, or endeavor to find out the certainty of something in question.

Thomas Hobbes, De Corpore

6.1 Introduction

Any good theoretical enterprise will raise more questions than it answers. It will suggest more need for elaboration, formalization and systematization than it can ever accomplish. It will be intensely relevant and important to many enterprises. And it will be relevant to enterprises which are only tangential by comparison.

The disadvantage of having a good theory as opposed to a bad one is that for the good one it is impossible to state everything which needs stating and it is impossible to trace our relationships completely. As a result, there is much left unsaid in the good theory. Hopefully, it will by virtue of being a good theory, stimulate a desire in others to fill in the blank spaces left by the theorist as he ranges widely over important theoretical concerns.
A somewhat biased perspective about this theory is that it is a good one. It does in fact raise many more questions than it can ever hope to answer. It requires extensive systematization. It is relevant to many other enterprises such as psychology, economics, administrative science, systems engineering, philosophy and so on. Hopefully, in being a good theory, it will suggest many things to many theorists, raise many new questions, stimulate controversy and foster subsequent research activities.

Unfortunately, being a good theory, it is limited in the number of topics with which it can immediately deal. Therefore, the theory will address only a few points in this chapter which are immediately of interest, especially from a political science perspective and hope that the momentum gathered by the theory will carry over into more complex subsequent analyses. So, in this final section the analysis will identify and evaluate what would appear to be some important implications of the theory of rational individual choice and supporting evidence for the political science enterprise. More specifically the analysis will focus upon three concerns. First, the analysis will attempt to paint a wide panorama of what the theory and experimental evidence has accomplished. Second, the analysis will suggest some important implications for political socialization and public opinion, two fields in political science which are relevant to the enterprise above. And third, the
investigation will suggest several subsequent research proposals based upon results of the experiments analyzed.

6.2 The Theory of Rational Individual Choice: A Summation

The topic for investigation was rational individual choice under conditions of certainty. Rational individual choice so conceived involves determining the rationality of individual choice-making wherein an individual when faced with a set of alternatives which have unique, identifiable consequences selects one or more of these alternatives to the exclusion of others. An individual might be faced with the possibility of voting for one of six political candidates in a Democratic Party primary. The individual desires to determine which candidate he prefers given their positions on various political issues by selecting that candidate who comes closest to his own issue positions on the largest number of issues. The question then becomes, is this individual choice behavior rational?

The analysis of rational individual choice under certainty divided naturally into three parts. The first concerned the construction of a theory of individual choice which would overcome as many of the limitations and shortcomings of its competitors as possible, while at the same time including as many desirable or potentially desirable features of these competing theories. The second concerned the development of criteria whereby individual choice could be evaluated according to its rationality, irrationality or
extra-rationality. And a third part developed an experimental design which was used to empirically test the theory of rational individual choice. Each of these major sections may be summarized in the following sections below.

6.2.1 A Theory of Individual Choice

One of the major limitations of many individual choice theories is that they present choice as a set of "givens" involving presentation sets, preference or judgment, choice functions and choice sets, but show little concern for representing choice as a process. As a result, individual choice behavior cannot account for stimulus perception, selective perception, context effects, memory storage and retrieval, choice processing mechanisms, response set effects and so on. Having not accounted for these considerations related to the choice process, many theories of individual choice cannot represent the cognitive processes or dynamics which might have produced individual choice behavior, they cannot suggest what effect cognitive processes might have on individual choice behavior and they cannot provide an explanation of individual choice behavior.

This limitation on many individual choice theories motivated the search for an alternative framework in which to represent individual choice behavior. One way to accomplish this is to conceive of individual choice as follows. An analyst is given a "black box" which represents an individual chooser. The analyst must find a way to present the black
box with choice task environments which will lead to certain responses. The analyst's problem is to manipulate or control stimulus input into the black box so that given the responses attained, inferences about the possible processes sufficient to represent individual choice can be made. This is individual choice recast as a problem in "representation." The analogy of the black box is referred to as the "sealed carton analogy."

A framework which is both amenable for analyzing individual choice in general and consistent with the sealed carton analogy is provided by "information processing theory." An individual chooser in this framework is represented by an information processing system having the following components. There is a receptor, labeled the "perceived stimulus," which receives structures from the choice task environment and modifies them as a result of selective perception or perceptual distortion. This divergence (or possibility thereof) accounts for the change in incoming symbol structures by virtue of their being processed from the external choice task environment. These may be referred to as "context effects." The receptor is interfaced with a processing mechanism, referred to as the "choice mechanism." In this system component, symbol structures are input from the receptor and processed by preferences, judgments and decision-rules which are contained therein. Choice processing, then, may be either preference-based, judgmental
or decision-rule produced depending upon the characteristics of the symbol structure. The choice mechanism interfaces with a "memory" component in which various kinds of symbol structures are stored. These symbol structures may be stored for immediate use in short term memory or retained for longer periods in long term memory. The choice mechanism with its access to the memory component interfaces with a component called a "choice set." The choice set is a component from which equally acceptable alternatives are chosen, or stated somewhat differently, the component containing alternatives which are at least as good as every other alternative in the set considered. The choice set acts as an effector, as well, since it interfaces with the external environment as an observed response. Of course the observed response and the choice set may not be equivalent or identical.

By representing individual choice as an individual choice mechanism, the analysis was able to accomplish the following. First, the analysis was able to represent by means of formalisms the important structures and processes which are sufficient to produce observed choice behavior. Second, since the processes and components chosen in the representation were based upon theories about how individuals cognize, the representation may be thought of as relating to one possible way in which cognitive dynamics in the choice process might operate. Third, the analysis took advantage
of the power of formalisms in the model; but it was also sensitive toward the theory-ladeness of these formalisms. In other words, certain formalisms were used to represent structures such as preferences, but in addition, the structure of the formalisms themselves were also employed since they might be used to capture the processes involved in representing choice. So for example, production systems as formalisms not only represent choice, but they also have structural characteristics such as serial processing which can be taken advantage of when dealing with choice as a process. In so doing, the analysis was able to extend the domain of choice from the general choice paradigm to one which is related to cognitive processes. And fourth, since the representation is sufficient to account for individual choice behavior, one can say that it is "complete," that is, it represents what it is supposed to. In so doing, choice is not only represented, but also is explained.

