THE EFFECT OF PERSONALITY CHARACTERISTICS
ON INFORMATION SELECTION, UTILIZATION
AND DECISION-MAKING

DISSERTATION

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By

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The problem with which this investigation is concerned is that of determining the role of personality in information acquisition and utilization during the decision-making process, by replicating the Schkade-Scarborough box design and the Kernan-Mojena chip design, using an expanded battery of psychological tests.

This investigation seeks to accomplish the following objectives: (1) review and summarize the present literature which relates personality and binary decision behavior; (2) review and summarize the present literature which relates personality with information transmission and utilization; (3) administer the *Minnesota Multiphasic Personality Inventory* (MMPI), the *Gordon Personal Inventory* (GPI), the *Gordon Personal Profile* (GPP), *EAS 7*, and *EAS 10* to a group of subjects who will also participate in both the box and the chip experimental designs; (4) replicate both the box and the chip experimental designs with a different set of subjects to test for consistency of findings; (5) perform canonical analysis on the box design, endeavoring to extend and refine the analysis of the data; and (6) compare the findings from the box and chip experimental designs, and identify areas for further research.

The purpose of this study is twofold. The first is to replicate and test the research findings of Schkade-Scarborough and Kernan-Mojena, which suggested that there is a statistically significant relationship
between decision performance, as defined by a set of decision performance metrics, and personality, as defined by a set of psychological test scales. The second purpose is to test the hypothesis that the same psychological scales which are significantly related to decision performance, as defined by the box performance metrics, are also related to decision performance, as defined by the chip performance metrics.

When regression analysis was carried out on the data, it supported the findings of the original researchers that personality is related to decision performance. Canonical analysis provided a much stronger coefficient of multiple correlation for the Schkade-Scarborough and Kernan-Mojena experimental designs than did the correlation analysis. Canonical analysis established a relationship between the predictor set and the criterion set which was significant at the .001 level.

When canonical analysis was conducted on the uniform set of predictor variables for the two experimental designs, the relationship between the predictor variables and the criterion variables was found to be significant at the .001 level. Five of the six most important predictor variables for the box design were found to be within the six most important predictor variables for the chip design, and ten of the top eleven variables related to the box decision-performance metrics were contained within the top fourteen predictor variables related to the chip decision-performance metrics.

This investigation supports the Schkade-Scarborough and Kernan-Mojena findings that personality, as defined by the psychological scales of the MMPI, GPI, GPP, EAS 7, and EAS 10 tests, seems to be related to decision performance. The evidence also strongly suggests that the same
psychological scales which are related to the way in which a person acquires and utilizes information in the box design are also related to the quantity and efficiency of information use as measured by the chip decision-performance metrics.
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CHAPTER I

INTRODUCTION

In contrast to all that man knows about aerodynamics, atomic energy, energy transformation, interstitial flows within an economy, and a myriad of other phenomena which account for the level of the current standard of living, very little is known about a process which has been instrumental in creating this reservoir of knowledge—the decision-making process. Not only is decision-making found in such esoteric areas as microbiology, genetics, energy transformation, and nuclear physics; it is also found to be an integral part of everyday life.

Herbert A. Simon, an eminent contributor to management theory, suggests that management and decision-making are essentially the same (21, 22) and that "management is a universal process in all organized living" (23, p. 182). This suggests that decision-making is an inherent part of everyday life, both in and out of the work environment. "One notes that families, homes, clubs, churches, schools, ball teams, offices, and one's personal affairs all need skillful management. Primarily, however, management is a basic operative force in all complex, purposive organizations, such as a business enterprise" (23, p. 182). Recognizing the significance of decision-making in the evolution of man, it seems most appropriate to try to understand more about the process or processes used by man in decision-making.
Statement of the Problem

During the decision-making process, there are two factors of interest to students of decision theory. First, one individual may require many times as much information as another prior to committing himself to a decision. For example, while one physician requires a battery of x-rays, a urinalysis, a series of blood tests, and answers to a multitude of questions before he is willing to recommend treatment, another physician asks a small number of questions and requests only a urinalysis to diagnose accurately the problem and to recommend treatment (10).

Not only do people require differing quantities of information prior to decision-making, but they utilize the information available in different ways. It is not uncommon for a physician who requires a great quantity of information prior to making a decision to arrive at an incorrect diagnosis while another physician who characteristically requires considerably less information upon which to base his decisions may consistently arrive at an accurate diagnosis (10). It should be observed that both physicians have identical information at their disposal—-one having much more information than the other. The question arises as to why one information processor or decision-maker consistently arrives at a more accurate decision than the other. Can the factors which cause one decision-maker to be a better information processor than another be identified, and can an individual's adroitness in decision-making be predicted by observing these factors? Which of the psychological scales are related to decision behavior and what is the nature of that relationship?
Jerry Scarborough and Lawrence Schkade developed an experimental design and apparatus designed to measure the quantity of information used during decision-making and the way the information is utilized in a laboratory binary-choice setting. In an endeavor to explain a subject's deviation from the normative model, the Minnesota Multiphasic Personality Inventory (MMPI) was administered to the subjects to determine if a relationship existed between the scales of the MMPI and the three performance scales, NS, CS, and IU, developed to describe the different observable propensities manifested by the subjects of the binary-choice experiment. The data compiled from these experiments were subjected to multiple linear regression and correlation analysis by employing a "stepwise" algorithm which established a statistically significant relationship among the three decision-performance metrics and selected experimental scales on the MMPI (6, 14, 15).

Working independently to ascertain the reasons why different decision-makers select different alternatives when confronted by the same decision situation, Jerome Kernan and Richard Mojena (9) reached the same conclusion as Scarborough and Schkade (15), that different decision-making strategies apparently emanate from psychological differences within the decision-maker. To test this hypothesis, three metrics, $\overline{P}_1$, $\overline{P}_2$, and $\overline{P}_3$, were developed (16), and these measures used the Shannon and Weaver basic information unit, called a "bit", to measure the utilization of the acquired information in decision-making (16). An efficiency scale, PS, was also developed to relate the amount of information acquired by the decision-maker to the correctness of his decision (9, 11). This metric was designed to compare information utilization among decision-makers.
Both research teams felt that the major determinant for the decision-making strategy selected by the decision-maker was in some way a reflection of the decision-maker's personality. Kernan-Mojena administered two psychological tests, the Gordon Personal Profile (GPP) and the Gordon Personal Inventory (GPI), to all of their subjects and used both multiple linear regression-correlation and canonical correlation to test this hypothesis (4, 5, 9). Both studies revealed a statistically significant relationship between personality and decision performance as defined by the respective psychological tests and decision-performance metrics.

The primary difference in the findings of the two studies was the fact that when chip experimental design and performance metrics were used, multiple linear regression and correlation failed to establish a statistically significant relationship between decision-making and personality as defined by the eight Gordon scales and the four Kernan-Mojena metrics, while canonical correlation established a relationship which was significant at the .01 level.

Although Scarborough-Schkade, using an information box design, and Kernan-Mojena, using a chip design, found a significant relationship between personality and decision performance, it is impossible to compare the two results, since the researchers used different psychological tests to measure personality and employed different analytical techniques to establish the relationship between personality and decision performance.

Therefore, the contribution of this study was to administer a uniform battery of psychological tests to a group of respondents, subject the results to a uniform group of analytical techniques, and compare
the results from these two different experimental techniques designed to establish a possible relationship between personality (as defined by the test results) and decision performance (as measured by the respective decision-performance metrics).

Objectives of the Study

This study had the following eight major objectives:

1. Review and summarize the present literature which relates personality and binary decision behavior.

2. Review and summarize the present literature which relates personality with information transmission and utilization.

3. Administer three psychological tests, the Minnesota Multiphasic Personality Inventory (MMPI), the Gordon Personal Profile (GPP), and the Gordon Personal Inventory (GPI), to a group of subjects who participate in both the chip and the box experimental designs. This allowed a comparison of the personality factors with subject performance in the experimental designs.

4. Increase the base of psychological tests by including tests of abstract reasoning, in an endeavor to account for a proportion of the decision behavior which is presently unexplained in both the box and the chip designs.

5. Replicate both the box and the chip experiments with a different set of subjects, to test for consistency of findings (25).

6. Perform canonical analysis on the box design, endeavoring to extend and refine the analysis of the data.

7. Perform comparative analysis of the findings on the box design and the chip design, in an endeavor to ascertain what relationships
exist between transmitted information and the utilization of that information in binary decision-making.

8. Identify areas for further research, including possible changes in the metrics used to measure behavior, changes in the experimental designs, and possible biophysiological interfaces with the decision-making process.

Hypothesis of the Study

Previous studies suggest that personality, as measured by the Minnesota Multiphasic Personality Inventory (MMPI), the Gordon Personal Profile (GPP), and the Gordon Personal Inventory (GPI), is related to both the quantity of information which an individual feels that he must have prior to committing himself to a decision and the way in which the acquired information will be utilized (9, 15, 19). Building upon the findings of these studies, it was hypothesized that:

1. Replication of the box and chip research designs will support the findings of the two previous studies that personality, as reflected by a group of psychological scales, is related to decision performance.

2. Abstract reasoning, as defined by the psychological tests, EAS 7 and EAS 10, is related to the quantity of information acquired (box design metric, NS, and chip design metrics, $\bar{P}_1$, $\bar{P}_2$, and $\bar{P}_3$), the quality of the information selected (box design metric, IU), and the utilization of the information for decision-making (box design metric, CS, and chip design metric, PS) (9, 12, 13, 14, 15).

3. The same personality scales which are related to a person's acquisition and utilization of information in the box design are related
to the power and the effectiveness of the search heuristic in the chip design.

4. Canonical analysis is a better analytical technique for the data generated by the box and the chip designs than regression-correlation analysis. As a consequence, the coefficient of canonical correlation will be larger than the Pearson Coefficient of Correlation.

Assumptions

It was assumed that an individual's decision-making behavior in a repetitive decision-making environment is affected by prior responses and prior reinforcements (2, 3, 24). It was also assumed that reward affects a decision pattern (18).

Delimitations

This research was confined to experimentation with binary-choice, uncertain-outcome situations which did not involve interpersonal factors in decision-making. The amount of information transmitted prior to decision-making was measured with the chip design information theoretic metrics (8, 9). These metrics concern the decision-maker's study of the possible alternatives, a procedure which resembles a k-step maze (8). Information utilization was measured by using the information box design (15). The psychological battery of tests used in attempting to find correlates between binary decision-making behavior and personality characteristics was the eleven experimental scales of the Minnesota Multiphasic Personality Inventory (MMPI), the four scales of the Gordon Personal Profile (GPP), the four scales of the Gordon Personal Inventory (GPI), the Employee Aptitude Survey 7 (EAS 7)
scale, and the Employee Aptitude Survey 10 (EAS 10) scale. The research was conducted with approximately thirty subjects from the Arlington, Texas, area.

Definitions

1. **Decision-making** is the selection between two or more alternatives.

2. The decision process encompasses identification of alternatives, discrimination between alternatives, and the follow-through necessary to act upon the basis of the alternative chosen.

3. A **closed decision model** is a decision framework in which all alternatives are assumed to be known, each alternative leads to a unique outcome, there is an established criterion for selecting between alternatives, and the criterion of effectiveness is designed to maximize or minimize income, pleasure, or some kind of utility. Secondly, given a closed model, it is assumed that an individual has access to all the information necessary to establish and correctly evaluate all the alternatives (1).

4. An **open decision model** is a decision framework which recognizes the dynamism of a decision environment and the limited amount of time available to choose between alternatives. Hence, the assumptions which are concomitant with the open decision model are (a) that only a limited number of alternatives can be considered and (b) that objective probabilities relevant to each alternative are not available. Consequently, objectives are replaced with aspiration levels, the changing decision environment reduces the quality and quantity of information available.
for discriminating between alternatives, and, instead of ranking alternatives in order to maximize utility, the decision is made on the basis of examining only a few alternatives and selecting one which is congruent with the individual's aspiration level. Closed and open decision models may be viewed as representing opposite extremes of a decision model continuum (1, 17, 20). Although completely closed or open decision models exist, when a reference is made to a closed or open decision model, what is generally meant is that the decision model is actually relatively closed or relatively open.

5. The chip decision performance metrics are the metrics developed by Kernan and Mojena to measure both the power and the efficiency of a decision-maker's search heuristic, which are respectively $F_1$, $F_2$, $F_3$, and $PS$.

6. $F_1$, $F_2$, and $F_3$ are metrics developed by Kernan and Mojena to measure the power of a person's search heuristic. These metrics use the Shannon and Weaver basic unit of information, called a "bit", to measure the quantity of information selected by a decision-maker prior to making his decision. A bit is defined as the amount of information necessary to choose between two alternatives. In the Kernan-Mojena experimental design, five cups were employed containing various numbers of poker chips. Each chip selection made by the respondent constituted a bit of information. The respondent continued to select chips from the five available cups until he indicated which of two colors he believed to be the predominant color across the five cups. A person selecting a relatively small chip sample prior to making his ultimate decision is said to have a strong search heuristic, while a person requiring a relatively
large chip sample prior to making his decision is said to have a weak search heuristic.

The only difference among the three separate metrics used to measure the power of a person's search heuristic is the formula employed to measure the number of bits acquired by the decision-maker prior to making his decision. Although all three of these metrics measure in bits the amount of information acquired by the respondent prior to his decision as to which of two chip colors is the predominant color, the quantitative difference among these three metrics is significant. This accounts for the fact that different search heuristic metrics \( F_1 \) are significantly related to different groups of psychological scales.

7. **PS or Point Score** is a metric designed by Kernan and Mojena to reflect the power and efficiency of a person's search heuristic. The PS scale diminishes with the acquisition of information, meaning that it reflects the power of a subject's search heuristic, and the scale is automatically zero if the respondent's decision is incorrect. The PS scale thus becomes an effectiveness scale.

8. The **box decision performance metrics** are the metrics developed by Scarborough and Schkade to measure the process through which a person employs information in decision-making, and they include NS, CS, and IU.

9. **NS** is a box scale designed by Scarborough and Schkade to measure the quantity of information (number of sources) which a person acquires prior to decision-making. The NS scale increases as the amount of information which a person acquires increases.

10. **CS** is a box scale developed by Scarborough and Schkade which measures a respondent's consistency of source selection. Each time the
respondent changes the source from which he acquires information, his CS, or consistency index, is increased.

11. IU is a box scale designed by Scarborough and Schkade to measure information utilization. The scale reflects a person's ability to select the best sources of information. Each information source in the box experiment has a different statistical probability of being correct, varying from .4 for selecting information source A to .8 for selecting information source C. The value of IU increases as the respondent selects better sources of information.

12. CMC is the Pearson Coefficient of Multiple Correlation, which is a measure of the co-variance between the dependent and independent variable(s). It is computed for both multiple regression and canonical analysis.

13. Canonical analysis is the maximum correlation between two linear functions, $L_1$ and $L_2$, where $L_1$ is a linear function defined over set one and $L_2$ is a linear function defined over set two (7). The advantage of using canonical analysis instead of regression analysis to determine the extent and direction of the relationship between two or more dependent variables and the predictor set for this study is the fact that it would be virtually impossible to prove that either the three-box design metrics or the four-chip design metrics are statistically independent. In fact, the metrics were not designed with independence in mind; hence, it is most likely that there is a considerable amount of overlap in the three-box design (NS, CS, and IU) and the four-chip design ($\tilde{F}_1$, $\tilde{F}_2$, $\tilde{F}_3$, and PS) behavioral performance metrics.
14. The predictor variables are the different scales from the psychological test battery, consisting of the eleven experimental scales of the MMPI, the four scales of the GPI, the four scales of the GPP, the EAS 7 scale, and the EAS 10 scale.

15. MMPI is the Minnesota Multiphasic Personality Inventory psychological test, consisting of the eleven experimental scales: Anxiety (A), Repression (R), Ego Strength (Es), Low Back Pain (Lb), Caudality (Ca), Dependency (Dy), Dominance (Do), Social Responsibility (Rs), Prejudice (Pr), Social Status (St), and Emotional Control (Cn).

16. GPP is the Gordon Personal Profile psychological test, consisting of the four scales: Ascendancy A(G), Responsibility R(G), Emotional Stability (E), and Sociability (S).

17. GPI is the Gordon Personal Inventory psychological test, consisting of the four scales: Cautiousness (C), Original Thinking (O), Personal Relations (P), and Vigor (V).

18. EAS 7 is the Employee Aptitude Survey 7, designed to test for verbal reasoning.

19. EAS 10 is the Employee Aptitude Survey 10, designed to test for symbolic reasoning.

20. The chip predictor set is a subset of the extended predictor set, consisting of the four scales of the Gordon Personal Inventory and the four scales of the Gordon Personal Profile.

21. The chip experiment or design refers to an experimental design developed by Kernan and Mojena to measure in bits both the quantity of information which a person acquires prior to predicting the predominant poker chip color spread over five containers and the efficiency with
which he uses the acquired information. The quantity of information contained in any one container is varied from two to sixty-four bits. The subject is allowed to sample from any or all of the chip containers until he feels that he knows the predominant color. Each subject is exposed to five different chip variations, in which the quantity of chips in each of the chip containers and possibly the predominant chip color are changed. The only constant is the color proportion, which is maintained at a sixty-forty ratio over the five chip containers.

22. The box predictor set is a subset of the extended predictor set, consisting of the eleven experimental scales of the Minnesota Multiphasic Personality Inventory.

23. The box design refers to the Feldman binary-iterative experimental process, which has been modified by Scarborough and Schkade to include sources of information from which a subject can buy information as to which of the binary symbols (v or +) will be displayed next from a random process. The degree to which any one of the three information sources is correct is controlled at 60 percent, 40 percent, and 80 percent, respectively, or the subject can choose not to acquire information from any of the information sources. The probability of either symbol appearing on any trial is 50 percent. This experimental design is described in more detail in Chapter II.

24. The extended box experiment or design refers to using the extended predictor set with the box experimental design.

25. The extended predictor set refers to using the four scales from the Gordon Personal Profile, the four scales from the Gordon Personal Inventory, the eleven experimental scales from the Minnesota Multiphasic
Personality Inventory, the EAS 7 scale, and the EAS 10 scale as the predictor set (independent variables) for the NS, CS, IU, \( \tilde{P}_1 \), \( \tilde{P}_2 \), \( \tilde{P}_3 \), and PS metrics.

26. The extended chip experiment or design refers to using the extended predictor set with the chip experimental design.
CHAPTER BIBLIOGRAPHY


This chapter presents a historical perspective of decision-making as it reflects the evolution of cultural advancement and sophistication from the prehistorical, biological origin of decision-making to its present level of sophistication. There are six major milestones which are believed to be important in understanding how decision-making arrived at its present state, including a significant variation between individuals in information utilization. In covering these major milestones, this chapter deals with the accelerating advancement in the understanding of the process of decision-making, the development of models to explain decision-making, the contradiction between the predictions made by certain predictive models, the Siegel model developed to overcome this contradiction, the limitations of the Siegel model, and the effect of information on the decision-making strategy.

The historical evolution of decision-making can be grouped into three distinct stages: (1) biological decision-making, (2) cultural decision-making, and (3) specialized decision-making. The history of decision-making goes back to the beginning of time when biological sophistication was limited to the unicellular organisms. The survival of the tiny organisms depended upon their ability to discriminate between toxic and nutritious substances for assimilation. This small biological decision-maker was the first organism to be confronted with
the problems of decision-making, and in no case were the consequences of an incorrect decision more costly (2).