The processes identified as possible representations of an individual choice mechanism have a "capacity" for processing symbol structures. Capacity refers to the rate, amount and accuracy of information which can be processed by an individual choice mechanism. Now, the capacity for processing information is contained in an interval which delimits some level of maximum and minimum processing capacity. The analysis limited its focus to this minimum level.
The capacity of a choice mechanism in an absolute sense cannot be measured directly because of certain confounding effects attributable to context effects such as familiarity or similarity, selective perception, choice of decision-rules, error-making, memory loss, lack of feedback and so on. These effects which mask capacity are treated as measures of performance. One goal of the analysis of choice in this framework would be establishing possibilities for manipulating and controlling performance in order to: (1) discover functional relationships according to which it varies given different choice task environments and (2) reduce the confounding aspects of performance in order to reduce the variation between measurement of performance and identification of capacity.

The entire framework above lends itself nicely to empirical analysis. This empirical testability possibility in addition to the need for manipulation and control, made the above theory of individual choice especially amenable to experimental design and execution, a characteristic made use of in the third phase of this investigation.

6.2.2 Toward a Theory of Rational Individual Choice

Having represented individual choice as an individual choice mechanism in a choice task environment, the second phase of the investigation went on to develop a criteria whereby rationality could be included in order to develop a theory of rational individual choice. The analysis at
this stage began with a rejection of rationality as predi-
cated of individuals, individual choosers, preferences,
decision-rules or choices. Instead, rationality was
predicated of the individual choice mechanism which proc-
esses symbol structures in a choice task environment.

Rationality as conceptualized in this analysis was
viewed as follows: an individual choice mechanism will be
considered rational if it can be formulated as a process
which provides a representation of one possible cognitive
process such that given a choice task environment that
requires the mechanism to produce transitive relations
among objects of choice. This rationality criteria was
further subject to the additional considerations that (1)
variation between the stimulus as objectively presented and
the stimulus as subjectively perceived is minimal, (2)
memory as a mechanism for storage and retrieval retains all
relevant structures without memory loss, (3) errors are
permitted, (4) choice processing by means of preferences,
judgments and decision-rules are internally determined
within the system; and (5) only the minimal capacity is
considered.

Transitive behavior, as with most theories of rational
individual choice, is of paramount importance to this theory
of choice. Transitivity was discussed in the analysis
according to its various appearances. The first major
distinction identified was between transitivity as a formal
relation and transitivity as a rule of inference. Transitivity relations were classified as either probabilistic or algebraic, and within this dichotomy weak and strong criterion were discussed. Transitive inference was then discussed, by dichotomizing rules of inference initially into syllogistic and linear array inference possibilities. These two categories were subsequently divided into serial, parallel and hybrid processing possibilities. Once transitivity as a relation and rule of inference was identified, the analysis considered how one might have inferred in choice-making given a set of choice data manifesting transitive relations. This theoretical analysis motivated an experimental design and execution which was completed in stage three of this analysis.

It was mentioned previously that rationality for purposes of this analysis referred to some minimal process capable of producing transitive relations among objects of choice when required to do so for specific choice task environments. This "minimum rational capacity" when predicated of an individual choice mechanism was hypothesized to have the following characteristics. First, the minimum rational capacity is not considered developmental in the same sense as Piaget (1928) had originally formulated. In this analysis, the capacity for exhibiting transitivity among objects of choice is believed to be developed much sooner than the "concrete-operational" stage identified for
age 7 or 8. This analysis considers the ability to be innate in individuals at all ages. There would, however, be a tendency to commit errors at younger ages than at older ones. Therefore, transitivity levels will differ across age groups, but it will nevertheless be manifested. Second, minimum rational capacity is hypothesized in this theoretical framework to remain stable throughout one's life for given choice tasks much the same way as intelligence (as measured by IQ tests) remains stable. This is not to say, however, that capacity cannot increase by virtue of developing more complex processes to process information. And third, minimum rational capacity is hypothesized to vary little according to gender.

Transitivity as a rule and relation, and capacity as developmental, stable and gender related formed the basis for empirically testing the theory of individual choice and its criterion of rationality.

6.2.3 Experimental Design and Results

Experimental Design. In order to empirically test the theory of rational individual choice, two experiments were designed. One experiment, a judgmental valuation, provided the choice task environment for individual choosers. Judgmental valuations in this experiment required that: individuals simultaneously coordinate pairwise comparisons of sticks as choice objects having length and color. This experiment followed closely the design of Bryant and
Trabasso (1971) and Trabasso, Riley, Wilson (1975). The experiment served several important purposes with regard to the theory: (1) it would provide evidence suggesting that in general (at least on the basis of this choice task) individuals can exhibit transitive relations among objects of choice, (2) it allowed one to reduce the confounding effects of memory loss, especially on the party of younger subjects, (3) it allowed one to eliminate the confounding effects of language which has been indicative of many choice task environments, and (4) it would serve as a replication of the very important Trabasso, Riley and Wilson (1975) study; and if successful would provide a measure of validity for the preference-based experiment which had never been attempted before.

The other experiment involved preference-based choice. In this experiment subjects were presented with contextual situations in which they were required to select from pairs of authority figures the person they would more prefer to obey. In terms of testing the theory empirically, the preference-based experiment: (1) allowed one to determine whether or not the general transitive ability would transfer over to political choice situations, (2) it allowed one to manipulate transitivity levels by changing the effects of context by placing subjects in different contextual situations which varied according to familiarity, (3) it allowed for the control of the effects of memory by providing one
experimental group with an external memory board, and (4) allowed one to test the effects of stimulus perception and response effects for one experimental group.

Both experiments, in addition to the above, permitted analysis of transitivity based upon key variables such as: grade, which allowed for a test of the developmental hypothesis; intelligence/achievement, which allowed for a test of the stability hypothesis; and gender which allowed for the gender hypothesis.

In addition, both experiments allowed one to measure: the accuracy of responses, which amounted to the number correct in the judgmental task and the degree of deviation from a perfect ordering in the preference task; response latency; and step size, which was a measure of the number of inference steps required to determine the longer or more preferred element in a pair. These measures, of course, correspond to indicators of the minimum rational capacity mentioned above.

**Experimental Results.** The most important empirical results in terms of the theory being tested may be briefly summarized as follows. First, a major hypothesis in the theory of rational individual choice being tested here was that individual choosers represented by an individual choice mechanism manifest some minimum level of transitivity for task-specific choice task environments and therefore may have rationality predicated of their elementary process.
The judgmental and preferential experiments both confirmed this hypothetical expectation, since mean judgmental transitivity scores were 92.9 percent correct and mean preferential transitivity coefficient scores were 0.96. The three main effects, due to grade, intelligence/achievement and gender, showed only grade to be significant. At the very high transitivity levels obtained with transitivity increasing slightly across grade, one conclusion would be that the capacity to behave in a minimally transitive way is quite high irrespective of grade, but that within this high level, grade may be used to predict error differences across subjects. Therefore, the developmental hypothesis seems to hold in the sense of predicting performance, but in terms of transitivity capacity manifested at some minimum most subjects are included at least at some minimally acceptable level.

Second, the choice data from the judgmental experiment, based upon response latency, accuracy and stepsize yielded important results in terms of representing the choice mechanism for an individual chooser. Based upon the choice data in this experiment (and equivalent results in the Trabasso, Riley, and Wilson, 1975; Bryant and Trabasso, 1971; experiments) it is apparent that a linear array inference mechanism with serial processing characteristics produced the choice data observed in this analysis. This seems to be the case since all four of the hypothetical expectations
were fulfilled; that is, the data manifested a serial position effect, step-function effect and end-anchored effect with respect to stepsize and error, and appropriate mean reaction times with respect to stepsize and response latency. The data is important, then, because it provides a means for representing a choice mechanism sufficient to account for the observed choice data for an individual.

Third, another theoretical consideration in this investigation was that memory ought to be controlled and manipulated in order to determine its effect upon the processing of symbol structures. The judgmental experiment suggested that memory was a major factor in producing or exhibiting transitive relations among objects of choice. In this experiment it was shown that if the confounding effects of memory loss are controlled by appropriate pre-training and training sessions that transitivity is manifested in choice data. The preferential experiment provided another measure of the effect of memory by allowing for its manipulation. It seems to be the case that memory, of the external variety, is less important as a main effect than having some knowledge (familiarity) of the stimulus task. In addition, it suggests that memory is in part based upon experiential factors: fifth graders and college students, for instance, when they changed preference patterns based upon external memory always increased their transitivity score, while first graders tended to change preference patterns randomly. The importance
of these results are that it is possible at least in these choice task environments to "control" and "manipulate" the effect of memory on transitivity scores and in so doing gain some understanding of memory as a system component in an individual choice mechanism.

Fourth, another hypothetical consideration in this theory of rational individual choice is that in order to construct representations of processes internal in the individual choice mechanism one ought to manipulate stimulus structure input and choice set structure output. Or in other words, one ought to account for the effects of "stimulus perception" and "response set." This possibility was allowed for by including a "Stimulus Group" in the experimental design. In general, the results show that this group as compared with the Memory and Control Groups, always scored higher on transitivity scores for the given choice task environments and overall responded much faster than subjects in other groups. This suggests, then, based upon this analysis that information about the stimulus, but not about transitivity, that reducing the variance between the objective stimulus and perceived stimulus is not only possible at least relative to the other experimental treatments, but also that this leads to higher levels of transitivity. One can assume then that given these responses which were overall transitive that perhaps the variance between the internal choice set component and the observed response were
reduced as well. Of course, had the responses been transitive, the inference could not have been made.

And fifth, the theory of rational individual choice required that choice task environments be varied so as to induce different responses with the possibility of inferring in this procedure the kinds of processes which receive, process, and effect information. The two most obvious instances of task differentiation were the judgmental and preferential experiments. One concerned judgmental valuation based upon length and color, and the preferential based upon preference-based choice. As suggested in points one through four above, both contributed immensely to our understanding of the individual choice mechanism. But, there were additional choice tasks contained within the preferential experiment. These involved different "contextual situations," the home, school, citizenship and war which provided a context for expressing preferences over political authority figures. The situations were experimental treatments intended to effect transitivity. In this experiment contextual situation alone was not a significant main effect. It did, however, become significant as it interacted with other factors. For example, intelligence/achievement interacted with contextual situation with high achievers being more transitive on these situations than were low achievers. This suggests, then, that context does make a difference when transitivity scores are being produced so that persons
who are transitive on one task may not be so on another. This conclusion allows one to vary the choice tasks across subjects so that inferences about process can be made.

6.3 Some Implications for Rational-Activist Models in Political Science

A theory which draws heavily from three disciplines, political science, psychology and economics, is bound to suggest many more interesting things than it can immediately cover. This being the case, this portion of the analysis will deal only with the suggestive implications which seem most relevant to politics and more specifically, rational-activist models (see Berelson, et al, 1954) of political linkage in political socialization and public opinion. These areas were chosen since they constitute one of the main foci of the theory, whereas other related topics although relevant and important are intended as areas for subsequent analysis. So what are the major implications of this investigation for political socialization and public opinion based upon a rational-activist foundation?

6.3.1 The Rational-Activist Model of Political Linkage

The rational-activist model which explains the linkage between individuals and the political system is reviewed by Berelson (1952) as follows. Generally the model requires that individuals "participate" in political affairs out of a sense of duty, interest and proper motivation. This participation may take many forms including discussion of
politics with others and donation of time and money to campaign activities of political candidates. This participation is not random, haphazard or unreasonable, but instead is motivated by the principles of democratic politics in its classical form. More specifically, the individual is aware of the principles of freedom, justice, equality and so on, and always acts not only for his own good but for the good of the community. Now, the principles which dictate political action are general in character, so the individual must examine political situations from an informed point of view, that is, the individual must seek "knowledge" about political events and activities and evaluate specific cases in terms of the known general principles. In short, the individual must possess accurate information about all matters political. This portion of the model encompasses the "activist" criteria in political linkage of the individual with the political system.

But, the activist portion above is only part of the model. The other part deals with rational behavior in political action. Rationality as a concept is very illusive in literature concerning rational-activist models. Nevertheless, it seems to manifest at least the following characteristics. The individual in all politically related activity is assumed to use "reason" in constructing preferences, attitudes, opinions and beliefs. Reason is generally contrasted with emotion, randomness, perverseness, whimsy
and so on. Since reason is the vehicle by which preferences are formed, the objects and relations interpreted or represented by preferences must manifest certain logical characteristics. These include "constraint" which is the capability of predicting one set of preferences given knowledge of another set; "consistency" which suggests that for a given state of affairs, the same preferences are always manifested; "centrality" which means that certain preferences are higher in an ordering than others, or in other words the individual is not indifferent over all objects and relations. These preferences, having the above properties derived out of reason, are used to produce or generate politically relevant choices over sets of political objects which given a preference pattern are "logically" implied. In short, some class of choice functions posited as important for the individual are used to convert preferences over sets of objects into appropriate choices. Now, this class of choice functions require some kind of optimizing behavior for the individual. This usually amounts to selecting "efficient means" for "appropriate ends."