With the passage of time, all types of organisms became more complex, and their survival depended upon being able to perceive signs of danger by way of stimulus-response circuits or the cognitive process. At this point, they not only were dependent upon their "hard-wired behavior" or instincts, but they were also dependent upon parental education (27). This is called cultural decision-making by Bross, since it involves a base of knowledge that must be transferred from generation to generation. As an example, research indicates that cats must be taught to eat mice (2, 27).

The increasing population and the economic changes that were responsible for the growth in townships were responsible for many cultural changes. It appears that concomitant with the growing complexity of the social order in the new townships was a search for decision-makers to provide a degree of stability to what had been a chaotic state. It was these early social conditions which engendered the first figures of specialized social authority, including priests, kings, and warlords (2, 27).

Outcome Rationale

With the arrival of specialized decision-makers whose responsibility was to make decisions which affected the entire society, decision-makers found it necessary to explain failure. As these early decision-makers did not understand the elements and the laws of nature, they attributed all adverse conditions and outcomes to evil spirits
or devils (2). Thus, superstition or mysticism became the vehicle employed by decision-makers to explain outcomes or phenomena beyond their present level of comprehension.

As men became more sophisticated in the use of words, language was used and misused in the process of decision-making to the extent that it became necessary to construct a taxonomy in which rules governing the use of language could be codified. This set of rules was called logic, and the art of applying these rules was called reason (2). This was a very important concept in the evolution of decision-making, since it was the point at which decision-makers tacitly recognized the difference between the process of decision-making and the outcome or result of the decision-making process.

The objective of decision-making experimentation has been to predict which alternative the subject would choose. Until relatively recently, the focal point of decision-making research has been to try to associate decision behavior patterns with a person's alternative selection. The decision-making problem was approached by first considering all the significant alternatives and then selecting one of the alternatives, using some criteria for discrimination. Any selection which did not maximize expected outcome was considered irrational. It should be emphasized that the attention is focused upon the end product of decision-making--the outcome.

The method which is now being employed to understand and explain decision-making is called the scientific method (2). This method calls for the decision-maker to recognize the alternatives, collect and evaluate information related to the probability of each alternative,
and then employ a criterion of efficiency (assess the subjective expected utility in view of the information at hand) to arrive at a decision (19). Rationality in this model is defined in terms of the criterion of efficiency; hence, what is considered to be the rational decision is mutable, changing with the fickleness of the decision-maker's changing assessment of the situation and the weight which he attaches to the different information sources.

As is the case in most evolving disciplines, the development must first begin with a word model, and as the discipline becomes more developed, attempts are made to quantify what is perceived. Quantification minimizes the ambiguity in model description. Secondly, quantification helps describe the complex interrelationship among parts. With the ability to quantify comes the ability to predict outcomes, and with the ability to predict outcomes, comes the ability to change outcomes by effecting a change in input.

Although the formal study of decision-making can be traced as far back as Plato's early work on the motivation for decisions in Republica Kybernetike, this historical perspective will be limited to modern times during which the focal point of decision study has been decision-making inside a developed economic system.

The formal study of decision-making in economics began with Bentham's observations of the forces which cause individuals to choose between alternatives. Bentham's decision-making tenet, called hedonism, postulated that humans were pleasure-pain calculators and that all decisions were made by endeavoring to maximize pleasure and minimize pain (12). Over time, this tenet became suspect, and the main thrust of
decision-making was toward trying to quantify the difference in outcomes with the assumption that a rational person would choose the alternative which would maximize the expected outcome. Recognizing that an absolute quantity of any substance would not necessarily have equal value for all persons, J. Von Neumann and O. Morgenstern developed the game theoretic model which incorporated the subjective factor into a decision-making formulation and concluded, on the basis of a closed decision-model, that a rational decision is the one for which expected utility or satisfaction is maximized (26).

The primary postulate of the game theoretic formulation developed in the late 1940's was that a rational individual confronted with an uncertain-outcome situation would select that decision which would maximize his expected utility. This was especially true in the case of repetitive decisions. Von Neumann and Morgenstern postulated that in the case of repetitive decision choices, rational people learned to maximize expected utility (26). Siegel and Goldstein stated that,

one prediction consistent with this game theoretic model is that a person will learn to maximize the expected frequency of correct predictions. This is accomplished by his predicting the more frequent event on all trials (22, p. 162).

An example showing the rationale for this strategy of decision-making concerns the individual confronted with a binary uncertain-outcome situation where the outcome of the two events is random. If the two random events are controlled in such a way that the first event occurs with probability $P$ and the second event with probability $1 - P$ with the events set at .75 and .25, respectively, the game theoretic model states that, if the person chooses a pure strategy of selecting the most
probable event on every trial, his expected proportion of correct responses will be maximized.

If \( p \) equals the proportion of the time during which a person selects the most probable event \( T \) and \( 1 - p \) equals the proportion of the time during which a person selects the least likely event, then

\[
E_x = p^T + (1 - p)(1 - T)
\]

for \( p = 1 \)

\[
E_x = 1(T) + 0(1 - T) + 0.75;
\]

hence, the pure strategy of selecting the most probable event on every iteration, given the proportion of correct responses, is 75 correct to 25 incorrect out of each 100 trials. Given that a person chooses some strategy other than a pure strategy, for instance, choosing the most probable event on 90 percent of the choice iterations and the least probable event \( (1 - T) \) on 10 percent of the choice iterations, the proportion of correct responses would be reduced. Then

\[
E_x = .90(.75) = (.10)(.25) = .70,
\]

or the proportion of correct responses would be 70 percent.

It was shown by Von Neumann and Morgenstern, as a by-product of their development of the theory of games, that if the choice situation were extended to include choices among uncertain prospects, such as buying lottery tickets or purchasing insurance, cardinal utilities could be assigned to the outcomes in an unequivocal way. Under these conditions, if the subject's behavior were consistent, it was possible to measure cardinally the utilities that different outcomes had for him and to predict his behavior as a result (26).

To test the propensity of an individual to avoid risk and, hence, buy insurance, Schkade and Menefee (18) developed a normative model
designed to offset the premium costs of purchasing collision car insurance with larger deductibles. For a person to minimize car insurance cost, it was found that the optimal deductible is approximately $150. The study also observed that the preponderance of the policies sold are for $50 and $100 deductibles; hence, the insurance buying propensity of most people is contradictory to what is considered rational behavior from the normative expected value model (18).

The first formalized effort to describe quantitatively human choice behavior was developed by Von Neumann and Morgenstern in what has been called the game theoretic model (the utility of an outcome multiplied by the probability of an outcome). A person who behaves in a manner consistent with the axioms of choice described by Von Neumann and Morgenstern acts to maximize the expected value of his utility (26). The theory can be tested empirically, however, only on the assumption that the probabilities assigned to the alternatives by the subject are identical with the "objective" probabilities of these events as known to the experimenter (1, 24). Thus, a person operating under the conditions of uncertainty would maximize his expected utility derived from maximizing the number of correct responses by choosing a pure strategy. There are some research findings which indicate that under certain circumstances, people tend to behave in this manner (6, 7, 22, 25).

The second theoretic development designed to explain human choice behavior was developed by W. K. Estes in what has been called statistical learning theory. The Estes model predicts that an individual will learn to match his response ratios to the actual ratios between the events (4). The same prediction is made by the Bush-Mosteller model, given certain
restrictions on the parameters of the model (3). There is a substantial amount of experimental support for the statistical learning theory model (5, 8, 20).

Given the statistical learning theory model, if $\pi$ (the probability of the most probable event) is .75 and $1 - \pi$ (the probability of the least probable event) is .25, then the proportion of correct responses would be computed as follows:

$$E_x = p\pi + (1 - p)(1 - \pi)$$

$$E_x = .75(.75) + .25(.25) = .625,$$

or the respondent would have an expected correct response of .625.

It is of particular interest that the game theoretic and the statistical learning theory models support contrasting behavior patterns as manifesting rational behavior, and both models are supported by an impressive quantity of experimental findings as stated by Sidney Siegel:

Some behavioral scientists who have been influenced by game theoretic principles have asserted that people who match their response ratios to the probabilities of the events are acting irrationally, in that they are failing to maximize their expected proportion of correct predictions, a goal they could accomplish by predicting the more frequent event on every trial. The empirical fact is that in this situation most people do, after many trials, stabilize at matching their response ratios to the probabilities of $E_1$ and $E_2$. To assert that this is irrational is to rely on a highly restrictive meaning of that term. It was pointed out by Bernoulli in the first half of the eighteenth century that any theory of rational behavior which does not incorporate the concept of the utility or subjective value of the outcomes rather than their objective value will lead to paradoxes of the kind under discussion. As Simon has reminded us, one must bear in mind the distinction between objective rationality (rationality as viewed by the experimenter) and subjective rationality (behavior that is rational, given the perceptual and evaluational premises of the subject) (21, p. 149).
Siegel defined what he called subjective expected utility in order to clarify this apparent paradox. Subjective expected utility (SEU) is based on two factors: (1) the probability of a particular event happening; since the true probability is not known, the probability attached to an event is the subjective probability of the various outcomes and (2) the utility (the personal satisfaction) derived from an outcome. The utility attached to the different outcomes is affected by the reward structure associated with each event. In addition, Siegel pointed out that people have utility for more than a correct response. For a person to choose a pure strategy of selecting the most probable event on every trial would lead to kinesthetic and cognitive monotony (21).

Based upon these defined traits, three models were developed by Siegel which have the capability of predicting behavior from one end of the decision-making spectrum, as depicted by the Estes model, to the other end of the decision-making spectrum, as depicted by the Von Neumann and Morgenstern game theoretic model (21). If the utility of a correct decision and/or the negative utility of an incorrect decision is systematically varied and if the utility of an outcome is the knowledge that a person's prediction is right or wrong, the decision behavior would be expected to reflect the occurrence ratios between the events. If the utility (positive and/or negative) is systematically increased, a person's decision behavior should asymptotically approach a pure strategy. These predictions are based upon the following two models in which the second model is an extension of the first which allows for risk assumption (gambling) to be incorporated into the model.
Model I

Let $\tau$ = probability of occurrence of the more frequent event
$p$ = proportion of times the subject chooses the more frequent event
$a$ = marginal utility of a correct prediction
$b$ = marginal utility of varying one's responses

If the expectation that a subject's prediction will be correct, $E_x$ is

$$
E_x = \frac{1}{2} \left[ p \tau + (1 - p)(1 - \tau) \right] = \left[ (1 - \tau) + p(2\tau - 1) \right]
$$

then the expected utility of a correct prediction $U_x$ is

$$
U_x = aE_x = a \left[ (1 - \tau) + p(2\tau - 1) \right] \quad (21, \text{p. 151}).
$$

It is recognized that in some cases the payoff or utility of achieving a correct response by picking the least probable event $1 - \tau$ is greater than the utility of selecting $\tau$. A model which is sensitive to this possibility is much more powerful than Model I; it also is capable of taking into consideration a person's propensity to assume or to avoid risk (21).

As the propensity of a decision-maker to assume or avoid risk is an important decision-performance criterion, Model II overcame many of the weaknesses of Model I. Model II is an extension of Model I with the primary difference being that Model II considers the possibility that there can be a substantial probability associated with correctly predicting the least probable event. This utility could be considered the utility of gambling.

Model II

Let $\tau$ = probability of occurrence of the more frequent event
$p$ = proportion of times the subject chooses the more frequent event
$a$ = marginal utility of a correct prediction when and only when the subject chooses the more frequent event
$b$ = marginal utility of a correct prediction when and only when the subject chooses the less frequent event
$c$ = marginal utility of varying of one's responses

The expected utility of a correct prediction $E_x(U_x)$ is
\[ E_x(U_R) = ap\pi + b(1 - p)(1 - \pi) \]

and the utility of varying one's responses \( U_R \) is

\[ U_R = cp(1 - p) \]

The total expected utility of a particular strategy \( p \) is

\[ U(p) = ap\pi + b(1 - p)(1 - \pi) + cp(1 - p) \]

The strategy \( p \) which maximizes \( U(p) \) is at point

\[ \frac{dU(p)}{dp} = 0 \]

and is

\[ p = a\pi - b(1 - \pi) + c \]

If \( a = a/c \) and if \( \beta = b/c \), then

\[ p = \frac{(1 - \beta) + \pi(a + \beta)}{2} \]

(21, p. 153).

If \( a = b = c \), where \( \alpha = \beta = 1 \), Model II yields the special case where \( p = \pi \) or the proportion of the time in which the most probable event predicted is equal to the proportion of the time the more probable event occurs. This allows the payoffs to be varied for the more probable and less probable events in order to determine their effect on the decision strategy (21).

The principal limitation with either of the foregoing models is that, in order to ascertain information source \( A, B, \) or \( C \), it is necessary to use preliminary experimental results to predict decision behavior on later trials as stated by Robert Radlow:

The decision-making analysis of repetitive-choice behavior appears to be quite accurate and essentially valid. It leads to the prediction of approximately correct asymptotes of choice behavior and to an approximately correct evaluation of the effect of magnitude of reinforcement. These results are not conclusive, but they certainly encourage a closer examination of the theory.

One significant gap continues to exist. Although it has been shown that the acquisition of subjective probability appears to be a distinguishable process, as the formalization of the utility models discussed here would require, a theory for the acquisition of subjective probability is not included (17, p. 273).
A theory for the determination of subjective probability is not available. In fact, Siegel's model assumes that the utility of success is a linear function based on $p$, the proportion of the time that the most probable outcome is predicted, and $IT$, the theoretic probability of the most probable outcome over the entire range for both $p$ and $IT$. It would appear that this assumption is suspect, since the utility for a success would logically seem to change as the potential reward moves along a continuum from $.01$ to $1000$. Although this assumption is suspect, it is recognized that Siegel was not the only decision theorist assuming a linear success function since both the Von Neumann-Morgenstern and the Estes decision models assumed that subjective expected utility is not influenced by changes in the reward structure (4, 26).

Another problem of the Siegel model is its requirement that the decision process be a repetitive process so that the decision-maker will have a sufficient number of outcome iterations to assess the outcome relationships between the two collective exhaustive outcomes. Lastly, there is no indication as to how many iterations a decision-maker would have to go through in order to be able to assess correctly the true statistical proportions between the two outcomes.

Based upon the difficulty which a decision-maker has in assessing the statistical probability of the two outcomes, it is palpable that information is important to the "laboratory" decision-maker just as information is important to the decision-maker outside the laboratory setting. Whenever a decision-maker is confronted with the problem of choosing between alternatives, whether in trying to decide which consumer products to choose, where to locate a new plant, which channel of
distribution to be most advantageous, or which political party or candidate to support in the next election, he is beset with more alternatives and information germane to the decision than can be successfully analyzed. For example, the relatively small area of medicine known as dermatology is purported to have more than 6000 maladies which a dermatologist must be able to discriminate between on the basis of eclectic information (13). When one adds the astronomical number of symptoms associated with this number of maladies, the difficulty confronting a decision-maker comes into focus. As Lee B. Lusted indicated, it is impossible for a decision-maker (physician, in his case) to be able mentally to codify that many alternatives with the environmental cues (entropy) necessary to discriminate infallibly between the alternatives (13).

For this reason, a closed system with its assumptions of all alternatives being known, known probability associated with each alternative, availability of all knowledge germane to the decision, and adequate time to assimilate the information concerning an impending decision is important from a decision theoretic point of view but not from an application point of view. From a pragmatic (non-theoretical) point of view, the ability to enumerate accurately all possible alternatives and accurately assess the probability of an outcome, as assumed in the case of a closed decision model, is not possible; nor is it normal to have only three or four alternatives, as assumed in the case of an open decision model. Hence, theoretically open and closed decision models do exist, but in most cases, the decision-maker is faced with a situation in which not all of the alternatives are known and in which those that are known cannot be accurately predicted (1, 15, 23).
There are a number of factors which appear to limit an individual's ability to codify and assimilate information, including the limited resource time in information evaluation and the limited capacity of a person to process information (10, 14) where information is defined to be stimuli which result in a correct response (9, 14). This means that, when the number of environmental cues or entropy considered is excessive, noise or extraneous stimuli tend to reduce the information quality causing response errors. The number of stimuli which a person can accurately discriminate are said to mark physiological channel capacity as stated by George A. Miller:

If the observer's absolute judgments are quite accurate, then nearly all of the input information will be transmitted and will be recoverable from his responses. If he makes errors, then the transmitted information may be considerably less than the input. We expect that, as we increase the amount of input information, the observer will begin to make more and more errors; we can test the limits of accuracy of his absolute judgments. If the human observer is a reasonable kind of communication system, then when we increase the amount of input information, the transmitted information will increase at first and will eventually level off at some asymptotic value. This asymptotic value we take to be the channel capacity of the observer . . . . (14, p. 148).

When the limited resource time is considered in conjunction with the multiplicity of alternatives available in most decision settings and when channel capacity is considered in conjunction with the amount of information available which is relevant to the multiplicity of alternatives taken collectively, it is evident that decision-makers must employ some technique for reducing the number of alternatives and the amount of information considered.

The way in which the number of alternatives and the volume of information considered is reduced is by the employment of intrinsic heuristics
which Herbert A. Simon calls the employing of a planning heuristic and a search or selective heuristic (16). The planning heuristic reduces the number of alternatives, and the selective heuristic reduces the entropy germane to each alternative (10).

The factors which determine the power of these search heuristics are immensely important to decision theory where power is defined to be the extent to which the heuristics reduce the amount of environmental entropy processed in arriving at a decision (10). This means that individuals possessing power heuristics employ few environmental cues or stimuli to arrive at a decision, and individuals employing weak heuristics accept a large portion of the environmental cues available prior to decision-making (11, 13, 14). Not only do certain individuals use more powerful heuristics than others, but some individuals use more efficient heuristics than others (both the power and the efficiency of a heuristic are discussed in detail in Chapter III).

The efficiency of the intrinsic heuristics is a metric which not only measures the difference in quantities of information considered but also involves the accuracy of the decision. For instance, one physician may ask five questions, look at the results of two laboratory tests, and arrive at a correct diagnosis of the malady. Another physician, examining the same patient, may ask fifty questions, examine the results of ten laboratory tests, but not be willing to commit himself to a diagnosis, or if he does indicate a diagnosis, it may be wrong (13). In view of this paradox, it appears that some people not only have a powerful search heuristic, but they also have an efficient heuristic which adds the condition of a correct response or decision resulting from some stimuli.
From this example, the increased complexity of today's decisions in relation to that of the unicellular organisms is evident. Unfortunately, it does not appear that current knowledge of decision-making has kept pace with the increasing complexity of the decisions with which man is confronted.

Summary

Decision-making had its origin in prehistorical unicellular organisms, and the progress in decision-making seems to have paralleled the cultural progress of man. The evolution of decision-making resulted in the development of conflicting quantitative models in the 1900's. Siegel incorporated these two models into a single model which was capable of integrating the utility for success and the utility for variability.

Although the Siegel model was a significant step forward, it had major limitations, including the necessity for a decision-maker to participate in a decision model for several iterations before his behavior could be predicted. Observing the differences between an individual's utility for information and his propensity to use information caused several researchers to hypothesize that the manifested differences could be attributed to personality differences.
CHAPTER BIBLIOGRAPHY


CHAPTER III

THEORETICAL DEVELOPMENT OF AN INFORMATION ACQUISITION, SELECTION, AND UTILIZATION MODEL

Both the Scarborough-Schkade and the Kernan-Mojena experimental designs are developed in this chapter, and the original results are presented. An underlying premise of both designs is the notion that the quality of the final decision is influenced by the information acquisition, selection, and utilization as well as by the quantity of information acquired, the ability to choose between the better sources of information, and the confidence to utilize available information wisely which are functions of personality (13, 14, 15). Both designs have described personality by a selective group of psychological scales and have developed decision-performance metrics to reflect the manifest differences in individual decision patterns while participating in a laboratory experimental environment.