Both considerations in the model, the rational and activist, although necessary are somewhat lopsided with respect to importance: the rational criterion far exceeds any of the other criteria in its importance. This is the case since all of the other criteria depend and indeed are underpinned by some notion of rational political behavior.
So for example, participation, motivation, interest, knowledge and principle are all based upon reasoned cognitive and/or physical action. The variety of reasoned activity is that of rational action always.

The rational-activist model as proposed above is subject to disconfirming evidence. Therefore from an explanation standpoint, the model can be rejected as inappropriate given certain kinds of empirical results. The most vulnerable portion of the model seems to be the rational behavior assumption for individual political actors, since it provides the foundation for political activism and reason. The assumption of rationality is subject to one of two kinds of disconfirming evidence. One is that individual political actors cannot behave rationally in the political arena and therefore, do not reveal rational kinds of behavior. The other is that individuals under certain political situations simply do not reveal rational kinds of behavior.

The two varieties of disconfirming evidence are crucially important to classical democratic theory. The former variety suggests that democracy based upon any political foundation, where the "mass public" is involved, simply will not work in practice and will remain an "in principle" exercise (see Bachrach, 1967; Berelson, et al., 1954). The latter variety allows for the possibility that individuals may have the capacity for rational behavior, but, they simply do not exercise it; this would suggest, quite
importantly, that there is something awry with the political situation so that only the activist portion of the model is suppressed, but individuals essentially remain rational (see Key, 1966).

6.3.2 Political Socialization, Public Opinion and the Rational-Activist Model

Political socialization is the study of the mechanisms which act as stabilizing forces in society where individuals acquire support for political systems so that some sort of societal continuity is maintained (Almond, 1960; Easton, 1965). Stability through political socialization is provided by maintenance, integration and development (Almond and Verba, 1963). Political socialization maps into the classical democratic theory rational-activist model as follows. Socializing agencies, such as the family, peer group, school, community, government and so on, "socialize" the individual into behaving (or failing to behave) in ways appropriate to the persistence of democracy. These agencies accomplish this by "mirroring" the embodiment of democratic principles and then socializing the individual into also mirroring these principles at least abstractly in political actions. The method of political socialization, then, is to study the extent to which individual political behavior resembles the socializing agency. So, for example, democratic theory requires that members pressure one another to participate. And the individual as socialized also
participates. In time the individual may form his own socializing agency and the activity begins anew.

Political socialization as an enterprise tends to concentrate upon three areas of study. One is the cognitive-development manifested by individuals at different ages to see what kinds of political behavior or cognitions are present as a result of socialization and which are excluded because of cognitive developmental incapacity. For example, Rosenau (1975) suggests that analyses might well use Piagetian stages of development as explanations for political behavior. And Searing, et al, (1973) test two models, the "primacy principle" in which childhood learning endures through life; and the "structuring principle" in which basic orientations acquired in childhood structure later learning activity (p. 415).

Another focus involves an orientation concerning the source of political socialization for the individual. This focus asks whether behavior and cognition is learned from family, school or community related socializations among individuals. Lipset (1960) suggests that working class non-participation, isolation and alienation arise out of the authoritarian nature of the family setting. Greenstein (1965) discovers fairly articulate political orientations among school children with regard to political affairs. And Prothro and Grigg (1960) working at a more macro level
examine the political beliefs and knowledge of democratic principles in members of mass publics.

And a final focus concerns social learning which refers to the ways in which members of society, especially junior members, come to "learn" its values, attitudes, and other behavior. This focus looks, not at the source of learning, but instead at the learning process or mechanism of the individual. Hess and Torney (1967, pp. 22-26), for example, identify four models which might account for this learning process. (These models include: accumulation, interpersonal transfer, identification and cognitive-developmental.)

**Public opinion and the rational-activist model.** Public opinion is a very diverse conglomeration of attitudinal and behavioral studies which defies any comprehensive review. Yet, public opinion analysis seems to include at least the study of how individuals come to vote for candidates in the political arena, individual voting behavior, the knowledge individuals possess about the political situation, the affect of feeling individuals manifest toward political objects and activity, individual participation, and the normative aspects individuals associate with activity and belief in a political context (Berelson, et al, 1954; Campbell, et al, 1964; Lane and Sears, 1964).

Public opinion is very much associated with political socialization in that political socialization provides the
analysis of antecedants and determinants of individual attitudes and behavior which is the grist in the mill of public opinion (Dawson, 1966). So, for example, certain attitudes and beliefs developed in childhood may "structure" the acquisition of new attitudes in adulthood (Searing, et al., 1973).

Both political socialization and public opinion analyses are clearly bound up in the rational-activist model, since they both deal with investigations of political activism and rationality as formulated by Berelson (1952).

6.3.3 Political Socialization and Public Opinion: Some Empirical Results

Political socialization: some empirical results.
Members of society as they mature from infancy to adulthood pass through levels or stages according to which the individual acquires different kinds of political knowledge, has the capacity for acquiring different kinds of knowledge and uses acquired knowledge in the political arena. The acquisition, possibility of acquisition, and actual use of political knowledge in a socialization context is very much related to the activist portion of the rational-activist model. This is revealed in the data on socialization as follows. Political knowledge, motivation, principled-behavior, interest and so on tend to develop over time according to the following transitions from infancy to adulthood. Individuals tend to (1) develop affective components before cognitive
ones (Hess and Torney, 1967; Andrain, 1971); (2) develop concrete orientations before abstract ones (Werner, 1957); (3) develop simple notions before highly complex ones (Torney, 1965); (4) develop specific orientations before general ones (Hess and Torney, 1967); and (5) develop orientations toward individuals and then institutions (Greenstein, 1965). Although there are many other dimensions in this activist portion of the model, these comprise in general some of the major hypothetical considerations.

The rational portion of the model also manifests this same concern for transition from one stage to another, but it has been little developed in socialization literature. Torney (1965), Scott (1963), Hess and Torney (1967), and Dawson (1966) all suggest that individuals become more consistent, constrained, structured, or logical as they pass from infancy to adulthood. Apparently, individuals begin with somewhat unrelated attitudes, beliefs, opinions, preferences, or judgments which tend to come together in reasoned ways as the activist portion of the model fills in knowledge, experience, motivation, affective and cognitive dimensions. Both the interaction of the activist and rational portion of the models of transition through stages culminate at some threshold stage. This ultimate stage then tends to be the domain of public opinion which will be considered in the next section.
Thus far in this review, the specific model of transition from one stage to another has been carefully avoided. The reason for this is that almost all observers of political socialization agree that there are stages or levels, but most disagree as to whether they are learned, inherited, cognitive-developmental, experiential, and so on (for a review of some of these see Hess and Torney, 1967). This disagreement would not in and of itself be a problem if it were not for the fact that most of these models have not been tested in the political socialization context (Schwartz and Schwartz, 1975). At any rate, the most dramatic findings regardless of how it is "explained" is that the beginning stages, especially from infancy to early elementary school ages are not especially productive for study of individuals who will manifest high levels of consistent, constrained, logical behavior in a political context. As a result, most studies begin with children in third, fourth or fifth grade (Schwartz and Schwartz, 1975; Hess and Torney, 1967; Greenstein, 1965; Dawson, 1966). Younger children are only of passing interest politically, if they are of interest at all.