The significant milestone toward the ability to measure the amount of information transmitted was provided by Claude Shannon and Warren Weaver (17) in 1949 when they used the computer age unit of measure, the "bit", to develop a theoretical measure of information transmission (6, 18). This is also the unit of measure used by Kernan and Mojena (6) to measure the quantity of information transmitted. It is recognized that this logarithmic metric has been abused as frequently as it has been utilized correctly (10), but it remains a conceptually sound metric for measuring the quantity of information within a system (5).
To measure the amount of transmitted information in an information-theory sense, it is necessary to take into consideration the total information cues (bits) and the total number of transmitted cues, including noise. If \( T(I) \) represents the total number of environmental cues "available" to the decision-maker and \( T(S) \) represents the total number of environmental cues "accepted" by the decision-maker, \( T(S) \) includes environmental cues and noise. The transmitted information would be \( T(I \cap S) \leq T(I) \). Assuming that information selection is a search among sources of environmental cues (1, 2, 4, 6, 9) and that the information contained in these information sources is measurable in bits (8, 16, 18), the \( T(I) \) total information can be measured with the metric:

\[
T = \sum_{i=1}^{k} T_i; \quad i = 1, 2, \ldots, k
\]

where \( T_i \) is the quantity of information contained in each information source measured in bits such that

\[
T_i = \log_2 I_i.
\]

In the cross-cultural experimentation conducted by Lawrence Schkade, Vincent Cangelosi, and D. M. Robinson (15), it was shown that a person's decision-making strategy asymptotically approaches a pure strategy as a function of the outcome proportions (11). Given that the amount of information considered will affect decision strategy and, hence, the accuracy of the decision (5, 11), Kernan and Mojena formulated three metrics, \( \bar{F}_1, \bar{F}_2, \) and \( \bar{F}_3 \), to measure the amount of information used in decision-making. Assuming that a decision is preceded by some search strategy designed to provide a sufficient amount of information upon which to make a decision (1, 2, 4, 6, 9) and that the information transmitted can be measured in bits (7, 12, 18), the three metrics measure the amount
of available information used by a person prior to his decision. "In absolute terms (bits), this quantity is reported as $\overline{F}$—the average amount of information used ('transmitted' in an information-theoretic sense)"(6, p. 2).

Given these assumptions, the total amount of information or environmental cues can be measured by viewing a person's information search process as analogous to moving through a $k$-step maze where each step represents different stores, vendors, or vendees and where each step passes $A_i$ equally-likely alternatives which could be viewed as different products to choose between. In this experiment, the number of steps used is five, and the number of alternatives at each step (poker chips in a container) $A_i$ varies from two to sixty-four. Each subject faces five of these experimental information mazes. The total amount of information in any information maze measured in bits can be determined by

$$TI_i = \log_2 A_i$$

where

$$TI_i \text{ for } i = 1, 2, \ldots, k$$

is the amount of entropy in bits contained in the $i^{th}$ container. Hence, the total entropy in an information maze is expressed by

$$TI = \sum_{i=1}^{k} TI_i; \text{ } i = 1, 2, \ldots, k.$$

Transmitted information—the number of bits used by subjects—was measured in three alternative ways, each of which assumes additivity across steps (containers):

$$T_1 = \sum_{i=1}^{k} d_i/m_i \cdot TI_i; \text{ } i = 1, 2, \ldots, k. \quad \text{[Formula 4]}$$

$$T_2 = \sum_{i=1}^{k} (TI_i - TI_i^*); \text{ } i = 1, 2, \ldots, k. \quad \text{[Formula 5]}$$

$$T_3 = \sum_{i=1}^{k} \log_2 d_i; \text{ } i = 1, 2, \ldots, k. \quad \text{[Formula 6]}$$

where

$T_3 = \text{transmitted information in bits.}$

$TI_i = \text{total information available from } i^{th} \text{ container as calculated by Formula 2.}$
\(d_i = \) number of alternatives utilized \((m_i \text{ available})\) from the \(i^{th}\) container.

\(TI_i = \log_2 (m_i - d_i),\) amount of information left or not utilized in the \(i^{th}\) container.

The rationale for the alternative formulations . . . is comparatively straightforward. \(T_1\) determines transmitted information as a proportion of the original information available, that proportion determined by the ratio of alternatives utilized to alternatives available. \(T_2,\) on the other hand, calculates transmitted information as the algebraic difference between original and terminal (unexhausted) information states. Finally, \(T_3\) calculates the quantity directly as the number of binary alternatives utilized. Although each formulation proceeds directly or indirectly from Shannon's logarithmic metric, there is not typically equivalence among the quantity-of-information measures resulting from them (6, pp. 5-6).

After each subject's performance on the five information mazes had been recorded, absolute means \(T_1, T_2,\) and \(T_3\) were calculated to the mean transmitted information. From \(T_1, T_2, T_3,\) and \(TI,\) a metric can be established to measure the power of that subject's search heuristic.

\[P_j = \frac{T_j}{TI}; \ j = 1, 2, 3.\]

As \(P_j\) approaches unity, the power of the search heuristic becomes weaker, and as the metric asymptotically approaches zero, the power of the search heuristic becomes monotonically more powerful.

One significant deficiency in using either \(T\) or \(P\) to measure the effectiveness of the search heuristic is that neither considers whether the subject was correct or incorrect in his response or decision. Therefore, the Point Score (PS) used to rank each subject becomes a very important metric in measuring the information power of his search heuristic.

As Kernan and Mojena indicate, the objective and structure of PS is to (a) induce them to be adequately motivated, . . . and (b) afford an inferential measure of the efficiency of their heuristics. Prior to participating in the experiment, subjects knew of the potential rewards . . . but not of the precise method of determining their disposition (6, p. 7).
PS was determined by the metric:

$$\text{PS} = \sum \text{PS}_i; \ i = 1, 2, \ldots, k$$

where

- \(\text{PS}\) = the total Point Score over the \(k\) decision iterations.
- \(\text{PS}_i\) = the Point Score on the \(i^{th}\) decision iteration.

Further,

\(\text{PS}_i = 105 - 100 \frac{n_i}{N_i}\), given that the subject makes a correct decision. The PS value on any iteration is zero if the decision is not a correct one. (In this laboratory experiment, a correct decision means that a subject correctly chooses the predominant color from a colored poker chip mix of 60 percent/40 percent). In this formulation:

- \(n_i\) = the number of environmental cues accepted by the subject from the different environmental sources of information prior to his decision on the \(i^{th}\) decision iteration.
- \(N_i\) = the total amount of information available to the decision-maker from the \(k\) information sources.

Thus, the information-power of the subject's search heuristic monotonically increases and asymptotically approaches a high of 525. The lower limit of PS is zero which represents a very weak search heuristic. Kernan and Mojena warn that caution must be used in assessing the information-power of a heuristic because guessing could be a factor with some subjects.

The objective of PS is to effect ego involvement and to test the effectiveness of the subject's intrinsic heuristic. The subjects knew that they were vying for a $20, $10, and $5 reward which would be awarded on the basis of the highest PS. The subjects were informed only that the less information that they accepted, the higher their Point
Score, provided they made a correct decision. If the decision were incorrect, then no points would be given.

In an information-theoretic sense, $n_1$ would correspond to $T(I \cap S)$ and $N_1$ would correspond to $T(I)$. Although the amount of transmitted noise is very important, there does not seem to be any way that the sources of that noise or the number of transmitted bits of noise can be measured directly. It is possible to get some indication of the transmitted noise by observing how efficiently a decision-maker employs the environmental cues in arriving at a decision.

It would appear that, when objective information is transmitted in the form of environmental information bits, any noise which enters the system must be internally generated. If a person's personality characteristics are found to be a major factor in determining the quantity of information used in decision-making and the process through which the information is employed in arriving at a decision, then it would appear reasonable to assume that personality, as it reflects the emotional state of an individual, is a major source of "noise" in the informational channel which results in an irrational strategy given either the game-theoretic or the statistical learning-theory normative models.

Since it was found that $\bar{P}_j$ and PS were significantly correlated, a single measure $\gamma$ was devised to replace them where

$$\gamma = \frac{PS}{\bar{P}_j}.$$  

$\gamma$ = a decision-making efficiency measure over the $k$ decision iterations.

PS = a person's Point Score over the $k$ decision iterations.
\[ \tilde{P}_j \] = a subject's average power measure for all five decision iterations (\( \tilde{P}_j \) is the ratio of accepted environmental cues to the number of cues available).

The larger the value of \( \gamma' \), the more efficient a person's search strategy is said to be. The value of \( PS \) gets larger as the number of environmental cues accepted diminish and the number of correct decisions increase. The value of \( \tilde{P}_j \) gets larger as the number of environmental cues accepted as a proportion of the environmental cues available decreases; hence, a person's search heuristic becomes more efficient as \( PS \) increases in relation to \( \tilde{P}_j \).

The previously discussed metrics are designed to measure an individual's utility for information (the size of \( \tilde{F}_j \) and \( \tilde{P}_j \)) and how efficiently he utilizes the information which he accepts (\( PS \) and \( \gamma' \)). Given the assumption that there is considerable disparity in a person's propensity to acquire and utilize available information in decision-making, it has been hypothesized that this disparity can be attributed to personality differences (6, 8, 15).

To test this hypothesis, Kernan and Mojena contrived a laboratory experimental design where subjects sampled the population of poker chips \( T(I) \) or \( (\gamma'_1) \) from five chip containers (k information sources) with the objective of predicting the predominant chip color (a correct decision). Each subject was also administered the Gordon Personal Profile and the Gordon Personal Inventory as a measure of personality characteristics.

The quantity of information employed in decision-making (\( \tilde{F}_1 \)) given in Table I and the power of the search heuristic given in Table II show that the results of the experiment were very encouraging. It is
palpable that the quantity of information accepted in decision-making increases with an increase in the environmental complexity, but is not proportional to the increase in the number of environmental cues. $T_j$ and $E_i$ are hypersensitive to extremes in information transmission. The power measures indicate that subjects "tended to sample available information more heavily at low-bit levels than at high ones" (6, p. 12).

TABLE I

MEAN TRANSMITTED INFORMATION, IN BITS*

<table>
<thead>
<tr>
<th>Maze Size (Bits)</th>
<th>Number of Observations</th>
<th>Formulation</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$T_1$</td>
<td>$T_2$</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>2.08</td>
<td>3.47</td>
</tr>
<tr>
<td>7</td>
<td>13</td>
<td>3.08</td>
<td>4.22</td>
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<td>9</td>
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<td>2.86</td>
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<td>13</td>
<td>3.64</td>
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<tr>
<td>Mean</td>
<td></td>
<td>3.29</td>
<td>2.68</td>
</tr>
</tbody>
</table>


Another interesting measure is the average proportion of available environmental cues employed in decision-making. "As Table II shows, subjects made their decisions as regards color dominance of the chip
populations using an average of only 27 percent of the information available to them," (6, p. 12) or it appeared that subjects disregarded about 75 percent of the available information (6).

TABLE II

MEAN POWER MEASURES*

<table>
<thead>
<tr>
<th>Maze Size (Bits)</th>
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<th>Formulation</th>
<th>Mean</th>
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<td></td>
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<td>.19</td>
<td>.11</td>
</tr>
<tr>
<td>23</td>
<td>13</td>
<td>.17</td>
<td>.07</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>.28</td>
<td>.27</td>
</tr>
</tbody>
</table>


Table III is the zero-order intercorrelations matrix which presents some interesting, but problematic results.

First, the intercorrelations among the eight personality traits are higher than commonly assumed. . . . That these are statistically significant, however, hardly means that they are analytically troublesome; only six of the coefficients are as high as .50.

A second observation from Table III is that all three power measures are significantly intercorrelated. . . .
### TABLE III

**BASIC INTERCORRELATION MATRIX**

<table>
<thead>
<tr>
<th></th>
<th>A(G)</th>
<th>R(G)</th>
<th>(E)</th>
<th>(S)</th>
<th>(C)</th>
<th>(O)</th>
<th>(P)</th>
<th>(V)</th>
<th>$\bar{P}_1$</th>
<th>$\bar{P}_2$</th>
<th>$\bar{P}_3$</th>
<th>PS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascendancy A(G)</td>
<td>1.00</td>
<td>-0.448*</td>
<td>-0.216</td>
<td>0.771*</td>
<td>-0.536*</td>
<td>0.026</td>
<td>-0.070</td>
<td>0.148</td>
<td>0.003</td>
<td>0.015</td>
<td>-0.029</td>
<td>-0.376*</td>
</tr>
<tr>
<td>Responsibility R(G)</td>
<td>1.00</td>
<td>0.517*</td>
<td>-0.323</td>
<td>0.593*</td>
<td>0.107</td>
<td>0.377*</td>
<td>0.234</td>
<td>0.066</td>
<td>0.057</td>
<td>0.094</td>
<td>0.249</td>
<td></td>
</tr>
<tr>
<td>Emotional Stability (E)</td>
<td>1.00</td>
<td>-0.250</td>
<td>0.445*</td>
<td>-0.096</td>
<td>0.541*</td>
<td>0.209</td>
<td>-0.135</td>
<td>-0.17</td>
<td>-0.059</td>
<td>0.173</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sociability (S)</td>
<td>1.00</td>
<td>-0.408*</td>
<td>0.070</td>
<td>0.094</td>
<td>0.014</td>
<td>0.187</td>
<td>0.138</td>
<td>0.231</td>
<td>0.490*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cautiousness (C)</td>
<td>1.00</td>
<td>0.228</td>
<td>0.539*</td>
<td>0.213</td>
<td>0.125</td>
<td>0.116</td>
<td>0.132</td>
<td>0.031</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Original Thinking (O)</td>
<td>1.00</td>
<td>0.140</td>
<td>0.383*</td>
<td>-0.144</td>
<td>-0.213</td>
<td>-0.093</td>
<td>0.006</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal Relations (P)</td>
<td>1.00</td>
<td>0.059</td>
<td>-0.200</td>
<td>-0.184</td>
<td>-0.175</td>
<td>-0.022</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vigor (V)</td>
<td>1.00</td>
<td>-0.212</td>
<td>-0.275</td>
<td>-0.162</td>
<td>-0.025</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{P}_1$</td>
<td>1.00</td>
<td>0.965*</td>
<td>0.952*</td>
<td>-0.473*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{P}_2$</td>
<td>1.00</td>
<td>0.847*</td>
<td>0.467*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\bar{P}_3$</td>
<td>1.00</td>
<td>0.418*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS</td>
<td>1.00</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at the .05 level.

The correlations of power measures and point scores are significant, though not especially high. Their negative signs imply, as expected, that lower (i.e. more powerful) power measures are associated with higher point scores (successful and efficient search) (6, p. 15).

Power measures are not significantly correlated with any personality variables, and Point Scores are correlated with only two: Ascendancy and Sociability (6). When a significant relationship between personality traits and subject behavior could be established, canonical analysis was performed, with the results given in Table IV.

**TABLE IV**

**RESULTS OF CANONICAL ANALYSIS***

<table>
<thead>
<tr>
<th>Variable</th>
<th>Using Formula 4</th>
<th>Using Formula 5</th>
<th>Using Formula 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canonical Index</td>
<td>.721</td>
<td>.663</td>
<td>.702</td>
</tr>
<tr>
<td>Significance Level</td>
<td>.010</td>
<td>.010</td>
<td>.010</td>
</tr>
<tr>
<td>Criterion Coefficients:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Measure</td>
<td>.999</td>
<td>.993</td>
<td>.987</td>
</tr>
<tr>
<td>Point Score</td>
<td>-.050</td>
<td>.117</td>
<td>-.163</td>
</tr>
<tr>
<td>Predictor Coefficients:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ascendancy</td>
<td>-.024</td>
<td>-.033</td>
<td>-.356</td>
</tr>
<tr>
<td>Responsibility</td>
<td>.215</td>
<td>.505</td>
<td>.476</td>
</tr>
<tr>
<td>Emotional Stability</td>
<td>.068</td>
<td>.006</td>
<td>.239</td>
</tr>
<tr>
<td>Sociability</td>
<td>1.017</td>
<td>-.669</td>
<td>-.161</td>
</tr>
<tr>
<td>Cautiousness</td>
<td>1.161</td>
<td>-.417</td>
<td>-.262</td>
</tr>
<tr>
<td>Original Thinking</td>
<td>-.230</td>
<td>.075</td>
<td>.133</td>
</tr>
<tr>
<td>Personal Relations</td>
<td>-.075</td>
<td>-.046</td>
<td>-.365</td>
</tr>
<tr>
<td>Vigor</td>
<td>-.481</td>
<td>-.242</td>
<td>-.258</td>
</tr>
</tbody>
</table>


As this table shows, all three analyses produce reasonably high canonical indices—all of which are substantially higher.
than any corresponding zero-order coefficients in Table III—each of which is significantly associated with behavior, then, seems a prudent enough conclusion (6, p. 17).

From this analysis it appears that the power measures are the criteria measures which are overwhelmingly related to a decision-maker's personality traits with PS insignificantly related. Unfortunately, the relationship between the independent or predictor variables and the criteria variables is dependent on which of the three metrics is used to measure $T_i$ (transmitted information). Although these results are not as informative as had been hoped, it is highly significant that differences in decision behavior appear to be attributable to differences in personality.

While the Kernan-Mojena chip experimental design sought primarily the quantity of information employed and the efficiency with which it is transmitted, the Scarborough-Schkade box experimental design concentrated primarily upon what is done with the information during the decision process. Both designs are structured to test the hypothesis that the manifested individual differences in the decision process can in some way be attributed to personality differences. Both designs used psychological tests to establish personality differences with Kernan-Mojena using the Gordon Personal Inventory and the Gordon Personal Profile and Scarborough-Schkade using the eleven experimental scales of the Minnesota Multiphasic Personality Inventory. In observing how he believes personality characteristics are related to decision behavior, Schkade stated:

If personality characteristics influence decision behavior, it is reasonable to propose that this influence may be reflected in part in the way information is acquired and utilized. If
this influence is to be observed experimentally, then the experimental situation must be such that the subject be allowed not only to evaluate alternative-outcome relationships, but also to participate in the discovery of alternatives and in the differentiation of outcomes (12, p. 3).

To attain the measurement of an individual's performance in information acquisition and utilization, a modified Feldman binary design, the Scarborough-Schkade design (3), and the three metrics, IU-information utilization, NS-information acquisition, and CS-consistency of source selection, were developed. These three metrics were designed to measure the disparity in the decision-making process employed by different decision-makers.

The decision-makers were required to make a decision as to which binary symbol would appear next from a random process. Before the decision-maker made his decision, he had the opportunity to purchase information from one or more of three available "consultants" as to which of the two symbols, ∨ or +, would appear next. The consultants' responses were random sequences with each source being correct a different, but controlled, percent of the time. (See the Scarborough-Schkade design in the definition section for the exact percentages.) Records were kept for each decision-maker recording the number of consultants from which information was acquired (NS), the consistency with which the decision-maker opted to base his decision on the advice given by the same consultant(s) (CS), and the decision-maker's ability to perceive the best source(s) of information (IU).