Public opinion: some empirical results. Voting behavior and public opinion have produced evidence which is contradictory with respect to the rational-activist model. One school of thought, the so-called "elitists" marshal evidence which suggests that the model does not apply to the
American electorate and that when it applies, it is to small a number of political elites. The other school of thought, the "populists" marshal evidence which supports a rational-activist interpretation (see Brown, 1968; Cobb, 1973).

The Elitist View. The elitist school suggests that the assumptions relating to activism are not supported by various data analyses activities. More specifically, the individuals in mass publics fail to think in ideological terms about politics (Flanigan, 1968; Campbell, et al, 1964; Free and Cantril, 1968). Instead, individuals tend to behave mostly out of some nation of party affiliation (Stokes, 1966; Kessel, 1968; Campbell, 1966). For the most part, individuals have little awareness of political affairs. Individuals tend to be unfamiliar with most basic political issues (Flanigan, 1968; Campbell, et al, 1964) and when they are aware, they tend to be familiar only with very general basic, bread-and-butter issue areas (McClosky, et al, 1960; McClosky, 1964). The individual in general cannot even identify in many cases incumbents and opponents for political office (Stokes and Miller, 1962). The lack of awareness does not transfer over to basic democratic principles of which most individuals are aware; but the application of these principles to actual behavior is highly inconsistent (Prothro and Grigg, 1960). Coupled with this lack of awareness and unprincipled behavior, the evidence shows low
levels of participation of any kind (Berelson, et al., 1954).
Even on the discussion of politics, individuals tend to be very inarticulate (Flanigan, 1968; Converse, 1964, 1970; McClosky, et al., 1960). Sniderman and Citrin (1971) sum up the elitist school's results concerning the activism portion of the model:

"...The average citizen appears lamentably ill-informed about politics, unacquainted with the most basic and simple ideological distinctions, unwilling or unable to organize his ideas in a logical coherent fashion and, in many cases, apt to alter his position on important political issues on a random basis." (p. 415)

The evidence collected by the elitist school also tends to disconfirm the rationality criterion with the rational-activist model. With regard to the notions of "constraint," "consistency" and "centrality," three constructs indicative of rationality, the elitist school marshals evidence which suggests that there is little constraint among attitudinal configurations so that by knowing one set of attitudes and beliefs in a belief system will not allow one to "predict" other associated attitudes and beliefs which might also be there (Converse, 1964, 1970; McClosky, Hoffman, O'Hara, 1960), that individuals are inconsistent in attitudinal analysis since they choose one position on an attitude at one time and different position on the same attitude at another time without genuine attitude change (Prothro and Grigg, 1960; Brown, 1970, p. 67; McClosky, 1964); and individuals tend to possess certain core or central
attitudes, but this centrality rapidly decreases as one moves across the belief systems (Converse, 1964, 1970). Berelson, et al (1954), sums up the elitist's interpretation of the empirical evidence relating to the rationality criteria in the rational-activist model:

"The upshot of this is that the usual analogy between the voting "decision" and the more or less carefully calculated decisions of consumers or businessmen or courts, incidently, may be quite incorrect... In short, it appears that a sense of fitness is a more striking feature of political preference than reason and calculation." (p. 311)

The most general conclusion offered by the elitist school with regard to rational individual choice in the rational activist model is that individuals in mass publics do not and more importantly cannot fulfill the requirements of rationality (Converse, 1964, 1970; Achen, 1975, p. 1218). Berelson, et al (1954), sums up the elitist position quite well:

"'Individual voters' today seem unable to satisfy the requirements for a democratic system of government." (p. 312)

Hennessy (1972) suggests that this inability should lead to the following conclusion:

"What does this mean for the study of political opinions, attitudes and belief systems? I submit it means we are naive and inconsequential if we waste time with mass belief systems and mass attitudes." (p. 36)

The populist reaction. The populist school of thought has also marshalled an impressive body of empirical evidence
which supports the conclusion that individuals in mass publics can behave rationally in most political situations and when they fail to behave rationally it is generally because of the peculiarities of the political context in which they find themselves and not their own inability or incapacity. With regard to the activist portion of the model, many analysts suggest that earlier findings (especially of the elitist school) were a result of the lack of political turmoil, controversy, or salience of the 1950's which made people uninterested in political participation (see Bell, 1960; RePass, 1971; Pomper, 1972). So, the conclusion of the populist school is that political activism is a function of the "salience of the times." This theoretical position, then, states that individuals are active when they need to be, but not inactive as a result of incapacity (Key, 1966). The rationality portion of the model is also confirmed by the populist evidence. Page and Brody (1972), Pierce (1970), Pomper (1972), Shapiro (1969) and Brown (1970) all more or less reject the findings that individuals are irrational based upon some measure of constraint, consistency or centrality. A summary of the populist position is provided by V. O. Key (1966):

"...voters are not fools. To be sure, many individual voters act in odd ways indeed; yet in the large the electorate behaves about as rationally and responsibly as we should expect, given the clearity of the alternatives presented to it and the character of the information available to it." (p. 7).
Some attempts at reconciliation. In view of the contradictory evidence supporting both the elitist and populist positions, it is not surprising that some attempt should be made to reconcile the findings so that a unified picture of the rationality of individuals in mass publics might be attained. Using the general methodological framework common to both schools, much of the conflicting evidence may be reconciled. Kessel (1972) summarizes some major points. First, the elitists and populists tend to operationalize the same theoretical constructs in different ways so that the evidence is supporting two different considerations which are supposed to stand for the same thing. For example, Converse's (1964) measurement of "ideologue" is much different than that given by Field and Anderson (1970) who also use the concept. So when both are unpacked methodologically Converse is addressing information content, while Field and Anderson are addressing affectation. Second, the longitudinality of the data sets used manifest severe problems for comparison. Campbell, et al (1960), examined the electoral behavior of individuals in the 1950's, a time when salience in American politics was very low; while Pierce (1970), RePass (1971), Field and Anderson (1970) and Page and Brody (1972) all look at elections in the 1960's, a time of turmoil, tension, and conflict. When the data is viewed from a time perspective, the results generated by empirical analyses seem more comparable. And third, the actual
statistical techniques used tend to dictate or bias certain kinds of results. Converse (1964), for example, employed regression analyses as models for interpreting data. Pierce and Rose (1974) and Chen (1975) have examined Converse's statistical analyses and found them subject to other interpretations. Achen (1975) suggests:

"Here the problem with the weak original correlations is demonstrated to lie, not with the variability of respondents, but rather with the fuzziness of the questions and with other errors of measurement." (p. 1225)

6.3.4 A Critique of Rational-Activist Models

Both the political socialization and public opinion research enterprises, regardless of their impressive body of empirical evidence and attempts at reconciliation seem to suffer from one great limitation: neither has much concern for process as an explanation for the empirical results observed and as an alternative way of accounting for rational individual choice (see Schwartz and Schwartz, 1975, pp. 10-14; Merelman, 1969, p. 764; Dennis, 1968; Shapiro, 1969).

Some Theoretical Considerations. Having not been concerned with representing symbols, symbol structures, elementary processes, and system components, political socialization and public opinion studies tend to be greatly limited by the following.

Rational-activist models seem to have little concern for representing choice task environments as symbols and structures which can be processed by an individual choice
mechanism. For example, survey questionnaires are not treated as choice tasks having a certain formal relational structure which can be interpreted as very different kinds of empirical relational structures. Having included no concern for formal and empirical interpretations of the choice task, it may be impossible for this class of models to account for the transformation of these symbols and structures from the objective stimulus into the perceived stimulus. Or in other words, having provided no representation of the external choice task environment, it may be difficult to suggest how the individual actually might have perceived the task and what sorts of modifications, manipulations, or transformations might have been performed. Among other things, a lack of representation at this initial stage precludes such things as selective perception, perceptual screening; context effects and so on.

But, the "problem" of a lack of representation is merely beginning at this stage above. This is the case since the symbols and structures as characterized in some internal representation are assumed to be processed by various system components in order to yield some sort of choice data. These components may include the perceived stimulus block, choice mechanism, memory and choice set block. So, having provided no initial representation of task symbols and structures, this class of models cannot suggest (1) what sorts of processes might be sufficient to
produce choice data and (2) what effect these processes might have with respect to changing these structures. So with respect to this first point, there are many possible processes which when organized by various control structures look very different from a representation perspective, yet are sufficient to produce behavior. Memory, for example, may be accessed by a choice mechanism after processing a structure in one control structure setup or it may be accessed by a choice mechanism after processing a structure in one control structure setup or it may be accessed before processing in another. These control structures although different may produce equivalent choice data for one set of choice environments, but an entirely unequivalent choice data for other tasks. And with respect to point two above, a process may in fact change the structures being operated on in the system. Due to the serial position effect, for example, non-anchored pairs thereby producing different results than if non-anchored and anchored pairs were retained. The important criticisms behind both of these points, then, include the inability on the part of most rational-activist models to (1) show what processes might possibly have produced behavior observed, (2) how different control structures over these processes affect behavior observed and (3) how any particular component might affect behavior observed. In failing to consider these questions one cannot discuss memory
effects, preference versus judgmental choice, decision-rule generated choice, choice set effects and so on.

Of course, both concerns above, the stimulus-perceived stimulus interface and the process concern, only account for a portion of the problem. The other remaining portion concerns dealing with the interface between the choice set and the observed responses produced by the individual choice mechanism. This is important since one would like to account for whether or not the observed responses are those produced in the choice set. An individual might choose one choice as a result of processing a structure, but select another as a result of some mistake arising from some sensory/motor response. Rational-activist models do not account for this possibility of selection in an observed response set as being somehow different from the choice set. For the most part, choice is assumed to be that which is observed (Sigel, 1966, p. 3).

All three concerns above which center around the absence of internal and external representations of structures and processes have lead to the following shortcomings of rational-activist models from a process perspective: these rational-activist models seem to reduce themselves to simple stimulus-response models, with little or no concern for the mediating effect of component which process structures input by means of a choice task and stimulus. Models of individual choice behavior, then, treat individuals as "passive
creatures" who are bombarded by stimuli and produce manifest responses (Schwartz and Schwartz, 1975, p. 6; Sigel, 1966; Merelman, 1969).

Clearly, treating individuals as "passive creatures" in the stimulus-response mode suggests what would appear to be immense problems in prediction and explanation. In terms of prediction, the rational-activist models are hard pressed to suggest how an individual, given a set of complex stimuli, will respond. This results since it is unclear how one might map a set of stimuli into a set of responses which are associated with them. So, given a set of stimuli \( \{s_1, ..., s_n\} \) and a set of responses \( \{r_1, ..., r_n\} \), the model cannot predict the appropriate \( \{s_1r_1, ..., s_nr_n\} \) combinations. This is apparent in the literature based upon rational-activist models which finds that individuals give inconsistent, random, unconstrained responses (see Campbell, et al, 1964; Converse, 1964, 1970). And in terms of explanation, rational-activist models cannot account for behavior since they do not suggest what sorts of cognitive processes or processes in general might be sufficient to produce the results they observed. In one sense, they have identified the "antecedant" of choice (or observed responses) by offering an individual a stimulus which could be associated with sets of responses; but they have not identified the "determinants" of choice which would constitute an explanation of the choices observed. These determinants are
assumed to be cognitive processes which in turn are represented by an information processing system constructed to produce individual choice data.

Since the rational-activist models of behavior have not really provided the foundation for prediction and explanation as would be possible if a process orientation were added, the models can only be used to answer descriptive kinds of questions as suggested earlier, that is, they concern themselves with the question, do individuals behave transitively given some manifest choice data? The models cannot answer questions which ask whether or not the manifest choice data is produced by individual choice mechanisms that cannot behave in any other way (Shapiro, 1969; Merelman, 1969). Again, the concern is not only with what is observed, but also with whether this is observed because some process eliminates observing anything else.

Even though rational-activist models appear to be unable to answer questions about the capacity of individuals to manifest transitive behavior, some approaches of concern here appear to have a process orientation; yet, on closer examination seem to smuggle in a process orientation which is irrelevant to the analysis or which is a kind of post hoc explanation. Hess and Torney (1967, pp. 22-26) develop four models of learning which have a foundation in the processing framework, but they fail to link their empirical results to these models as on empirical tests for their
confirmation (Schwartz and Schwartz, 1975, p. 10). And Rosenau (1975) invokes a Piagetian framework for "making sense" of the political socialization of children for which it was not originally designed. Now, the problem with invoking process explanations in this way is that in many cases the data generated was not designed or is not sufficient for testing the processing theory or the theory is not designed or sufficient for the data. Explanations of political behavior which have this problem are limited since it is not clear whether one is really explaining anything at all by invoking processing explanations.