Information utilization, \[ M = TA(A) + TB(B) + TC(C) + TN(N), \] is a metric to measure a person's propensity to maximize his number of correct
decisions by choosing the information source(s) which have the most accurate information and, hence, maximize expected earnings.

\[ M = \text{the score depicting the extent of maximizing tendency.} \]

\[ TA = \text{the total number of times that a subject purchases information from information source A.} \]

\[ A = \text{the probability that A will be correct.} \]

\[ TB = \text{the total number of times that a subject purchases information from information source B.} \]

\[ B = \text{the probability that B will be correct.} \]

\[ TC = \text{the total number of times that a subject purchases information from information source C.} \]

\[ C = \text{the probability that C will be correct.} \]

\[ TN = \text{the total number of times that a subject does not purchase information from either A, B, or C.} \]

\[ N = \text{the probability that the subject will be correct if he chooses to guess which of the two random symbols will appear next.} \]

**Information acquisition**, \( RAV = n_1 + 3n_2 + 8n_3 \), is a metric designed to measure a person's propensity for risk aversion.

\[ n_1 = \text{the number of sources consulted on trials 1-25.} \]

\[ n_2 = \text{the number of sources consulted on trials 26-40.} \]

\[ n_3 = \text{the number of sources consulted on trials 41-50.} \]

**Consistency of source selection**, \( CS = 300 - (a_1 + 3a_2 + 8a_3) \), is a metric designed to measure decisiveness.

\[ CS = \text{the degree of consistency.} \]

\[ a_1 = \text{the total number of alternations between selected sources of information plus the total number of alternations between the} \]
sources influencing the binary symbol predictions on trials 1-25.

\[ a_2 = \text{the total number of alternations between selected sources of information plus the total number of alternations between the sources influencing the binary symbol predictions on trials 26-40.} \]

\[ a_3 = \text{the total number of alternations between selected sources of information plus the total number of alternations between the sources influencing the binary symbol predictions on trials 41-50.} \]

The results of the experimentation revealed that information acquisition is correlated with Prejudice (Pr) with an \( r^2 \) of .45 which is significant at the .001 level. The relationship is negative which "suggests the tendency for low Pr scores to be more open to the acquisition of information through purchase, while high Pr scores tend to acquire fewer sources, pay less for information (which is more consistent with expected monetary value maximization), and reflect a greater degree of cautiousness or inflexibility" (12, p. 8).

The relationship of information acquisition to decision-making concerns the reason for information acquisition. Information from an information-theory point of view reduces the entropy (uncertainty) and from a decision-theory point of view reduces the uncertainty of the outcome; hence, the acquisition of information reduces the decision-maker's risk, or if a decision-maker does not acquire information, it implies that he is assuming the risk.
As was shown in the analysis by Schkade, consistency of source selection proved to be positively related with Anxiety (A) with an \( r^2 \) of .54 which is significant at the .001 level (Table V). This means that the decision-maker manifested a tendency to vacillate "between information sources on the part of higher A scorers to come closer to adopting pure strategies in information selection" (12, p. 9).

**TABLE V**

**ANALYSIS OF THE EXPERIMENTAL DATA***

<table>
<thead>
<tr>
<th>Experimental Data</th>
<th>MMPI Scales</th>
<th>Determination Coefficients**</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Acquisition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Sources Acquired</td>
<td>Prejudice</td>
<td>.45</td>
<td>Negative</td>
</tr>
<tr>
<td>Consistency of Source</td>
<td>Anxiety</td>
<td>.54</td>
<td>Positive</td>
</tr>
<tr>
<td>Selection</td>
<td>Prejudice</td>
<td>.45</td>
<td>Negative</td>
</tr>
<tr>
<td>Information Utilization</td>
<td>Ego Strength</td>
<td>.52</td>
<td>Positive</td>
</tr>
</tbody>
</table>


**Significant at the .001 level.

Consistency (CS) in the box experiment reflects the decision-maker's ability to discriminate between information sources on the basis of the information quality possessed by the different sources. In this experimental design, information source A was correct 60 percent of the time, source B was correct 40 percent of the time, and source C was correct 80 percent of the time. Subjects with low A scores asymptotically
approached a pure strategy of going with information source C every time, and those with high A scores vacillated among the different information sources, including the number of sources queried, in arriving at their decision.

Information utilization (IU) was found to be negatively correlated with Prejudice (Pr) and positively correlated with Ego Strength (Es) with an $r^2$ of .52 which is significant at the .001 level. The subjects who were low Pr scorers tended to make predictions that were more consistent with the more reliable information sources and apparently had a higher utility for this information than subjects with higher Pr scores. . . . The positive correlation of Ego Strength scores with information utilization . . . implies that high Es scorers tend to utilize acquired information and to maximize the expected monetary value of event series predictions (12, p. 9).

Upon completion of the analysis, Schkade made the following conclusions:

1. Individuals to differ with respect to the propensity to acquire information for possible use in sequential decision selections and this tendency is related inversely to Pr scores, with low Pr scorers being potentially the better maximizers in terms of expected monetary outcomes.

2. There are significant differences between individuals in terms of the consistency with which information is sought from sources. The results of this experiment suggest that the higher the score on the Anxiety scale, the greater the tendency to alternate between information sources rather than adopt a pure strategy of acquiring information from a single source or combination of sources and tend toward maximization of monetary outcomes.

3. Personality characteristics are related to the manner in which information is utilized after it has been acquired. This conclusion is supported by the experimental results which suggest that information utilization is related inversely with scores on the Es scale.

4. Personality characteristics, as reflected by selected MMPI experimental scale scores, are associated with a significant portion of the variation that individuals exhibit in deviating from a pure strategy as the criterion for rational choice. In
this experiment, the rational choice would be to purchase information source C on every trial, for the expected value of this strategy is greater than that for any other source, combination of sources, or non-use of the sources (12, pp. 10-11).

Summary

A number of metrics were designed in this chapter to measure the quantity and utilization of information in decision-making. Among the metrics developed were $T_i$ for $i = 1, 2, \ldots, k$ where $T_i$ represents different formulas designed to measure the amount of information or number of environmental cues considered in decision-making. $P_i$ was developed to measure the percentage of the total information available used in decision-making; $\gamma$ was developed to measure the effectiveness of the information search as a ratio of $PS$, a metric dependent on the number of correct decisions, and $P_1$, the power of the search heuristic.

Endeavoring to explain individual differences in information acquisition, selection, and utilization, it was hypothesized that individual differences could be attributed to personality as defined by the Gordon Personal Profile and the Gordon Personal Inventory. It was found through canonical analysis that the power of the search heuristic is related to the personality characteristics of the GPP and the GPI at the .001 level.
CHAPTER BIBLIOGRAPHY


CHAPTER IV

ANALYSIS OF THE DATA

The results from the replication of the Kernan-Mojena chip and the Scarborough-Schkade box experimental designs plus an extension to both designs are presented and analyzed in this chapter. Specific topics included are the following: objectives of the data analysis, problems in metric development, contribution of canonical analysis to the Scarborough-Schkade experimental data, results from the replication of both the chip and box experimental designs, and the results from the extended experimental designs using both multiple regression-correlation and canonical analysis and correlation analytical techniques.

Prior to the presentation of the findings of this study, one caveat is perhaps in order. Many statisticians and mathematicians would seriously question the propriety of using a large number of predictor variables with a relatively small sample size. There is validity to the contention that, if predictor variables are added to the predictor hyperspace, at some point the number of predictor variables in relation to the sample size will overwhelm the sample size and result in a stronger relationship between the predictor hyperspace and the criterion hyperspace than is the case in reality. It was felt that in the case of canonical analysis, where all twenty-one of the predictor variables are employed in establishing a relationship between the predictor hyperspace and the criterion hyperspace, the analysis could be criticized with a
certain degree of justification on the basis that the sample size was small and twenty-one predictor variables were introduced. In keeping with the hypotheses and the objectives of this study, the extended predictor hyperspace was employed to determine if the same predictor variables, which were important in being able to predict decision performance on the chip experiment, were the same predictor variables which were most significant in predicting decision performance on the box experiment. The only variables which were deleted from the analysis were the predictor variables which had correlation coefficients very close to zero.

It should be observed that this is not a problem in performing stepwise-regression analysis, since the minimum contribution by a independent predictor variable can be specified. Hence, only those independent predictor variables having a significant relationship with the dependent variables are added to the mix of independent predictor variables.

In recognition of the possible criticism of using twenty-one predictor variables with a sample size of twenty-eight, the predictor hyperspace was reduced to five variables for both the box experimental design and the chip experimental design to ascertain if there were a statistically significant relationship between the dependency space that consists of as few as five predictor variables. The results from this analysis are reported following the analysis of the extended experimental design.

The second phase of the analysis presents the findings from the employment of an extended psychological test battery for the predictor
set. On the basis of the commonality of the predictor set, results from the regression analysis are presented, followed by the findings from performing the canonical analysis. This section is concluded with an endeavor to point out similarities in the findings from the box and chip experimental designs. Both the box and chip predictor spaces were reduced to five predictor variables and canonical analysis employed to ascertain if there is a significant relationship between personality (as defined for this study) and the decision-performance metrics or if the sample size is overwhelmed with predictor variables.

Objectives of the Replicated and Extended Research

Given the ambiguity of meaning associated with personality scores and the possible effects of emotional states on the precision of personality scales, the objective of this research is not to show that the same personality characteristics, shown to be significantly related to decision behavior by the original researchers, are necessarily the same characteristics significantly related to decision behavior in the replication sample; nor is the direction of the relationship necessarily significant. The hypothesis, based on previous research, is that differences in decision strategy are in some way related to a broad list of traits that are said to describe personality (7, 10, 11, 12). If this hypothesis can be substantiated, it can be inferred that a person's deviation from either the Von Neumann-Morgenstern or the Estes normative models may be attributed to personality differences. A significant assumption of the hypothesis that personality characteristics are in some way related to a person's decision performance or decision-making
strategy is that decision-performance metrics can be developed which are capable of measuring differences in decision behavior.

In addition to using several different weighting systems in computing the value of the box design performance metrics, a variety of schemes were employed in determining what should constitute a vacillation and how maximization should be determined as well as in addressing other problems which arise in the application of a metric system derived to measure decision behavior differences.

Although the original weights, the rationale behind what was considered a vacillation, and the method by which the other two metrics were administered appear to be valid, several different weights and administrative schemes were applied to the data with the results of the best revised scaling (Box Design Revised Scaling) presented in this study.

The Contribution of Canonical Analysis

After metrics have been developed to measure observable phenomena, there is always the question as to whether the metrics are actually independent or dependent. Assuming that the metrics are independent measures of some phenomenon (in this case, observable decision behavior), then it is appropriate to consider the results from each metric as describing a unique behavioral quality whose relationship to other phenomena can be studied. In this case, the analysis is concerned with the relationship between the decision-performance metrics and personality, which is operationally defined for this study as the eleven experimental scales of the MMPI, the four scales of the GPI, the four scales of the GPP, and the two short tests for abstract reasoning, BAS 7 and BAS 10.
In each of the experimental designs, it was observed that both sets of decision-performance metrics were developed to measure what appeared to be perceptable differences in decision schemes employed by decision makers. Schkade indicated that, upon the conclusion of a multinational study, all three of the researchers observed that the decision maker's behavior and decision strategy seemed to be related to personality (12). On the basis of these observations, the three metrics—CS-consistency of information sources, NS-number of information sources, and IU-information utilization—were developed (See Chapter II.) There does not appear to be any reason to assume, nor did Schkade suggest, that his decision performance metrics were independent. Consequently, canonical analysis was performed on both the chip and box designs. It should be recalled that Kernan-Mojena had run canonical analysis on the original chip sample, but canonical analysis had not been run on the data produced by the box design.

Given that the decision-performance metrics, CS, NS, and IU, cannot be shown to be disjointed, these variables should not be treated as distinct dependent or criteria variables but as a variable set over which a function can be defined, making up a dependency space. Canonical analysis selects a linear function, $L_1$, over the dependency space and a linear function, $L_2$, over the predictor space which maximizes the relationship between the two linear functions (6). The canonical algorithm is capable of showing which criteria or dependent variables are related to the linear combinations in the predictor space and their relative importance on the basis of the size of their coefficients. In many respects, canonical factor analysis is similar to multiple regression
and correlation analysis, with the significant difference being that in multiple regression and correlation a least squares regression line is fitted to a single dependent variable, whereas in canonical analysis the regression line is fitted through the dependent variables.

The multiple correlation coefficient then describes how much of the variance in the one variable is accounted for by the [variance in the other set of variables]. In canonical analysis, a set of [criterion] variables is given a least squares fit to another set of [predictor] variables. The canonical correlation [coefficient] measures how much the variance in one set [criterion set] is accounted for by the variance in the other [predictor set] (9, p. 121).

Results of the Replicated Box and Chip Experimental Designs

When Kernan and Mojena ran multiple-regression analysis on their data, they made two significant observations about the findings in the zero-order correlation matrix. First, they observed that the intercorrelation among the various personality scales was larger than is usually assumed with the intercorrelation approaching as much as 50 percent in some cases (7). The zero-order correlation matrix for the replication sample showed that there was a rather high intercorrelation between the Gordon personality scores (Table VI) with a 49 percent ($r = .719$ squared) correlation between Ascendancy A(G) and Sociability (S), both scores from the Gordon Personal Profile. Of the intercorrelation observed, six of the $r$-values proved to be significant at the .05 level.

The second observation made by Kernan and Mojena, based upon the findings from their zero-order correlation matrix, was that the intercorrelations between the predictor variables and the decision performance
**TABLE VI**

**INTERCORRELATION MATRIX FOR THE REPLICATED CHIP DESIGN**

Basic Intercorrelation Matrix
GPI and GPP vs P and PS

|                  | A(G) | R(G) | E   | S   | C   | O   | P   | V   | P1  | P2  | P3  | PS  |
|------------------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ascendancy A(G)  | 1.000| .075 | .048| .719| -.292| .557| .110| .348| .256| .028| -.109| .103|
| Responsibility   | 1.000| .576 | .008| .298| -.051| .131| .318| .050| .056| .074| .240 |
| Emotional        | 1.000| -.179| .361| .003| .327 | .177| -.107| .038| .133| .077 |
| Stability (E)    | 1.000| .413 | .088| .201 | .035 | .253| .014| .039| .073 |
| Sociability (S)  | 1.000| .105 | .324| .125 | -.236| -.013| .004| .068 |
| Cautiousness (C) | 1.000| .191 | .321| .005 | .011 | .005| .063 |
| Original Thinking (O) | 1.000| -.137| -.176| -.026| .032| -.125|
| Personal Relations (P) | 1.000| .227 | .048| .088| .221|
| Vigor (V)        |      |      |      |      |      |      |      |      |      |      |      |      |
| F1               | 1.000| .094 | .121| .557 |
| F2               |      |      |      |      |      |      |      |      |      |      |      |      |
| F3               |      |      |      |      |      |      |      |      |      |      |      |      |
| PS               |      |      |      |      |      |      |      |      |      |      |      |      | 1.000|
matrices were small. The results from the chip replication of this study support the original findings, inasmuch as none of the intercorrelations proved to be statistically significant (Table VII).

**TABLE VII**

REGRESSION ANALYSIS OF THE REPLICATED CHIP EXPERIMENTAL DESIGN

<table>
<thead>
<tr>
<th>Experimental Metric (Criterion Variables)*</th>
<th>Predictor Scales</th>
<th>Multiple r</th>
<th>T-Value Significance Level</th>
<th>F-Value Significance Level</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\overline{F}_1$</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>$\overline{F}_2$</td>
<td>Emotional Stability</td>
<td>.134</td>
<td>.20</td>
<td>.5</td>
<td>Inverse</td>
</tr>
<tr>
<td>$\overline{F}_3$</td>
<td>Responsibility</td>
<td>.240</td>
<td>.02</td>
<td>.5</td>
<td>Direct</td>
</tr>
<tr>
<td>PS</td>
<td>Ascendancy</td>
<td>.329</td>
<td>.02</td>
<td>.5</td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>Personal Relations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Formulas for estimating decision performance:

$$\overline{F}_1 = \text{(No estimation)}.$$  
$$\overline{F}_2 = 2.920 - .091E.$$  
$$\overline{F}_3 = .076 + .004R(G).$$  
$$PS = 295.609 + 3.600A(G) - 3.285P.$$  

The only observable difference in the two samples is that the original chip sample showed the two personality scales of Ascendancy $A(G)$
and Cautiousness \( (C) \) to be significantly correlated with \( PS \) at the .05 level, while the replication sample showed none of the personality scores to be significantly correlated with the decision-performance metrics at the .05 level. Although superficially this might seem significant, it should be observed that, to be significant at the .05 level, \( r \) in Table VI must be .38 or greater, and Ascendancy and Cautiousness, while not exceeding .38, both do exceed .25. This difference does seem to be significant. This disparity can be attributed to a basic psychological difference between the replication sample and the original Kernan sample or to a multiplicity of other factors, but it does not refute the original hypothesis of this study which was the speculation that in some way a person's behavioral deviation from either philosophically rational "pure" decision strategy or the "proportional prediction" made by the Estes model is related to personality characteristics.

The next phase of the replication was to run canonical analysis on the decision-performance metrics to ascertain if the replication sample supported the original findings that a significant relationship exists between the decision-performance metrics (criterion variables). Contrary to the original findings, which found the relationship between the decision-performance subsets, \( PS \) and \( P_i \) (for \( i = 1-3 \)), with the eight Gordon scales to be significant at the .01 level regardless of which metric had been used to measure the average transmitted information, \( \bar{T}_1 \), across a particular maze size, the replication sample appeared to be hypersensitive to the metric used in measuring the T-Value with the significance level varying between .5 (or chance relation) when \( \bar{T}_1 \) was used to a level of .005 when \( \bar{T}_3 \) was used (Table VIII).
TABLE VIII

CANONICAL ANALYSIS OF THE REPLICATED CHIP DESIGN

<table>
<thead>
<tr>
<th>Variable</th>
<th>Using Formula 4</th>
<th>Using Formula 5</th>
<th>Using Formula 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient Multiple Correlation</td>
<td>.389</td>
<td>.413</td>
<td>.442</td>
</tr>
<tr>
<td>Significance Level</td>
<td>.500</td>
<td>.100</td>
<td>.005</td>
</tr>
<tr>
<td>Criterion Coefficients:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency Measure</td>
<td>.998</td>
<td>- .928</td>
<td>.043</td>
</tr>
<tr>
<td>Power of Search</td>
<td>.057</td>
<td>.371</td>
<td>.999</td>
</tr>
<tr>
<td>Heuristic Measure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictor Coefficients:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ascendancy</td>
<td>-.329</td>
<td>.015</td>
<td>-1.706</td>
</tr>
<tr>
<td>Responsibility</td>
<td>.161</td>
<td>- .077</td>
<td>.621</td>
</tr>
<tr>
<td>Emotional Stability</td>
<td>-.110</td>
<td>- .010</td>
<td>.364</td>
</tr>
<tr>
<td>Sociability</td>
<td>.625</td>
<td>- .471</td>
<td>.954</td>
</tr>
<tr>
<td>Cautiousness</td>
<td>-.022</td>
<td>-.001</td>
<td>-.065</td>
</tr>
<tr>
<td>Original Thinking</td>
<td>.112</td>
<td>.069</td>
<td>1.160</td>
</tr>
<tr>
<td>Personal Relations</td>
<td>-.223</td>
<td>.256</td>
<td>-.310</td>
</tr>
<tr>
<td>Vigor</td>
<td>.819</td>
<td>-.719</td>
<td>.706</td>
</tr>
</tbody>
</table>

Replication of the Box Experimental Design

In analyzing the results of the replication of the box experiment, there was a noticeable difference in the predictor variables which entered the mix and a noticeable difference in the correlation coefficients (Table IX). Superficially, this implies a difference between the replication sample and the original box sample, but in analyzing the zero-order correlation matrix (Table X), it is observed that the intercorrelation between the MMPI personality scales approaches $r = .92$ between Anxiety (A) and Caudality (Ca). The intercorrelation between
several of the personality scales is exceedingly large which could account for the difference in the variables entering the predictor mix.