To summarize briefly, then rational-activist models can only describe how individuals behave. They cannot and do not predict or explain whether or not this observed behavior was produced or could have been produced by some rational individual choice mechanism. In terms of rationality, then, they can only say that transitive behavior was not observed (or was observed for that matter), but they cannot say that the processes involved are irrational in the sense of being incapable of producing transitive relations among objects of choice under any conditions.

As stated throughout this investigation, rational individual choice theory in an information processing framework may provide a context in which to include process in explanations of individual choice behavior. The approach would do this by accomplishing three things. First, it allows one to
represent the choice task environment. Second, it allows one to constrict some representation of the processes sufficient to produce choice behavior observed. And third, it allows one to analyze manifest choice data which can be mapped into some internal representation. In short, all three points provide the preliminaries for solving the "problem of representations."

Once process is included in the framework, then rationality may be predicated of the process if the process can produce structures which conform to the requirements of the choice task environment. In this case, the requirement would be the production of transitive relations among objects of choice.

Only when one can meaningfully address questions which relate both to manifest, observed choice data and to the processes which are sufficient to produce this choice data, can one determine whether or not individuals can produce transitive relations among objects of choice, and not simply whether or not they do produce these relations. Clearly, then, political socialization and public opinion, based either upon the acceptance or rejection of rational-activist models, has no basis for answering capacity questions. In order to gain this ability which would transcend description, these explanations might well include a process orientation. One way to do this would be to reformulate rational individual choice in an information processing framework.
Some Empirical Considerations. Of course, the proof-of-the-pudding so to speak with regard to developing a criticism of rational-activist models from a process perspective and offering a processing framework for analyzing rational individual choice as an alternative is based upon an "empirical decidability criterion." In short, can empirical evidence be used to support a process interpretation of individual choice and if so can this evidence better account for individual choice than can the rational-activist models?

One way to illustrate the impressive empirical evidence generated by and supportive of a process model approach would be to show that the major empirical conclusions generated by political socialization and public opinion may be disconfirmed when considering a process orientation. This would include at least the following kinds of activity. First, a major portion of the rational-activist model may be debunked if one can demonstrate that individuals do have the capacity to behave transitively under certain politically relevant choice task environments. This would show, that it is simply not the case that individuals are incapable, but instead do not behave transitively under certain conditions. And second, the idea that rational-activist models are not predictive or explanatory may be supported by (1) showing that choice behavior can be manipulated, (2) that this manipulation can be used to make powerful inferences
about process, and (3) that when process is considered many empirical conclusions not process oriented simply are incorrect.

Clearly, the results of the experimental analyses, judgmental and preferential, are sufficient to debunk any notion that individuals cannot behave transitively because of an incapacity to do so. The results of both the judgmental and preferential experiments suggest that there is a high capacity for this behavior on a wide range of choice task situations under various kinds of context effects. As a result of this evidence, it is clear that only the activist portion of the rational-activist model is confirmed, that is, it is the case that individuals are politically inactive, unmotivated, uninformed, unprincipled; but it is not the case that individuals are illogical by any stretch of the imagination. If anything, it is amazing that they can be so "logical" in such ambiguous, context effect laden choice task environments. This result, then, supports the notion of a "responsible electorate" which has the capacity to behave rationally when necessary.

Now, the results above are certainly possible without any process orientation at all. They could have been generated just as easily under the rational-activist model. What needs to be shown now is that a concern for process makes a difference. Although there is a plethora of evidential results which could be marshalled, the following
seem most supportive. First, this analysis has developed an extensive body of theory which can be interpreted in light of such concepts of error, time and stepsize among alternatives in a presentation set and choice data. Using these measurement concepts the experiments reveal that individuals do not seem to use syllogistic inferences in their so-called logical reasoning as suggested by Piaget (1928), but instead use a concept known as a linear array (Trabasso, et al, 1975). This experimental evidence is extremely important from a process perspective since it illustrates that when such things as error, stepsize and time are considered, it is possible to find a process which could have produced the observed choice data and in this case the data tends to disconfirm long established beliefs about the way individuals infer. Had the analyses not had a process orientation, such things as serial position effects, step-functions, and end-anchored effects would not have been especially relevant. If these were not considered relevant then the linear array mechanism could not be constructed. Hence, the process orientation in this respect is much more powerful in terms of explanation and prediction than its competitor.

Second, the analyses in the first point above concerned identifying a process or mechanism which could produce choice data. But, it was stated earlier that process may transform, mediated or change structures being processed. This experimental investigation gives conclusive evidence
that process does affect choice data. In the judgmental experiment, for example, it was shown that training sessions are necessary to imbed critical structures in memory for latter processing: adjacent pairs of sticks were "memorized" so that inferences over non-adjacent pairs could be performed. Previous to this time other studies, notably Piaget (1928) did not account for this memory component and this has been used to explain the intransitive behavior observed (Trabasso, et al, 1975). Once memory is controlled, transitive behavior is more likely to be observed. Clearly, this concern for process is which memory acts as a storage area for structures is of critical importance in explaining transitive behavior, yet most rational-activist models simply do not account for its effects. In failing to account for memory, most rational-activist models have suggested that the very occurrence of transitive inference ability is developmental. Piaget, et al (1970), suggests that this ability occurs at age eight, the "concrete-operational stage." But the experimental results herein completely reject this, suggesting that performance can be increased with regard to transitivity, but that the capacity is perhaps innate.

Third, process models of individual choice are sensitive to the effects of context, that is, to the effects of familiarity, similarity and so on. These effects are important for several reasons, but most importantly they can explain how symbol structures in the choice task
environment are transformed by a perceived stimulus mechanism. So, the preference-based experiment showed that when context effects were minimized by reducing the variation in the objective stimulus and perceived stimulus by means of a stimulus experimental group, transitivity scores were likely to be higher than other groups regardless of the choice task environment considered. Clearly, rational-activist models do not have this capability. They posit an interpretation of the objective stimulus for the individual instead of assuring that this interpretation is consistent with the perceived stimulus interpretation. A major contribution of the process orientation, then, is that it illustrates that choice behavior is contingent upon context as a major explanatory factor. Context cannot be assumed away; it must be accounted for.