**TABLE IX**

**REGRESSION ANALYSIS OF THE REPLICATED BOX DESIGN USING THE ORIGINAL SCALING**

<table>
<thead>
<tr>
<th>Experimental Metric (Criterion Variables)*</th>
<th>Predictor Scales</th>
<th>Multiple r</th>
<th>T-Value Significance Level</th>
<th>F-Value Significance Level</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>Dominance</td>
<td></td>
<td>.001</td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Caudality</td>
<td></td>
<td>.010</td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Social Responsibility</td>
<td></td>
<td>.010</td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Anxiety</td>
<td>.837</td>
<td>.050</td>
<td>.001</td>
<td>Inverse</td>
</tr>
<tr>
<td>NS</td>
<td>Social Status</td>
<td></td>
<td>.010</td>
<td></td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>Emotional Control</td>
<td>.706</td>
<td>.050</td>
<td>.001</td>
<td>Inverse</td>
</tr>
<tr>
<td>IU</td>
<td>Dominance</td>
<td></td>
<td>.050</td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Dependency</td>
<td>.541</td>
<td>.050</td>
<td></td>
<td>Direct</td>
</tr>
</tbody>
</table>

*Formulas for estimating decision performance:

\[
CS = -855.739 + 8.412Do + 13.589Ca + 4.311Re - 7.332A.
\]

\[
NS = 735.650 - 6.302St - 2.347Ca.
\]

\[
IU = -29.905 + .691Do + .577Dy.
\]

Where Schkade's analysis using the original box sample showed the one variable, Anxiety, to be significantly related with CS, a measure of decisiveness at the .001 level, the replication sample showed Dominance (Do), Caudality (Ca), Repression (R), and Anxiety (A) to be significantly related with CS, having an F-value significant at the .001 level and a multiple correlation coefficient of .837. This implies that as
much as 70 percent of the vacillation between information sources can be attributed to variations in the personality scales of Do, Ca, R, and A. The seemingly justified conclusion from these results is that a person's vacillation between information sources is in some way related to personality as reflected by the MMPI scales.

Analysis of the original box sample showed NS (number of sources acquired), a measure of an individual's propensity to accept risk by not acquiring information or to avoid risk by acquiring information, to be significantly related with the Prejudice (Pr) scale at the .001 level and the coefficient of determination between Pr and NS to be $r = .45$ on the original box sample. The replication sample showed NS to be significantly related with the two scales, Social Status (St) and Emotional Control (On), at the .001 level for the F-value and to produce a coefficient multiple correlation of .706 (Tables IX and X).

The last metric designed to describe differences in decision behavior, IU (information utilization), measures the decision maker's ability to discriminate among information sources on the basis of how frequently each information source correctly predicts the ultimate outcome. In analyzing the findings from the original box sample, Schkade found that IU was significantly related with the scales, Prejudice (Pr) and Ego Strength (Es), at the .001 level, producing a coefficient of multiple determination of $R^2 = .52$. In replicating the experiment using the replication sample, the two personality scales, Dominance (Do) and Dependency (Dy), were found to be related to IU, being statistically significant at the .05 level for the F-value and producing a coefficient of multiple correlation of .541.
<table>
<thead>
<tr>
<th>Basic Intercorrelation Matrix</th>
<th>MMPI vs CS-NS-IU</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TABLE X</strong></td>
<td></td>
</tr>
<tr>
<td><strong>INTERCORRELATION MATRIX FOR THE REPLICATED BOX DESIGN</strong></td>
<td></td>
</tr>
<tr>
<td><strong>USING THE ORIGINAL SCALING</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(A)</th>
<th>(R)</th>
<th>(Es)</th>
<th>(Lb)</th>
<th>(Ca)</th>
<th>(Dy)</th>
<th>(Do)</th>
<th>(Re)</th>
<th>(Pr)</th>
<th>(St)</th>
<th>(Cn)</th>
<th>(CS)</th>
<th>(NS)</th>
<th>(IU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anxiety (A)</td>
<td>1.000</td>
<td>- .490</td>
<td>- .686</td>
<td>- .071</td>
<td>.918</td>
<td>.875</td>
<td>.259</td>
<td>.417</td>
<td>.537</td>
<td>.218</td>
<td>.703</td>
<td>.109</td>
<td>- .263</td>
</tr>
<tr>
<td>Repression (R)</td>
<td>1.000</td>
<td>.026</td>
<td>.055</td>
<td>.477</td>
<td>- .375</td>
<td>.382</td>
<td>.647</td>
<td>.559</td>
<td>.050</td>
<td>.613</td>
<td>.282</td>
<td>.338</td>
<td>.315</td>
</tr>
<tr>
<td>Ego Strength (Es)</td>
<td>1.000</td>
<td>.308</td>
<td>- .648</td>
<td>- .547</td>
<td>.276</td>
<td>.135</td>
<td>.401</td>
<td>.437</td>
<td>.230</td>
<td>.001</td>
<td>.004</td>
<td>- .089</td>
<td></td>
</tr>
<tr>
<td>Low Back Pain (Lb)</td>
<td>1.000</td>
<td>- .082</td>
<td>- .157</td>
<td>.156</td>
<td>- .221</td>
<td>.061</td>
<td>.584</td>
<td>.233</td>
<td>.030</td>
<td>- .215</td>
<td>.168</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caudality (Ca)</td>
<td>1.000</td>
<td>.781</td>
<td>- .410</td>
<td>.513</td>
<td>.676</td>
<td>.315</td>
<td>.633</td>
<td>.135</td>
<td>- .156</td>
<td>.183</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dependency (Dy)</td>
<td>1.000</td>
<td>- .258</td>
<td>- .353</td>
<td>.527</td>
<td>- .376</td>
<td>.532</td>
<td>.044</td>
<td>- .001</td>
<td>.326</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dominance (Do)</td>
<td>1.000</td>
<td>.437</td>
<td>- .543</td>
<td>.613</td>
<td>- .499</td>
<td>.430</td>
<td>- .343</td>
<td>.332</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Social Responsibility (Re)</td>
<td>1.000</td>
<td>- .767</td>
<td>.131</td>
<td>- .499</td>
<td>.430</td>
<td>.205</td>
<td>.271</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Prejudice (Pr)</td>
<td>1.000</td>
<td>- .403</td>
<td>.100</td>
<td>.360</td>
<td>- .040</td>
<td>.168</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Status (St)</td>
<td>1.000</td>
<td>.100</td>
<td>.360</td>
<td>- .571</td>
<td>.164</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional Control (Cn)</td>
<td>1.000</td>
<td>.095</td>
<td>- .469</td>
<td>.188</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>1.000</td>
<td>- .345</td>
<td>.570</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NS</td>
<td>1.000</td>
<td>- .050</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IU</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Of the several revised scalings used, the best scaling was analyzed using both regression analysis and canonical analysis with the results referred to as the box design using the revised scaling (BDRS).

**TABLE XI**

**REGRESSION ANALYSIS OF THE REPLICATED BOX DESIGN USING THE REVISED SCALING**

<table>
<thead>
<tr>
<th>Experimental Metric (Criterion Variables)*</th>
<th>Predictor Scales</th>
<th>Multiple T-Value</th>
<th>F-Value Significance Level</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>Ego Strength</td>
<td>.475</td>
<td>.050</td>
<td>.500</td>
</tr>
<tr>
<td>NS</td>
<td>Dependency</td>
<td>.100</td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Prejudice</td>
<td>.402</td>
<td>.200</td>
<td>.500</td>
</tr>
<tr>
<td>IU</td>
<td>Ego Strength</td>
<td>.001</td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Repression</td>
<td>.010</td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Anxiety</td>
<td>.001</td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Emotional Control</td>
<td>.830</td>
<td>.050</td>
<td>.001</td>
</tr>
</tbody>
</table>

*Formulas for estimating decision performance:*

\[
CS = 229.361 - 3.089Es. \\
NS = 67.890 + 1.591Dy - 1.294Pr. \\
\]

When the revised scaling was used, CS, which had been significantly related to the predictor variables—Dominance (Do), Caudality (Ca), Social Responsibility (Re), and Anxiety (A)—at the .001 level for the F-value and which had a coefficient of multiple correlation (CMC) of .837 for the original scaling, was found to be related to Ego Strength (Es)
statistically significant at the .05 level (Table XI) and with a CMC of .475.

With the use of the revised scaling, the two personality scales, Dependency (Dy) and Social Responsibility (Re), were found to be related to NS with a T-value for Dy of .1 and a T-value for Re significant at the .2 level; both produced a CMC of .402. The relationship is, at best, weak between NS and personality, as defined for this study, when the revised scaling is used.

IU was found to be related to the personality scales, Ego Strength (Es), Repression (R), Anxiety (A), and Emotional Control (Cn), producing a F-value significant at the .001 level and a CMC of .83. This is the only metric which indicated that the revised scaling had strengthened the relationship between one of the decision-performance metrics and the personality scores.

Conclusions Based on the Replicated Box Experimental Design

Given that the relationships between the two decision-performance metrics, CS and NS, and the eleven experimental scales of the MMPI are significant at the .001 level and the relationship between IU and the MMPI scores are significant at the .05 level, there is strong support for Schkade's findings that the variation in a person's decision-making behavior is in some way related to his personality which presupposes at this point that the MMPI experimental scales are in some way a measure of personality. This proposition is further supported by the results of the BDRS (Box Design Revised Scaling) analysis. If the revised scaling is used to compute CS, NS, and IU, the relationship between the decision
performance metrics and the personality scores from the MMPI were found to be statistically significant with the relationship between NS and the personality scores being somewhat weak, but the F-value for IU was significant at the .001 level. This is somewhat stronger than the relationship between IU and the eleven experimental scales of the MMPI using the original scaling.

Canonical Analysis of the Box Experimental Design

When one recognizes that the decision-performance metrics, NS, CS, and IU, were developed to measure quantitatively what appeared to be discernible differences in decision-making strategy, a question arises as to whether these metrics measure different decision behavior or a different view of the same decision behavior or whether part of the decision behavior reflected in these decision-performance metrics is shared in common by the three metrics.

Since the relationship between the decision-performance metrics and the predictor variables was not clearly discernible, canonical analysis was run on the data using NS, CS, and IU as a multidimensional dependent variable space and the eleven MMPI experimental scales as a predictor hyperspace. Canonical analysis was run on both the original and the revised scaling for the decision-performance variables, NS, CS, and IU.

The results of canonical analysis using original scaling produced a correlation coefficient of .89 (Table XII), and the relationship was significant at the .001 level for chi square. Based on the coefficient magnitudes, the Anxiety (A) scale appears to be the most important predictor variable, having an inverse relationship to both CS and NS and a
direct relationship to IU. This relationship implies that, as the A scale increases, a subject has a greater tendency to vacillate between information sources although he may know that some sources are more accurate than others. Also, as the A scale increases, NS decreases, which implies that a person with a low A score is more consistent in acquiring information prior to making a decision.

TABLE XII
CANONICAL ANALYSIS OF THE REPLICATED BOX DESIGN USING THE ORIGINAL SCALING

<table>
<thead>
<tr>
<th>Criterion Variables</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient Multiple Correlation</td>
<td>.895</td>
</tr>
<tr>
<td>Significance Level</td>
<td>.020</td>
</tr>
<tr>
<td><strong>Criterion Coefficients:</strong></td>
<td></td>
</tr>
<tr>
<td>Consistency of Information Source Selection (CS)</td>
<td>- .879</td>
</tr>
<tr>
<td>Number of Sources Acquired (NS)</td>
<td>- .454</td>
</tr>
<tr>
<td>Information Utilization (IU)</td>
<td>.142</td>
</tr>
<tr>
<td><strong>Predictor Coefficients:</strong></td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>2.058</td>
</tr>
<tr>
<td>Repression</td>
<td>.151</td>
</tr>
<tr>
<td>Ego Strength</td>
<td>.156</td>
</tr>
<tr>
<td>Low Back Pain</td>
<td>- .154</td>
</tr>
<tr>
<td>Caudality</td>
<td>-1.889</td>
</tr>
<tr>
<td>Dependency</td>
<td>- .638</td>
</tr>
<tr>
<td>Dominance</td>
<td>- .377</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>- .613</td>
</tr>
<tr>
<td>Prejudice</td>
<td>.272</td>
</tr>
<tr>
<td>Social Status</td>
<td>.014</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>- .027</td>
</tr>
</tbody>
</table>

The direct relationship between the Anxiety (A) scale and IU, which reflects the accuracy of the information source selected by an individual, superficially appears to be contradictory, since it would appear that individuals with high A scores and the tendency to vacillate between sources,
as indicated in the relationship between CS and the A scale, would have lower IU scores than, for instance, individuals with low A scores who are inclined to adopt the pure strategy of acquiring information from information source C which was right 80 percent of the time.

This apparent contradiction seems to dissipate when it is realized that IU is made up of two factors—the quantity of information acquired and the quality of the information source. This means that IU tends to increase as the number of information sources from which the decision-maker acquires information increases, as well as when he selects from the "better" sources of information (the sources having a greater probability of being right). The direct relationship between Anxiety and IU could suggest that the increase in the number of information sources acquired prior to decision-making more than offsets the reduction in IU brought about by the vacillation between information sources.

Another factor which could explain the relationship between Anxiety (A), CS, and IU is the observation that the increase in the number of vacillations as a consequence of A increasing would not necessarily be followed by a reduction in the value of IU stemming from the fact that a decision-maker can consistently acquire information from a poor source of information. In this case, vacillation will tend to raise and lower the value of IU. Because of the small contribution of the IU metric to the criterion space (a coefficient of .14257), the criterion variable appears to be relatively insignificant in either case.

The only other predictor variable that stands out in its relationship with the dependency hyperspace is Caudality (Ca). There is a direct relationship between the predictor variable, Ca, and the decision
performance metrics, CS and NS, and an inverse relationship to IU. The relationship of this personality variable with the decision-performance variables is a curious one inasmuch as the Ca scale was primarily designed to measure the arithmetic ability of persons who had suffered brain damage (1, 2). Although it is difficult to rationalize the relationship between the predictor variable, Ca, and the box decision-performance metrics, the presence of this variable as an important predictor variable was not completely unexpected. In the original box experiment, Ca was one of the first predictor variables to enter the predictor variable mix, although its contribution was not statistically significant. It was concluded upon examination of the original results that there was more than a fortuitous relationship between Ca and the box decision-performance variables which led to the hypothesis that the reason why Ca was appearing to have more than a chance relationship with the decision-performance metrics was that it in some way reflected a person's abstract reasoning acumen.

Based upon this hypothesis, two short tests designed to measure abstract reasoning, EAS 7 and EAS 10, were included in the testing battery on the assumption that, if the relationship of Ca with the decision-performance metrics were attributable to its measure of a person's abstract reasoning acumen, then one or both of these tests should enter the predictor variable mix early with Ca becoming a redundant variable. Although this was not found to be the case when the extended data set was run, any extensive analysis of why Ca appears to be related significantly to the decision-performance hyperspace will be deferred until the analysis is run on the extended predictor hyperspace.
The predictor variable with the third largest coefficient was Dependency (Dy). There was a direct relationship between the Dy scale and the decision-performance metrics, CS and NS, and an inverse relationship between the Dy scale and IU. This suggests that, as the Dy scale increases, a person's tendency to vacillate between information sources decreases. The inverse relationship between Dy and IU suggests that, as the Dy scale increases, a person is more likely to accept the "advice" of an inferior information source. The direct relationship between Dy and NS suggests that, as a person tends to score higher on the Dy scale, he is inclined to acquire more information prior to making a decision. This also suggests that, as the Dy scale tends to increase, a person's propensity to avoid risk (propensity for risk aversion) by acquiring more information also increases.

The variable with the fourth largest coefficient was Social Responsibility (Re). There was a direct relationship between the personality scale, Re, and the decision performance metrics, CS and NS, and an inverse relationship between the Re scale and IU. This suggests that, as a person tends to score higher on the Re scale, concomitantly he is expected to score lower on both the CS and NS metrics. The direct relationship between Re and CS implies that, as a person tends to score higher on the Re scale, he will also tend to vacillate less between information sources which tends to raise the magnitude of the CS score. The direct relationship between the personality scale, Re, and the decision performance metric, NS, implies that, as the magnitude of the Re scale tends to increase, a person tends to acquire less information prior to making a decision, thus increasing the magnitude of the metric, NS.
Concomitant with the relationship between Re and NS is the observation that a person who tends to score higher on the Re scale tends to have a smaller propensity to avert risk through the acquisition of information prior to decision-making. The inverse relationship between the personality scale, Re, and the decision-performance metric, IU, suggests that, as a person tends to score higher on the Re scale, he is expected to score lower on the IU scale. This implies that, as a person tends to score higher on the Re scale, he will tend to select information from the poorer sources of information which will lower the IU score.

When canonical analysis was run on BDRS (Box Design Revised Scaling) (See Table XIII), the correlation coefficient was .87319 which is significant at the .001 level. When the revised scaling was used, the only variable in the dependency hyperspace which appeared to have a significant relationship with the predictor hyperspace was IU with the coefficients of the two criterion variables, CS and NS, approaching zero. The predictor variable with the largest coefficient, using the revised scaling, was Anxiety (A); this is consistent with the findings, using the original scaling, for the decision-performance metrics. The difference between the two results is that the direct relationship between IU and A has been strengthened, indicating that as the A scale increases, there is an increasing propensity on the part of the subject to utilize the best source(s) of information. This relationship will be found to be consistent throughout the analysis regardless of which scaling is used to compute the box decision-performance metrics or regardless of the changes in the predictor hyperspace, as will be seen when the extended predictor set is employed.
TABLE XIII
CANONICAL ANALYSIS OF THE BOX DESIGN
USING THE REVISED SCALING

<table>
<thead>
<tr>
<th>Criterion Variables</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient Multiple Correlation</td>
<td>.873</td>
</tr>
<tr>
<td>Significance Level</td>
<td>.500</td>
</tr>
<tr>
<td>Criterion Coefficients:</td>
<td></td>
</tr>
<tr>
<td>Consistency of Information Source Selection (CS)</td>
<td>-.101</td>
</tr>
<tr>
<td>Number of Sources Acquired (NS)</td>
<td>.052</td>
</tr>
<tr>
<td>Information Utilization (IU)</td>
<td>.993</td>
</tr>
<tr>
<td>Predictor Coefficients:</td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>2.950</td>
</tr>
<tr>
<td>Repression</td>
<td>.913</td>
</tr>
<tr>
<td>Ego Strength</td>
<td>1.959</td>
</tr>
<tr>
<td>Low Back Pain</td>
<td>-.025</td>
</tr>
<tr>
<td>Caudality</td>
<td>-.826</td>
</tr>
<tr>
<td>Dependency</td>
<td>-.617</td>
</tr>
<tr>
<td>Dominance</td>
<td>.134</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>.260</td>
</tr>
<tr>
<td>Prejudice</td>
<td>.596</td>
</tr>
<tr>
<td>Social Status</td>
<td>-.315</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>-.657</td>
</tr>
</tbody>
</table>

The variable with the next largest coefficient, using the revised scaling, was Caudality (Ca). The inverse relationship between the Ca scale and IU was consistent with the relationship between these two variables when the original scaling was used. This relationship suggests that, as the Ca scale increases, a person's tendency to acquire information from poorer sources of information is increased. Given the prior description of Ca and the problems which this relationship engenders, any observations on this relationship will be retained until the discussion on the box design, using the extended predictor space (enlarged psychological test battery).
Summary

Since the box decision-performance variables were developed to measure perceptible differences between decision strategies, it was felt that canonical analysis, which considers the decision-performance metrics to constitute a dependency space instead of a unique measure of decision performance, could make a significant contribution to the analysis. Canonical analysis sustained the findings of regression analysis that a statistically significant relationship exists between the decision performance metrics and personality as reflected in the eleven experimental scales of the MMPI. Canonical analysis found the Anxiety (A) scale to be the predictor variable with the predominant relationship to the decision-performance metrics, and its relationship to the criterion variables did not change by changing the metric scaling. Changing the scaling did change the order of importance for some of the predictor variables from the predictor space, but in addition to Anxiety being significant, using either metric scaling, the Caudality (Ca) scale also proved to be significant, using either the original scaling or the revised scaling to compute the decision-performance metrics for the box design.