In summarizing this section, then one might say that the theoretical and empirical evidence offered in this investigation more than illustrates a need for a process orientation to rational individual choice. This is the case since it is possible to generate theoretical and empirical results which (1) are entirely contradictory with existing rational-activist models and (2) can better account for the phenomenon of individual choice.
6.4 Prospects for Future Research

6.4.1 Production Systems and Individual Choice.

The investigation of individual choice in this analysis was motivated by a flow diagram which was intended to represent certain structures and processes sufficient to produce certain kinds of choice behavior given various kinds of choice task environments (see Chapter 2). A flow diagram representation was chosen since a well-formulated production system could not be immediately constructed given the seminal nature of the theoretical enterprise.

But, the construction of a production system is and ought to be an intermediate goal in an analysis of individual choice as contained in this investigation. Research which leads to the attainment of this goal, therefore, is a logical subsequent step to be undertaken based upon this analysis.

The construction of production systems as suggested in this analysis ought to proceed as follows. First a production system model for the simple psychophysical task in Experiment 1 (see Chapter 5) should be constructed. Next a production system model for a scaled-down, simple version of the preferential task in Experiment 2 (see Chapter 5) should be constructed. Once the individual systems are operative, then an analysis should attempt to find some common representation of the structures and processes involved which will account for both experimental tasks. This stage should then culminate in some sort of simple
simulation model for individual choice in certain choice task environments.

A production system model, once constructed, is not a final goal in an analysis of this kind. The "leapfrog approach" (see Chapter 2) requires that at least two additional activities be engaged in. One involved the further modification of the "logic" of the production system so that (1) areas in need of additional analysis are identified and (2) the structures and processes are complete, consistent and well-formulated as possible. The other involves the further modification of the system based upon additional empirical evidence and analyses, especially of the experimental variety. The analysis will now turn to a consideration of this latter suggestion in more detail.

Psychophysical choice tasks and experimental research. The possibilities for useful research based upon psychophysical experiments using the two dimensions of length and color are virtually infinite. Therefore, only a few suggestive remarks on some further possibilities for experimentation will be suggested.

One major theoretical proposition in the analysis suggested that context effects were somehow important determinants of individual choice behavior. Using this as justification, the psychophysical experiment (see Chapter 5, Experiment 1) might be modified in the following ways in order to better understand the structures and processes
involved in the cognitive dynamics of individual choice. First, the number of sticks of varying lengths could be manipulated. This would allow one to determine possible threshold points at which the sheer number of alternatives becomes impossible to process. Second, the types of colors associated with stick sizes could be varied to determine how similar or dissimilar shades of color affects the transitive choice behavior of individuals. Third, the analysis suggests that certain stick pair-types (primarily premise and inference pairs) are of critical importance in making inferences across stick lengths and transitivity relations. Using this information on interesting series of experiments might include a concern for eliminating various crucial stick types to see what effect this has upon various possibilities for transitive inference. On the other hand, an analysis might include stick types which are ambiguous, irrelevant, or non-essential to the transitivity tasks at hand in order to determine what effect these kinds of context effects have upon transitive behavior.

**Preferential choice tasks and experimental research.** Many possibilities for subsequent preferential choice experiments which are relevant to this theoretical individual choice enterprise exist. Some of the major, generic possibilities may be treated as follows. First, the design, mostly because of lack of resources, was unable to completely counterbalance all major experimental treatments across
groups, Memory, Stimulus and Control, and the four contextual situations (see Chapters 4 and 5). Subsequent experiments might therefore, attempt to rectify this experimental limitation in the present study by counterbalancing more extensively over experimental treatments. Second, in addition to providing analysis possibilities by counterbalancing, subsequent investigations might combine experimental treatments in various ways in order to allow for more complex analysis of treatment interactions. One might, for example, experiment upon subjects who all used the external memory device, but provide additional stimulus treatments and controls upon this group. Third, the present analysis gave little attention to the actual substantive nature of the preferential orderings attained other than their degree of transitivity. A subsequent analysis might construct more complex contextual situations and alternatives given as authority figures to determine how the substance of these choices and situations related. So for example, one might examine preference change by situation to determine whether one authority figure appeared to be always lowest in an ordering and another always highest. Since the analysis was done in a political context, these concerns for substance could be related directly to political socialization and public opinion studies. Fourth, subsequent analyses could be used to vary and manipulate additional contextual choice situations which would diverge substantially from
those involving obedience in the home, school, war and citizenship. Different situations might be geared toward an electoral voting context, legislative decision-making and so on.

Some general experimental opportunities. The specific suggestions for research above reflect general categories according to which subsequent research might be organized for both kinds of choice situations. These include a concern for the following subsequent analyses: (1) analyses should attempt, in general, to vary, manipulate and control the choice task environment, (2) analyses should vary the alternatives for choice, (3) analyses should impose additional opportunities for selecting in subjects according to interesting theoretical attributes, (4) analyses should extend possibilities for sorting out main effects, simple effects and interactions for experimental treatments, and (5) analyses should be geared more toward substantive considerations. Needless to say, any of these possibilities (and many unmentioned ones) will aid in specifying the structures and processes sufficient to represent individual choice behavior.

6.4.2 Rationality and Individual Choice

In Chapter 3, the investigation suggested that if rationality is to be predicated of a subject, then that subject, the individual choice mechanism, ought to be able to produce transitive relations among objects of choice
when certain choice task environments were presented. The problem of analysis, then, was to determine some minimum capacity for producing these transitive relations. When transitive relations were not found even as expected in certain choice task environments, then the theory being investigated required that the effect of context be considered.

But, transitivity as an indicator of rationality for certain choice situations is not always "appropriate." Or in other words, there are good reasons why an individual might choose objects which satisfy other than the transitive relation. The next step in a subsequent elaboration of the theory of rationality would include a concern for when non-transitive relations are found. This would involve the same procedure as the search for transitive behavior although the choice task environment would substantially change.

With the capacity to produce transitive relations clearly established as one criteria for rationality on the one hand, and the capacity to produce non-transitive relations on the other, then a complete theory of rational individual choice could be established. And in so doing, perhaps the empirical and formal results which tend to be task specific could be reconciled and combined into a consistent theoretical/methodological framework.

Of course, rational individual choice up to this point has only been considered in choice task environments under
certainty. Clearly a next step in building a general rational individual choice theory would be to perform extensive analysis in choice situations under risk and uncertainty. This would proceed along similar lines as the above investigation, using theoretical and empirical techniques within risk and uncertainty choice, treating each separately. Once production systems are constructed for each choice situation, then all three could be combined into an all-encompassing production system. This production system, once constructed, would then be subjected to further formal modification based upon subsequent empirical research.
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