The inverse relationship between such predictor variables as Anxiety (A) with the decision-performance metric, CS, suggests that, as the A scale increases, a person's propensity to vacillate between information sources increases. The direct relationship between the A scale and IU suggests that, as the A scale increases, a person has a propensity to utilize either more information or a more reliable source of information. When the original scaling was employed, the coefficient of IU was small which indicated that IU was relatively unimportant to the
dependency space, and in the case of using the revised scaling, CS approached zero which means that it made very little contribution in establishing the linear function across the dependency space.

Analysis of the Extended Chip Design

One of the major hypotheses of this study is that the same personality traits which are related to the quantity of information which a person acquires prior to his decision-making are the same personality traits which will be related to the process by which a person employs the acquired information for decision-making. To test this hypothesis, the subjects were all given a uniform battery of tests which included the Gordon Personal Profile and the Gordon Personal Inventory, which Kernan employed in the chip experiment using the original chip sample, the Minnesota Multiphasic Personality Inventory, which Schkade employed in the box experiment using the original box sample, plus the Employee Aptitude Survey 7 and Employee Aptitude Survey 10, which are short tests designed to measure a person's abstract reasoning acumen.

When regression analysis was performed on the extended chip design, Point Score (PS), which is a measure of decision efficiency, was found to be related to EAS 7, EAS 10, Vigor (V), Social Responsibility (Re), Emotional Control (Cn), Cautiousness (C), Dominance (Do), and Ego Strength (Es) (Table XIV). This relationship was found to be statistically significant at the .001 level with a CMC of .809.

The first predictor variable to enter the predictor mix was EAS 7, which was inversely related to the decision-performance metric, PS. This relationship suggests that, as the value of the predictor variable, EAS 7,
tends to increase, the value of the decision performance-metric, $PS$, is expected to decrease. As the value of the EAS 7 scale tends to increase,

**TABLE XIV**

**MULTIPLE REGRESSION ANALYSIS OF THE REPLICATED CHIP DESIGN USING THE EXTENDED ANALYSIS**

<table>
<thead>
<tr>
<th>Experimental Metric (Criterion Variables)*</th>
<th>Predictor Scales</th>
<th>Multiple $r$</th>
<th>T-Value Significance Level</th>
<th>F-Value Significance Level</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>$PS$</td>
<td>EAS 7</td>
<td>.001</td>
<td></td>
<td></td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>Vigor</td>
<td>.001</td>
<td></td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>EAS 10</td>
<td>.001</td>
<td></td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Social Responsiblity</td>
<td>.001</td>
<td></td>
<td></td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>Emotional Control</td>
<td>.001</td>
<td></td>
<td></td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>Caudality</td>
<td>.001</td>
<td></td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Dominance</td>
<td>.001</td>
<td></td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Ego Strength</td>
<td>.809</td>
<td>.050</td>
<td>.001</td>
<td>Inverse</td>
</tr>
<tr>
<td>$\bar{P}_1$</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>$\bar{P}_2$</td>
<td>EAS 7</td>
<td>.297</td>
<td>.010</td>
<td>.500</td>
<td>Inverse</td>
</tr>
<tr>
<td>$\bar{P}_3$</td>
<td>EAS 7</td>
<td>.001</td>
<td></td>
<td></td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>Anxiety</td>
<td>.001</td>
<td></td>
<td></td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>Prejudice</td>
<td>.001</td>
<td></td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Dominance</td>
<td>.577</td>
<td>.020</td>
<td>.005</td>
<td>Direct</td>
</tr>
</tbody>
</table>

*Formulas for estimating decision performance:

$$PS = 694.424 - 14.402EAS 7 + 3.779V + 7.596EAS 10 - 7.155Re - 4.327Cn + 4.888C + 4.088Do - 2.331Es.$$ $$\bar{P}_1 = (\text{No estimation}).$$ $$\bar{P}_2 = 5.278 - .253EAS 7.$$ $$\bar{P}_3 = .100 - .005EAS 7 - .004A + .005Pr + .002Do.$$
the power and efficiency of a person's search heuristic is expected to decrease which is manifested by the acquiring of more bits of information prior to making a decision with the decisions having an increasing tendency to be incorrect. The tendency of the subject to acquire more information prior to making a decision suggests that he is a risk-avert in that, by acquiring larger quantities of information, he tries to transfer the risk to the information source.

The second and third predictor variables to enter the predictor mix were Vigor (V) and EAS 10, which were directly related to the decision-performance metric, PS. The direct relationship between the predictor variables, V and EAS 10, with the decision-performance variable, PS, suggests that, as the magnitude of the two predictor scales tend to increase, the value of the PS metric is expected to increase. The increase in the magnitude of the decision-performance metric, PS, implies that the decision-maker has acquired less information prior to making his decision and that the tendency for the decisions to be accurate has increased. The tendency of the decision-maker to acquire less information prior to decision-making suggests that he is a risk-assumer in that he tends to assume the risk of his decision by acquiring a small amount of information.

The next two predictor variables to enter the predictor mix were Social Responsibility (Re) and Emotional Control (Cn), which were inversely related to the decision-performance metric, PS, a measure of the efficiency of a person's search heuristic based on both the quantity of information acquired by the subject and the correctness of his decision. This relationship suggests that, as a person's scores on both
Re and Cn diminish, the efficiency of his search heuristic is enhanced. This implies that a person is inclined to make decisions based upon less environmental information and that these decisions are apt to be correct ones more often than in the case of the person who scores higher on the Re and Cn scales.

There was a direct relationship between the two predictor variables, Cautiousness (C) and Dominance (Do), and the decision-performance metric, PS. This direct relationship suggests that, as the scores on the two predictor variables, C and Do, tend to increase, the search heuristic efficiency scale, PS, is also expected to increase. As the scores on the two scales, C and Do, increase, it is expected that the amount of environmental information used in decision-making will diminish and that the probability of the decisions being correct will be enhanced.

The last predictor variable to enter the predictor hyperspace at a significant level was the personality scale, Ego Strength (Es). The inverse relationship between Es and the search heuristic efficiency scale, PS, suggests that, as the score on Es increases, the PS score is expected to decrease. This implies that a person who tends to score highest on the Es scale is inclined to acquire larger portions of the environmental information prior to making decisions and that his decisions will tend to be incorrect a larger portion of the time than those of the person with a lower Es score. Regression analysis was run on the data, using the extended psychological test battery for the predictor set and $P_1$ as the decision-performance metric. $P_1$ was found not to have a statistically significant relationship with any of the twenty-one scales defining personality for this experiment.
The decision-performance metric, $P_2$, was found to have an inverse relationship with the predictor variable, EAS 7, which was statistically significant at the .01 level for the T-value. This inverse relationship suggests that, as the value of the EAS 7 scale tends to increase, the value of $P_2$ has a tendency to decrease. The decrease in the $P_2$ metric indicates that the power of the search heuristic is increased in that the decision-maker acquires a smaller proportion of the environmental information prior to making his decision.

The decision-performance metric, $P_3$, was found to have an inverse relationship with the two predictor variables, EAS 7 and Anxiety (A), which were both statistically significant at the .001 level for the T-value. The inverse relationship suggests that, as the value of the score for either the EAS 7 or the A scale tends to increase, the score for the decision-performance metric, $P_3$, is expected to decrease. This means that, as the value of EAS 7 or A tends to increase, the power of the search heuristic tends to increase in that a decrease in the magnitude of the $P_3$ scale indicates that a smaller proportion of the available environmental information has been acquired by the decision-maker prior to making his decision. There is a direct relationship between the decision-performance metric, $P_3$, and the two predictor variables, Prejudice (Pr), which is statistically significant at the .001 level for the T-value, and Dominance (Do), which is statistically significant at the .02 level for the T-value. The direct relationship between $P_3$ and the two predictor variables, Pr and Do, suggests that, as the value of the Pr and/or Do scales increase, the value of the $P_3$ scale is expected to increase. This means that, as the value of Pr and/or Do tends to increase,
an individual is inclined to acquire a larger proportion of the environmental information prior to making his decision, indicating a relatively weak search heuristic.

**Summary**

The most important predictor variable in the extended predictor space was the EAS 7 scale. Consistent with the findings of the replicated chip design, the relationship between the decision-performance metrics and the predictor hyperspace was hypersensitive to whichever formulation was employed to compute $\bar{F}_1$. There was very little relationship between $\bar{F}_1$ and $\bar{F}_2$ and the predictor hyperspace and a statistically significant relationship between $\bar{F}_3$ and the predictor hyperspace. These results were consistent with the results from the predictor variable set, but $\bar{F}_3$ showed a relationship significant at the .02 level. In both cases, $PS$, which is a measure of the efficiency of the search heuristic, was the dependent variable which had the strongest relationship with the predictor set.

**Regression Analysis of the Extended Box Design Using Both the Original and the Revised Scaling**

In running regression analysis on the box design, using the extended psychological test battery for the predictor set and CS for the decision performance metric (Table XV), Dominance (Do) was the first predictor variable to enter the mix, having a direct relationship with the criterion variable, CS, and being statistically significant at the .001 level for the T-value. This suggests that, as the value of Do tends to increase, the expected value of CS will tend to increase. This means that, as a
A person's score on the Do scale increases, he is expected to increase the number of vacillations among the information sources.

**TABLE XV**

**REGRESSION ANALYSIS OF THE EXTENDED BOX DESIGN USING THE ORIGINAL SCALING**

<table>
<thead>
<tr>
<th>Experimental Metric (Criterion Variables)*</th>
<th>Predictor Scales</th>
<th>Multiple r</th>
<th>T-Value Significance Level</th>
<th>F-Value Significance Level</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>Dominance</td>
<td>.001</td>
<td></td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Caudality</td>
<td>.010</td>
<td></td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Social Responsibility</td>
<td>.010</td>
<td></td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Anxiety</td>
<td>.837</td>
<td>.050</td>
<td>.010</td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>Emotional Stability</td>
<td>.001</td>
<td></td>
<td></td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Social Status</td>
<td>.001</td>
<td></td>
<td>.001</td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>EAS 10</td>
<td>.887</td>
<td>.001</td>
<td>.001</td>
<td>Direct</td>
</tr>
<tr>
<td></td>
<td>Sociability</td>
<td>.010</td>
<td></td>
<td></td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>Dominance</td>
<td>.640</td>
<td></td>
<td></td>
<td>Direct</td>
</tr>
</tbody>
</table>

*Formulas for estimating decision performance:

\[
\text{CS} = -855.743 + 8.412\text{Do} + 13.589\text{Ca} + 4.311\text{Re} - 7.332A. \\
\text{NS} = 457.451 + 6.385E - 7.934St + 4.245EAS 10. \\
\text{IU} = 147.930 - 12.747S + 8.465\text{Do}. \\
\]

The second and third predictor variables, Caudality (Ca) and Social Responsibility (Re), were found to have the same direct relationship with the criterion variable, CS, as did Do and were found to be statistically significant at the .01 level. The implications of this relationship are the same as those for the predictor variable, Do.
The predictor variable, Anxiety (A), was the fourth variable to enter the mix, having an inverse relationship with the criterion variable, CS, which is statistically significant at the .05 level for the T-value. This inverse relationship suggests that, as the value of the A scale increases, the value of the CS scale is expected to increase, meaning that, as the score for the A scale increases, the number of vacillations between information sources will have a tendency to increase. The four predictor variables, Do, Ca, Re, and A, produced a CMC of .837.

In analyzing the relationship between the extended predictor set and the decision-performance metric, NS, Emotional Stability (E) was the first predictor variable to enter the mix, having a direct relationship with the criterion variable, NS, which was statistically significant at the .001 level for the T-value. The direct relationship between NS and E suggests that, as the score of the E scale increases, the value of the NS metric is expected to increase. This implies that, as the value of E increases, the amount of information used in the decision-making process increases, since an increase in NS indicates an increase in the amount of information acquired prior to making a decision. This relationship is of primary importance to a decision-theorist because it is indicative of a person's propensity for risk aversion. The more information that a person acquires prior to making a decision, the more concerted is his effort to avert risk, and likewise, the less information that a person acquires prior to making a decision, the greater is his propensity to assume risk.

The second variable to enter the mix was Social Status (St), which had an inverse relationship with the criterion variable, NS. The relationship between these two variables was statistically significant at
the .001 level for the T-value. The inverse relationship suggests that, as the score on the St scale increases, the amount of information acquired by the subject prior to making his decision will tend to diminish. This means that, as a person's St score tends to increase, the number of information sources acquired prior to making a decision will tend to diminish, indicating a propensity to assume risk.

The third predictor variable to enter the mix was EAS 10, which had a direct relationship with the decision-performance metric, NS. The relationship was significant at the .001 level for the T-value. The inverse relationship between EAS 10 and NS suggests that, as the score of the EAS 10 scale increases, the value of the decision-performance metric, NS, is expected to decrease. This implies that, as EAS 10 increases, the amount of information which a subject acquires prior to making a decision is expected to decrease. This inverse relationship also suggests that a person who scores high on the EAS 10 scale tends to have a propensity to assume risk by acquiring smaller amounts of information or that a person who scores low on the EAS 10 scale tends to be a risk-avertor by acquiring large amounts of information prior to making a decision.

The three predictor variables, Emotional Stability (E), Social Status (St), and EAS 10, produced a CMC of .887 in relation to the criterion variable, NS. This suggests that about 78 percent of the variation in the decision-performance metric, NS, can be explained by the variation of the three predictor variables, E, St, and EAS 10.

In analyzing the relationship between the decision-performance variable, IU, and the extended psychological test battery, it was found
that the predictor variable, Sociability (S), had an inverse relationship to the criterion variable, IU, and that the relationship between these two variables was statistically significant at the .01 level for the T-value. This inverse relationship suggests that, as the score of the S scale increases, the value of the IU scale is expected to increase. This implies that a person who scores low on the S scale tends to acquire information from sources which have a greater probability of being correct. A person who approaches some extreme position on the S scale tends to adopt a pure strategy which would maximize his expected number of correct decisions.

The second predictor variable to enter the mix was Dominance (Do), which had a direct relationship with the criterion variable, IU. This relationship was significant at the .01 level for the T-value. The direct relationship between Do and IU suggests that, as a person tends to score higher on the Do scale, he also tends to score higher on the IU criterion metric. This means that a person who scores high on the Do scale also tends to acquire information from the best sources of information. A person who scores extremely high on Do tends to select a pure strategy which would maximize his expected number of correct decisions. The two predictor variables, Sociability (S) and Dominance (Do), produced a CMC of .640 in relation to the criterion variable, IU. This suggests that more than 37 percent of the variation in the criterion variable, IU, can be explained by the variation in the two predictor variables, S and Do.

Regression analysis was run, using the extended psychological test battery for the predictor space and the revised scaling to compute
the decision-performance metrics. As Table XVI shows, the revised scaling does not produce as strong a relationship between the predictor space and the decision-performance metrics as the original scaling; hence, it is assumed that the weights used in the revised scaling are not as good as the ones used in the original scaling.

**TABLE XVI**

**REGRESSION ANALYSIS OF THE EXTENDED BOX DESIGN USING THE REVISED SCALING**

<table>
<thead>
<tr>
<th>Experimental Metric (Criterion Variables)*</th>
<th>Predictor Scales</th>
<th>Multiplier</th>
<th>T-Value Significance Level</th>
<th>F-Value Significance Level</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>Ego Strength</td>
<td>.475</td>
<td>.05</td>
<td>.5</td>
<td>Inverse</td>
</tr>
<tr>
<td>NS</td>
<td>Responsibility</td>
<td>.363</td>
<td>.20</td>
<td>.5</td>
<td>Inverse</td>
</tr>
<tr>
<td>IU</td>
<td>Ego Strength</td>
<td>.646</td>
<td>.10</td>
<td>.5</td>
<td>Inverse</td>
</tr>
<tr>
<td></td>
<td>Sociability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Formulas for estimating decision performance:

\[ CS = 229.361 - 3.089E_{5} \]
\[ NS = 154.200 - 2.699R(G) \]
\[ IU = -124.701 + 10.966E_{5} - 6.198S \]

Consistent with all prior research findings, and also a major hypothesis of this study, was the finding that personality, as operationally defined for this study, was significantly related to the box metrics. The direct relationship between Dominance (Do) and the decision performance metrics, CS and IU, suggests that a person who tends to score higher on the Do scale also tends to vacillate between information sources.
less than a person who has lower scores, and the information sources which he bases his decision on tend to be the most reliable sources of information.

Using regression analysis to ascertain if there is a relationship between personality and the decision-performance metrics, the same MMPI predictor variables which were most significant in the replication analysis were the most significant when the extended test battery was used as the predictor variable set. In the regression analysis, when a relationship between the predictor variable set and only one dependent variable was forced, the two short tests for abstract reasoning made a significant contribution to the predictor hyperspace with EAS 7 being the independent variable which was able to explain the largest portion of the variation in the dependent variable in all three cases where there was a statistically significant relationship between the predictor variables and the chip decision-performance metrics. The only disappointment of the study to this point is the failure of the same predictor variables to be significant when the quantity and efficiency of information utilization and the process through which the information is utilized in reaching the ultimate decision were measured. Any further comment on this problem will be deferred until the results of canonical analysis are discussed using the extended test battery as the predictor set.

Canonical Analysis of the Extended Chip Design

To this point, there seems to be overwhelming evidence to support the hypothesis that there is a relationship between personality as it has been operationally defined for this study and the decision-performance
metrics developed for the box and chip experimental designs. This position was first attested in the original research and strongly supported in the prior research findings of this study where the original experimental designs were replicated.

The support of this hypothesis is made even stronger from the results of the extended regression analysis where the relationship between the box decision-performance metrics and personality, as defined by the extended psychological test battery, has proved to be significant at the .001 level and to have a higher CMC in every case (Table XVI). The extended analysis on the chip design found a statistically significant relationship between the decision-performance metrics and personality at the .001 level in every case except the decision-performance metric, $P_2$. This is particularly significant in view of the fact that regression analysis on the original chip sample and on the replication analysis did not show a significant relationship between decision-behavior performance and personality.

It should be recalled that canonical analysis did indicate a significant relationship between the decision metrics and personality on both the chip and the box experimental designs. To determine if the added personality scales improved the relationship between the predictor variables and the decision-performance metrics, canonical analysis was run on the extended predictor hyperspace and the criterion hyperspace.

The results of canonical analysis on the extended chip design (Table XVII) showed that the relationship between PS, $P_1$, and the predictor hyperspace was significant at the .001 level. The significance between $P_1$ and PS in the criterion space on the replication sample proved to be the
opposite of that found by Kernan and Mojena with $\bar{F}_1$ contributing almost nothing to the relationship between the predictor hyperspace and the decision-performance metrics. When the extended psychological test battery was employed, the relationship between $P_S$, $\bar{F}_1$, and the predictor space supported these findings.

TABLE XVII
CANONICAL ANALYSIS OF THE EXTENDED CHIP DESIGN

<table>
<thead>
<tr>
<th>Variable</th>
<th>Using Formula 4</th>
<th>Using Formula 5</th>
<th>Using Formula 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient Multiple</td>
<td>.999</td>
<td>.999</td>
<td>.999</td>
</tr>
<tr>
<td>Significance Level</td>
<td>.001</td>
<td>.001</td>
<td>.001</td>
</tr>
<tr>
<td>Criterion Coefficients:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency Measure</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Power of Search</td>
<td>.000</td>
<td>.000</td>
<td>.001</td>
</tr>
<tr>
<td>Heuristic Measure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictor Coefficients:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ascendancy</td>
<td>6.252</td>
<td>6.252</td>
<td>6.235</td>
</tr>
<tr>
<td>Responsibility</td>
<td>.757</td>
<td>.757</td>
<td>.754</td>
</tr>
<tr>
<td>Emotional Stability</td>
<td>-2.399</td>
<td>-2.399</td>
<td>-2.393</td>
</tr>
<tr>
<td>Sociability</td>
<td>-2.289</td>
<td>-2.289</td>
<td>-2.280</td>
</tr>
<tr>
<td>Cautiousness</td>
<td>2.603</td>
<td>2.603</td>
<td>2.603</td>
</tr>
<tr>
<td>Original Thinking</td>
<td>.574</td>
<td>.574</td>
<td>.581</td>
</tr>
<tr>
<td>Personal Relations</td>
<td>.731</td>
<td>.730</td>
<td>.718</td>
</tr>
<tr>
<td>Vigor</td>
<td>-2.064</td>
<td>-2.064</td>
<td>-2.063</td>
</tr>
<tr>
<td>EAS 7</td>
<td>-1.672</td>
<td>-1.672</td>
<td>-1.666</td>
</tr>
<tr>
<td>EAS 10</td>
<td>1.951</td>
<td>1.951</td>
<td>1.945</td>
</tr>
<tr>
<td>Anxiety</td>
<td>11.736</td>
<td>11.735</td>
<td>11.712</td>
</tr>
<tr>
<td>Repression</td>
<td>3.295</td>
<td>3.295</td>
<td>3.283</td>
</tr>
<tr>
<td>Ego Strength</td>
<td>4.076</td>
<td>4.076</td>
<td>4.076</td>
</tr>
<tr>
<td>Low Back Pain</td>
<td>.009</td>
<td>.009</td>
<td>.010</td>
</tr>
<tr>
<td>Caudality</td>
<td>-6.337</td>
<td>-6.336</td>
<td>-6.311</td>
</tr>
<tr>
<td>Dependency</td>
<td>-3.095</td>
<td>-3.095</td>
<td>-3.093</td>
</tr>
<tr>
<td>Dominance</td>
<td>-2.603</td>
<td>-2.603</td>
<td>-2.592</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>-3.657</td>
<td>-3.657</td>
<td>-3.644</td>
</tr>
<tr>
<td>Prejudice</td>
<td>1.985</td>
<td>1.985</td>
<td>1.985</td>
</tr>
<tr>
<td>Social Status</td>
<td>-3.089</td>
<td>-3.089</td>
<td>-3.089</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>-2.684</td>
<td>-2.685</td>
<td>-2.693</td>
</tr>
</tbody>
</table>
These results appear to be consistent with what would logically be expected, since the PS metric is based on both the power of the search heuristic ($P_1$) and the effectiveness of the search heuristic (number of correct decisions). It should be recalled that the size of PS is dependent on the amount of information that is transmitted with PS increasing as the quantity of information acquisition or the amount of transmitted information decreases whether or not a correct decision is made. From this analysis, it appears that the $P_1$ variables are redundant.

Because of the vast number of variables in the predictor hyperspace, only the few with the largest coefficients will be discussed. The personality scale, Anxiety ($A$), appears to be the most significant predictor variable, producing a coefficient of 11.7 and being directly related to the criterion variable, PS. This indicates that, as the $A$ score tends to increase, the value of the PS metric is expected to increase. This suggests that a person who tends to score high on the $A$ scale will tend to have a more powerful and efficient search heuristic than a person who tends to score low on $A$. This implies that, as a person tends to score higher on the $A$ scale, he will tend to acquire a diminishing proportion of the environmental information prior to making his decision, but the number of correct decisions will tend to increase.

A corollary to the relationship between the Anxiety scale and PS is that, as a person's score tends to increase, he also tends to be a risk-assumer. This is evident in that a person who tends to score high on the $A$ scale tends to acquire a smaller proportion of the available information prior to decision-making which in turn suggests that he
has a propensity to assume risk; whereas, a person who tends to acquire large proportions of the available information prior to decision-making manifests a propensity to avoid risk by transferring the risk to the information source.

The predictor variable with the second largest coefficient was Caudality (Ca) which was inversely related to the decision-performance variable, PS. The inverse relationship between Ca and PS suggests that, as the value of the Ca scale tends to increase, the value of the criterion variable, PS, will tend to decrease. This means that a person who tends to score high on the Ca scale is inclined to acquire a larger proportion of the available environmental information prior to making a decision, and there will be an increasing tendency for the decisions to be incorrect. The corollary to the relationship between Ca and PS is that a person who tends to score higher on the Ca scale would be considered a risk-averter because of his tendency to acquire a larger proportion of the available information prior to making a decision.

The predictor variables with the third and fourth largest coefficients were Ascendancy A(G) and Emotional Stability (Es), which were directly related to the decision-performance variable, PS. The implications from these relationships are the same as those of the relationship between Anxiety and PS. As the value of the A(G) and the Es scales increases, the value of the efficiency scale, PS, tends to increase which implies that the decision-maker tends to acquire a smaller proportion of the available information prior to making a decision and that the decisions have a tendency to be progressively more accurate. A person who tends to score high on the Es scale tends to be a risk-assumer.
In terms of defining the relationship between the predictor hyperspace and the dependency hyperspace (in this case, PS), the other variables were of descending importance. The interpretation of the direct and inverse relationship between the predictor variables and the criterion variables will be the same as the interpretation for the variables reported above. For all the variables having an inverse relationship with PS, this relationship suggests that, as the magnitude of the score for the predictor scale increases, the proportion of the available information acquired by the decision-maker prior to making a decision is expected to increase and that the decisions have a tendency to become more inaccurate. The corollary to the inverse relationship between the predictor variable and the decision-performance variable is that, as the score of the predictor scale increases, the decision-maker progressively becomes more intent on averting risk through the acquisition of information.

For all of the predictor variables with a direct relationship with the decision-performance variable, PS, this relationship suggests that, as the magnitude of the score for that scale increases, the proportion of the available information acquired by the decision-maker prior to making a decision is expected to decrease and that the decisions have a tendency to become more accurate. The corollary to the direct relationship between the predictor variable and the criterion variable(s) is that, as the score of the predictor scale increases, the decision-maker progressively becomes more intent on assuming risk through the acquisition of smaller quantities of information.

Since PS was found to be the only criterion variable making a significant contribution to the dependency space when PS was run with the three
power metrics, $P_i$ ($i = 1, 2, 3$), an analysis of the data from computer runs involving PS and $P_2$ or PS and $P_3$ will not be necessary because the predictor variables were found to have almost the same coefficients, changing only slightly from that found when PS and $P_1$ were analyzed (Table XVII). For this reason, the results from considering PS and $P_2$ or PS and $P_3$ as dependency spaces will not be analyzed, but the results from these two computer runs will be reported in Table XVII. The interpretation of the meanings attached to the direction of the relationship and its significance is the same as that reported when PS and $P_1$ were used as the criterion variables making up the dependency space. It should be observed that the relationship between the dependency spaces and the predictor space was statistically significant at the .001 level.

**Canonical Analysis of the Extended Box Design**

Canonical analysis was conducted on the box design using the extended test battery to ascertain if the predictor variables from the expanded predictor hyperspace made a greater contribution toward explaining the variation in the criterion hyperspace than did the MMPI experimental scales and if the same predictor variables which were most significantly related to the variation in the chip decision-performance metrics were the same variables which were most significantly related to the variation in the box decision-performance metrics (Table XVIII).

The predictor variable with the largest coefficient was Anxiety (A), which was inversely related to CS and NS and directly related to IU. This suggests that, as $A$ increases, both CS and NS are expected to decrease and that IU is expected to increase. Since CS is a decision-performance
### TABLE XVIII

**CANONICAL ANALYSIS OF THE EXTENDED BOX DESIGN USING THE ORIGINAL SCALING**

<table>
<thead>
<tr>
<th>Criterion Variables</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient Multiple Correlation</td>
<td>.990</td>
</tr>
<tr>
<td>Significance Level</td>
<td>.001</td>
</tr>
<tr>
<td>Criterion Coefficients:</td>
<td></td>
</tr>
<tr>
<td>Consistency of Information Source Selection (CS)</td>
<td>.712</td>
</tr>
<tr>
<td>Number of Sources Acquired (NS)</td>
<td>.682</td>
</tr>
<tr>
<td>Information Utilization (IU)</td>
<td>-.164</td>
</tr>
<tr>
<td>Predictor Coefficients:</td>
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<tr>
<td>Ascendancy</td>
<td>-.2582</td>
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<tr>
<td>Responsibility</td>
<td>-.602</td>
</tr>
<tr>
<td>Emotional Stability</td>
<td>.777</td>
</tr>
<tr>
<td>Sociability</td>
<td>1.584</td>
</tr>
<tr>
<td>Original Thinking</td>
<td>.977</td>
</tr>
<tr>
<td>Personal Relations</td>
<td>-.2792</td>
</tr>
<tr>
<td>EAS 7</td>
<td>1.708</td>
</tr>
<tr>
<td>EAS 10</td>
<td>-1.286</td>
</tr>
<tr>
<td>Anxiety</td>
<td>-7.312</td>
</tr>
<tr>
<td>Repression</td>
<td>-2.559</td>
</tr>
<tr>
<td>Caudality</td>
<td>6.998</td>
</tr>
<tr>
<td>Dependency</td>
<td>1.462</td>
</tr>
<tr>
<td>Dominance</td>
<td>1.896</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>3.618</td>
</tr>
<tr>
<td>Prejudice</td>
<td>-.210</td>
</tr>
<tr>
<td>Social Status</td>
<td>.123</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>-1.566</td>
</tr>
</tbody>
</table>

A metric designed to measure a person's propensity to vacillate between the information source(s) from which he buys information prior to decision-making and since CS decreases as the number of vacillations increases, the relationship between the score on the A scale and CS suggests that, as a person tends to score higher on A, the number of times that he is expected to vacillate between information source(s) is expected to increase. The inverse relationship between the magnitude of the score on
the A scale and the magnitude of the score on the decision performance metric, NS, suggests that a person who tends to score higher on the A scale has a propensity to acquire information from a decreasing number of information sources prior to making his decision. A corollary to this inverse relationship is that a person who tends to score low on the A scale has a propensity to avert risk through the acquisition of information. This suggests that a person who tends to score low on the A scale tends to try to transfer risk to information sources through the acquisition of information.

IU is a decision performance metric designed to measure a person's propensity for maximizing his earnings based upon the strategy employed in selecting the information source(s). The direct relationship between the magnitude of the Anxiety (A) score and the magnitude of the IU score suggests that a person having a tendency to score high on the A scale tends to select inferior information sources and, hence, suboptimizes his economic return when participating in the experiment. It should be observed that the relationship between the predictor variable, Anxiety (A), and the decision performance metrics, NS and IU, is an interesting one in that it suggests that a person who tends to score high on the A scale tends to select fewer information sources (lower NS), but his information sources tend to be good ones in that IU is expected to increase. For a person to optimize his expected earnings, he should have selected a pure strategy of following the "advice" of information source C on every iteration. Any other strategy would suboptimize his expected earnings.

The predictor variable with the second largest coefficient was Caudality (Ca) which had a direct relationship with the two decision
performance variables, CS and NS, and an inverse relationship with the decision-performance variable, IU. The direct relationship between the Anxiety (A) scale and the decision-performance metrics, CS and NS, suggests that, as the value of the Ca score tends to increase, the corresponding score on the two decision-performance metrics, CS and NS, is expected to increase. The direct relationship between Ca and CS means that, as the magnitude of Ca increases, CS increases which implies that the number of vacillations between information sources has declined. Likewise, when the value of the Ca scale increases, the value of the NS scale is expected to increase which means that the number of information sources considered prior to decision-making has tended to decline.

A corollary from the above analysis suggests that, as a person tends to score higher on the Ca scale, he tends to acquire information from a greater number of information sources prior to making a decision and that he also tends to acquire information from the same information sources (reduction in the number of vacillations).

The inverse relationship between Ca and IU suggests that, as a person tends to score higher on the Ca scale, the value of the IU metric is expected to decrease. This means that a person who tends to score high on the Ca scale tends to acquire information from the more accurate sources of information, and thus he increases his number of correct decisions.

The interpretation and significance of all the predictor variables which are inversely related to CS and NS and directly related to IU is the same as that given to the predictor variable, Anxiety. The inverse relationship between the predictor variable and CS and NS suggests
that, as the magnitude of the predictor scales increases, the magnitude of both CS and NS is expected to decrease. Since CS is an inverse function, an increase in the magnitude of the predictor variable will suggest an increase in the number of vacillations which will decrease the magnitude of the CS scale. NS is a direct function which suggests that, as the value of the predictor variable increases, the value of the NS metric is expected to increase, meaning that a large number of information sources has been acquired prior to decision-making.

The direct relationship between the predictor variable and the decision-performance metric, IU, suggests that, as the value of the predictor variable increase, the magnitude of the metric, IU, will increase; given that NS is decreasing, this implies that the decision-maker is employing information from the more accurate information sources. Or, in other words, as the magnitude of the predictor variable increases, the decision-maker will tend to acquire information from fewer information sources and will tend to acquire information from the more accurate information sources.

The interpretation and significance of predictor variables which have direct relationships with the two decision-performance metrics, CS and NS, and an inverse relationship with the decision-performance metric, IU, are the same as were given to the predictor variable, Caudality (Ca). The direct relationship between the predictor variable and the decision-performance metrics, CS and NS, suggests that, as the magnitude of the predictor variables increases, the magnitude of the two decision performance-metrics, CS and NS, tends to increase which means that the number of information sources is increasing and that the number of vacillations between information sources is decreasing. The inverse relationship
between the predictor variable and the decision-performance metric, IU, suggests that, as the predictor variable score increases, the value of the IU metric is expected to decrease, implying that the decision-maker is employing information from inferior information sources in arriving at his decision.

Canonical analysis was conducted on the extended box design, using the revised scaling (Table XIX). Since the original scaling has consistently appeared to provide a better relationship between the predictor variables and the criterion variables, discussion of this analysis will be foregone with the observation that the CMC's using the two different scalings are almost identical. Also, although the size of the coefficients was changed, the order of predictor variable importance, based on coefficient size of the predictor variable, was almost the same. The only significant difference between the two results was the change in the coefficient signs.

The results from the extended design indicate that the same predictor variables which made the greatest contribution in establishing a statistically significant relationship between the predictor variables and the chip decision-performance metrics are the same one which were significantly related with the box decision-performance metrics, using the original scaling.

The variable with the largest coefficient in both cases was the Anxiety (A) scale from the MMPI, and the variable with the second largest coefficient in both cases was the Caudality (Ca) scale from the MMPI. Five of the top six predictor variables which were related to the box decision-performance metrics were contained within the top six predictor
variables related to the quantity of information selected and the ef-  
ficient use of this information in decision-making, and ten of the first  
eleven predictor variables related to the box decision-performance metrics  
were found within the first fourteen predictor variables related to the  
chip decision-performance metrics. This depicts a remarkable con-  
sistency between the predictor variables which are related to the two  
decision-performance metrics.

TABLE XIX
CANONICAL ANALYSIS OF THE EXTENDED BOX DESIGN  
USING THE REVISED SCALING

<table>
<thead>
<tr>
<th>Criterion Variables</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient Multiple Correlation</td>
<td>.996</td>
</tr>
<tr>
<td>Significance Level</td>
<td>.005</td>
</tr>
<tr>
<td>Criterion Coefficients:</td>
<td></td>
</tr>
<tr>
<td>Consistency of Information Source Selection (CS)</td>
<td>.597</td>
</tr>
<tr>
<td>Number of Sources Acquired (NS)</td>
<td>.027</td>
</tr>
<tr>
<td>Information Utilization (IU)</td>
<td>.801</td>
</tr>
<tr>
<td>Predictor Coefficients:</td>
<td></td>
</tr>
<tr>
<td>Ascendancy</td>
<td>-4.588</td>
</tr>
<tr>
<td>Responsibility</td>
<td>-1.362</td>
</tr>
<tr>
<td>Emotional Stability</td>
<td>.922</td>
</tr>
<tr>
<td>Sociability</td>
<td>2.597</td>
</tr>
<tr>
<td>Original Thinking</td>
<td>.971</td>
</tr>
<tr>
<td>Personal Relations</td>
<td>-3.706</td>
</tr>
<tr>
<td>EAS 7</td>
<td>1.529</td>
</tr>
<tr>
<td>EAS 10</td>
<td>-1.322</td>
</tr>
<tr>
<td>Anxiety</td>
<td>-1.643</td>
</tr>
<tr>
<td>Repression</td>
<td>-2.769</td>
</tr>
<tr>
<td>Caudality</td>
<td>7.170</td>
</tr>
<tr>
<td>Dependency</td>
<td>1.310</td>
</tr>
<tr>
<td>Dominance</td>
<td>1.873</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>4.171</td>
</tr>
<tr>
<td>Prejudice</td>
<td>- .435</td>
</tr>
<tr>
<td>Social Status</td>
<td>.938</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>-1.417</td>
</tr>
</tbody>
</table>
Canonical Analysis of the Reduced Predictor Spaces

In recognition of the possible criticism that the sample size used in this study was overwhelmed by the number of predictor variables in the predictor space, when canonical analysis was conducted, the predictor spaces for both the chip experiment and the box experiment were reduced by excluding the four predictor variables with the smallest coefficients on successive runs until the predictor spaces were reduced to five variables. It was felt that, if a statistically significant relationship could be established between the decision-performance variables and the predictor space with such a small number of variables in the predictor space, then there should be little doubt that there is a significant relationship between personality, as defined for this study, and decision performance or strategy, as defined by the decision-performance metrics. It was also felt that, if a statistically significant relationship could be established between such a small predictor space and the decision-performance metrics, decision strategy simulation could be meaningfully researched. The five predictor variables remaining in the chip predictor space were Ascendancy A(G), Caudality (Ca), Social Responsibility (Re), Social Status (St), and Emotional Control (Ca), and the five predictor variables which remained in the box predictor space were EAS 7, Anxiety (A), Caudality (Ca), Dependency (Dy), and Social Responsibility (Re).

Canonical Analysis of the Reduced Chip Experiment

Consistent with prior findings, PS was the predominant decision-performance metric in the criterion hyperspace with the metric, $\tilde{F}_i$,.
proving to be a redundant variable. Also consistent with previous findings was the sensitivity of the model for the formulation used to measure the quantity of information acquired prior to decision-making. Contrary to what had been found in earlier analysis, there was not a statistically significant relationship between the criterion variables and the predictor space when Formulation 6 was employed to measure the number of bits acquired prior to decision-making (Table XX), but when Formulations 4 and 5 were employed to measure the number of information bits acquired, the relationship between the predictor space and the criterion space was statistically significant at the .01 level. In

**TABLE XX**

**CANONICAL ANALYSIS OF THE REDUCED PREDICTOR SPACE**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Using Formula 4</th>
<th>Using Formula 5</th>
<th>Using Formula 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient Multiple Correlation</td>
<td>.507</td>
<td>.507</td>
<td>.300</td>
</tr>
<tr>
<td>Significance Level</td>
<td>.010</td>
<td>.010</td>
<td>.500</td>
</tr>
<tr>
<td>Criterion Coefficients: Efficiency Measure</td>
<td>.999</td>
<td>.999</td>
<td>- .892</td>
</tr>
<tr>
<td>Power of Search Heuristic Measure</td>
<td>.033</td>
<td>-.021</td>
<td>.451</td>
</tr>
<tr>
<td>Predictor Coefficients: Ascendancy</td>
<td>1.356</td>
<td>-.242</td>
<td>- .644</td>
</tr>
<tr>
<td>Caudality</td>
<td>.383</td>
<td>.827</td>
<td>-1.105</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>-.635</td>
<td>-.321</td>
<td>.113</td>
</tr>
<tr>
<td>Social Status</td>
<td>-.868</td>
<td>-.036</td>
<td>-.452</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>-.626</td>
<td>-.433</td>
<td>.780</td>
</tr>
</tbody>
</table>

previous analysis, Formulation 6 produced the most significant relationship between the predictor space and the criterion space.
The analysis will only relate the predictor variables with PS since the coefficients for $\hat{p}_1$ and $\hat{p}_2$ are approximately zero. Table XX indicates that, when Formulation 4 is used to compute PS, there is a direct relationship between PS and the two predictor variables, Ascendancy $A(G)$ and Caudality (Ca), and an inverse relationship between PS and the three predictor variables, Social Responsibility (Re), Social Status (St), and Emotional Control (Cn). These relationships suggest that, as the values of the $A(G)$ and Ca scales tend to increase, the value of the decision-performance metric, PS, will tend to increase, meaning that, as the value of the $A(G)$ and Ca scales increases, the decision-maker has a propensity to make more accurate decisions on the basis of a fewer number of bits of information.

The inverse relationship between the decision-performance metric, PS, and the three criterion variables, Social Responsibility (Re), Social Status (St), and Emotional Control (Cn), suggests that, as the value of the Re, St, and Cn scales increases, the value of the metric, PS, is expected to decrease. This means that, as the value of Re, St, and Cn tends to increase, the decision-maker tends to acquire more information prior to making his decision and that his decisions will progressively be less accurate.

**Canonical Analysis of the Reduced Box Design**

When canonical analysis was conducted on the box data (Table XXI), a direct relationship was found between the criterion variables, EAS 7, Caudality (Ca), Dependency (Dy), and Social Responsibility (Re), and the decision-performance variables, CS and NS. This relationship suggests that, as the value of the EAS 7, Ca, Dy, and Re scales tends to increase,
the value of the decision-performance metrics, CS and NS, is expected to increase. The direct relationship between EAS 7, Ca, Dy, Re, and CS means that, as the value of these criterion values tends to increase, the number of times that a decision-maker is inclined to vacillate between information sources will tend to decrease which will, in turn, increase the magnitude of the CS metric.

TABLE XXI

CANONICAL ANALYSIS OF THE REDUCED BOX DESIGN USING THE ORIGINAL SCALING

<table>
<thead>
<tr>
<th>Criterion Variables</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient Multiple Correlation</td>
<td>.963</td>
</tr>
<tr>
<td>Significance Level</td>
<td>.001</td>
</tr>
<tr>
<td>Criterion Coefficients:</td>
<td></td>
</tr>
<tr>
<td>Consistency of Information Source Selection (CS)</td>
<td>.689</td>
</tr>
<tr>
<td>Number of Sources Acquired (NS)</td>
<td>.704</td>
</tr>
<tr>
<td>Information Utilization (IU)</td>
<td>-.170</td>
</tr>
<tr>
<td>Predictor Coefficients:</td>
<td></td>
</tr>
<tr>
<td>EAS 7</td>
<td>.345</td>
</tr>
<tr>
<td>Anxiety</td>
<td>-1.661</td>
</tr>
<tr>
<td>Caudality</td>
<td>1.444</td>
</tr>
<tr>
<td>Dependency</td>
<td>.563</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>.680</td>
</tr>
</tbody>
</table>

The direct relationship between EAS 7, Ca, Dy, Re, and the decision-performance metric, NS, means that, as the value of the EAS 7, Ca, Dy, and Re scales tends to increase, the decision-maker has a tendency to acquire information from a larger number of information sources prior to making his decision.

The inverse relationship between the criterion variable, Anxiety (A), and the two decision-performance metrics, CS and NS, suggests that, as
the size of the A scale increases, the value of the CS and NS metrics is expected to decrease. This means that, as a decision-maker tends to score higher on the A scale, he has a propensity to vacillate between information sources which decreases the value of CS. The decision-maker who tends to score higher on the A scale is also inclined to acquire less information or to acquire information from a fewer number of information sources prior to making his ultimate decision.

A corollary of these findings is that a person who tends to score higher on the EAS 7, Ca, Dy, and Re scales and lower on the A scale tends to be a risk-averter. He attempts to avert risk by passing the risk to the information sources from which information is acquired.

There is an inverse relationship between the criterion variables, EAS 7, Ca, Dy, and Re, and the decision-performance variable, IU. This relationship suggests that a person who tends to score high on the EAS 7, Ca, Dy, and Re scales tends to score lower on the IU metric probably because he tends to employ the advice of the poorer sources of information.

The direct relationship between Anxiety and IU suggests that, as the value of the A scale tends to increase, the value of the IU metric also tends to increase. This means that a decision-maker who tends to score higher on the A scale has a tendency to employ information from the information sources providing the most accurate information.

Summary

The predictor spaces for both the chip design and the box design can be reduced to five criterion variables and still produce a significant
relationship between the criterion space and the predictor space. In the case of the box experiment, the most important criterion variable was Anxiety (A), and the second most important criterion variable was Caudality (Ca); this was the same order of importance found when analysis was run on the extended predictor set. In contrast to the findings from performing canonical analysis using the original scaling, the revised scaling (Table XXII) produced no significant relationship between the criterion space and the predictor space.

TABLE XXII
CANONICAL ANALYSIS OF THE REDUCED BOX DESIGN USING THE REVISED SCALING

<table>
<thead>
<tr>
<th>Criterion Variables</th>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient Multiple Correlation</td>
<td>.513</td>
</tr>
<tr>
<td>Significance Level</td>
<td>.500</td>
</tr>
<tr>
<td>Criterion Coefficients:</td>
<td></td>
</tr>
<tr>
<td>Consistency of Information Source Selection (CS)</td>
<td>-.593</td>
</tr>
<tr>
<td>Number of Sources Acquired (NS)</td>
<td>.096</td>
</tr>
<tr>
<td>Information Utilization (IU)</td>
<td>.799</td>
</tr>
<tr>
<td>Predictor Coefficients:</td>
<td></td>
</tr>
<tr>
<td>EAS 7</td>
<td>-.149</td>
</tr>
<tr>
<td>Anxiety</td>
<td>-1.180</td>
</tr>
<tr>
<td>Caudality</td>
<td>-.701</td>
</tr>
<tr>
<td>Dependency</td>
<td>1.289</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>.412</td>
</tr>
</tbody>
</table>

Conclusion
One of the major hypotheses of this study was that there is a relationship between personality, as defined for this study, and decision performance, as defined by the box and the chip decision-performance
metrics. When the box and chip experiments were replicated, regression analysis established statistically significant relationships between the dependent variables and the two respective predictor spaces. These findings were supported by the findings of canonical analysis (Tables VIII and XII).

When regression analysis was run on the findings of the chip and box experimental designs, the relationship between the predictor space and the two search heuristic metrics, \( P_3 \) and \( PS \), was found to be significant at the .005 and .001 levels respectively (Table XIV), and the relationship between the predictor space and the three decision performance metrics, \( CS \), \( NS \), and \( IU \), computed using the original scaling, was respectively .01, .001, and .1 (Table XV). When canonical analysis was run on the extended design, the relationship between the predictor space and the criterion spaces was found to be statistically significant at the .001 level on both the box and the chip data (Tables XVII and XX).

These findings were greatly reinforced when the predictor spaces for both the chip and the box designs were reduced from twenty-one predictor variables to five predictor variables with a statistically significant relationship continuing at the .01 level on the chip data and the .001 level on the box data. It would appear from these findings that a relationship apparently exists between personality, as defined for this study, and decision performance.

It was also hypothesized that the same personality variables which are related to the power and the efficiency of a person's information search heuristic are the same personality variables which are related to his decision behavior in gathering decision information and to his
utilization of the information once it has been accumulated. From the extended canonical analysis, where a common predictor space was employed to establish a relationship with the chip and the box data, it was found that the variable with the largest coefficient in both cases was the Anxiety (A) scale and that the variable with the second largest coefficient was the Caudality (Ca) scale. Five of the top six predictor variables related to the box decision-performance metrics were contained within the top six predictor variables related to the chip decision performance metrics, and ten of the top eleven variables related to the box decision-performance metrics were contained within the top fourteen predictor variables related to the chip decision-performance metrics.

From these findings it would appear reasonable to conclude that the same predictor (personality) variables which are apparently related to the power and efficiency of a person's search heuristic ($E_4$ and PS) are related to a person's decision behavior in acquiring decision information (NS and CS) and employing that information in decision-making (IU).

The fact that Anxiety proved to be the most important predictor variable in predicting both the quantity of information employed in the decision-making process and the process employed by the decision-maker in arriving at an ultimate decision implies that part of the noise that enters the information channel (4, 5, 8, 11) is internally generated. As Anxiety is a very complex psychological state in which the different emotions are hyperactive (3), the inverse relationship between A and the quantity of information available suggests that a hyperactive emotion generator reduces the quantity of information that a person is able to analyze and assimilate; hence, the higher the A scale (measuring
the activity of the emotion generator), the less information a decision-
maker acquires prior to decision-making.

The inverse relationship between NS and Anxiety supports the
findings from the chip design that, as the power of the emotion generator
increases, the individual acquires less information prior to his decision
response. The inverse relationship between CS and A suggests that an-
other reason why a person with high anxiety has a tendency to acquire
less information is that he seems unable to perceive the best source(s)
of information, and as a consequence, he tends to vacillate between in-
formation sources. This inability to determine the better sources of
information might tend to discourage a person from acquiring information,
or if he does perceive the best source(s) of information, there appears
to be something inherent in a hyperactive emotion generator that pre-
vents him from making the decision which he knows he should make (4).
Assuming that the decision-maker with high anxiety does know the correct
decision response, it appears that the hyperactive emotion generator
tends to destroy self-confidence and that this loss causes the decision-
maker to vacillate between information source(s).

The two measures of abstract reasoning were only significant under
the assumptions of disjoint, independent-dependent variables which is a
necessary assumption for running regression analysis. When these un-
tenable assumptions were made unnecessary by running canonical analysis,
neither of the two measures of abstract reasoning were found to be im-
portant, but Caudality (Ca) was found to be the second most important
variable in both the box and the chip experiments. From these results,
it appears that the two tests for abstract reasoning would become
important predictor variables if the assumptions necessary for running regression analysis could be supported, but in the case of the decision performance metrics developed for both the chip and the box designs, it would seem very difficult to substantiate that the decision-performance metrics are disjoint and independent. This being the case, it appears that canonical analysis is the most logical technique for determining if a statistically significant relationship exists between personality, as defined for this study, and the decision performance metrics.

When canonical analysis was performed on the chip and the box data, the importance of the Caudality (Ca) predictor variable to the predictor space and the lack of either EAS 7 or EAS 10 making a significant contribution suggests that the Ca scale is measuring some decision characteristic other than abstract reasoning or that Ca is a better measure of abstract reasoning than either the EAS 7 or the EAS 10 scale. As far as the original hypothesis is concerned, the two tests for abstract reasoning failed to conclusively make the Ca scale redundant when using regression analysis. The tests are of much less significance in establishing a relationship between the predictor space and a criterion space when using canonical analysis than the movement of the Ca scale.

In using personality scales to predict decision-performance behavior, it appears that the MMPI scales are better predictors of decision performance variation than the Gordon scales. When canonical analysis was run on the chip data using the Gordon scales to make up the predictor space, the relationship between the predictor space and PS with the three power metrics, $\bar{P}_1$, $\bar{P}_2$, and $\bar{P}_3$, was respectively .5, .1, and .005 (Table VIII). When the eleven experimental scales from the MMPI
were used to make up the predictor space, the relationship between the predictor space and PS with $\bar{P}_1$, $\bar{P}_2$, and $\bar{P}_3$ was significant at the .001 level in all three cases (Table XXIII).

**TABLE XXIII**

**CANONICAL ANALYSIS OF THE BOX DESIGN USING MMPI AS THE PREDICTOR SET**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Using Formula 4</th>
<th>Using Formula 5</th>
<th>Using Formula 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient Multiple</td>
<td>.721</td>
<td>.721</td>
<td>.722</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Significance Level</td>
<td>.001</td>
<td>.001</td>
<td>.001</td>
</tr>
<tr>
<td>Criterion Coefficients:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency Measure</td>
<td>1.000</td>
<td>.999</td>
<td>.994</td>
</tr>
<tr>
<td>Power of Search</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heuristic Measure</td>
<td>.002</td>
<td>.013</td>
<td>.100</td>
</tr>
<tr>
<td>Predictor Coefficients:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>-.089</td>
<td>-.100</td>
<td>-.227</td>
</tr>
<tr>
<td>Repression</td>
<td>-.468</td>
<td>-.474</td>
<td>-.471</td>
</tr>
<tr>
<td>Ego Strength</td>
<td>-.058</td>
<td>-.062</td>
<td>-.082</td>
</tr>
<tr>
<td>Low Back Pain</td>
<td>.297</td>
<td>.296</td>
<td>.285</td>
</tr>
<tr>
<td>Caudality</td>
<td>.860</td>
<td>.864</td>
<td>.894</td>
</tr>
<tr>
<td>Dependency</td>
<td>-1.060</td>
<td>-1.053</td>
<td>-1.054</td>
</tr>
<tr>
<td>Dominance</td>
<td>1.304</td>
<td>1.307</td>
<td>1.353</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>-.111</td>
<td>-.107</td>
<td>-.115</td>
</tr>
<tr>
<td>Prejudice</td>
<td>.539</td>
<td>.543</td>
<td>.594</td>
</tr>
<tr>
<td>Social Status</td>
<td>-.985</td>
<td>-.984</td>
<td>-1.016</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>-.654</td>
<td>-.655</td>
<td>-.621</td>
</tr>
</tbody>
</table>

When canonical analysis was run on the chip and the box data, only one Gordon scale was found within the top seven predictor variables on the chip data (Table XVII), and only two Gordon variables were found within the top seven predictor variables on the box data (Table XVIII).
CHAPTER BIBLIOGRAPHY


CHAPTER V

SUMMARY, CONCLUSIONS, AND RESEARCH IMPLICATIONS

Summary

Decision-making is viewed as an integral part of everyday life and is just as much a part of the housewife's activities as it is of the businessman's activities. The primary difference between the decisions made by these two groups is that the information available is more voluminous and the level of sophistication employed is higher for the businessman than for the housewife. Although decisions vary in their relative importance, the decision-making process is the same for all decisions, and the necessity to choose between alternatives cannot be avoided. A person's propensity to procrastinate must also be seen as the decision not to select between alternatives at a given time, and this decision, like all other decisions which decision-makers could choose, affects a person's or a company's future action or the outcome of their present actions.

The importance of decision-making as a phenomenon in the progress of society and mankind is evident when the evolution of living matter is paralleled with the evolution of decision-making. The earlier decision-makers were unicellular organisms whose survival depended upon their ability to recognize and reject toxic substances while satisfying their need for food. With the emergence of civilized man, a decision-making structure came into being, but history seems to suggest that the progress
of mankind from that of a scavenger to modern times has been limited by the level of sophistication which has been achieved in the decision-making process.

The process of decision-making underwent a substantial change with the emergence of tribal leaders, local sages, religious leaders, and kings as specialized decision-makers. The evolution of specialized decision-makers has continued to the point that decisions made by the decision-makers of today may ultimately touch the lives of everyone in the civilized world.

It is recognized that decision-makers both use and misuse information in arriving at decisions. After the information has been used to evaluate the different alternatives, some of the alternatives can be shown to be inferior to others. Although the inferiority of certain alternatives appears to be generally accepted, there is a considerable amount of disparity among the criteria used by different disciplines in describing a rational decision strategy. Regardless of which criteria are employed to explain decision behavior, very little is known about why some decision-makers choose alternatives which seem to be irrational, but as Jean Piaget observed, in many cases more can be learned by studying the exceptions in human behavior than can be learned by studying the normal tendencies (7). The impetus for the original research by Scarboorough-Schkade and Kernan-Mojena was the possibility that so-called irrational behavior is really a reflection of a person's psychological makeup. This study is an extension of those original studies with the objective of casting additional light on the motivation behind the seemingly irrational decision behavior of individuals in a laboratory setting.
It has also been observed that different decision-makers, exposed to the same situation and with access to virtually the same information about the possible alternatives, tend to select different alternatives. Endeavoring to discover the underlying causal agent that results in individuals making different decisions when availed with the same information and confronted with the same decision situation, L. L. Schkade and Jerry Scarborough developed an information-box experimental design, and Jerome Kernan and Richard Mojena developed a chip experimental design to test the hypothesis that individual differences in decision strategies can be attributed to differences in psychological makeup. Both of these experimental designs were constructed to measure the quantity of information employed by the decision-maker and to determine how effectively the information was used in the decision-making process. The objective of the decision-maker in both designs was to make decisions which would maximize a person's monetary earnings while he was participating in the experiment. Both Schkade-Scarborough and Kernan-Mojena had been able to show from their earlier experiments that decision performance, when measured by their respective decision-performance metrics, was related to psychological factors measurable by the scales from a variety of psychological tests which are usually known as personality tests.

Although both the Schkade-Scarborough and the Kernan-Mojena research results found a significant relationship between personality and decision performance, it has been noted by G. W. Walster and T. A. Cleary in *The American Statistician* that the difficulty in controlling the variables in behavioral research necessitates the replication of all such research to assume the validity of the results (17). One of the objectives of this
study has been to replicate both the box experimental design and the chip experimental design. In addition to validating the results from the original studies, this study used a uniform battery of psychological tests in addition to both regression-correlation and canonical analysis to compare the results from the two designs. The addition of the canonical quantitative-analytic technique in analyzing the box data made the comparison of the psychological scales, which were related to the decision-performance variables in one research design, comparable to the results from the other research design. The same was true when using regression-correlation analysis on both designs, but canonical characteristics of treating two or more dependent variables as dependency spaces in the line which is projected through the space to maximize the relationship between the dependent variables and predictor variables is very important. When metrics are developed to quantify manifest differences in decision performance, it is difficult to devise metrics which are statistically independent. The box and chip decision-performance metrics have a considerable amount of overlap; hence, the assumption that the various dependent metrics makeup a criterion space or dependency space is a more realistic assumption.

In both experiments, there was a considerable amount of individual difference in decision performance which could not be attributed to the scales used; however, the relationship established was highly significant. Also, in the case of the box design where the eleven experimental scales of the MMPI psychological test were used as the predictor set for the multiple regression analysis, Caudality was found to be a presistent predictor variable at the .8 significance level. Given that Ca is a scale designed to measure a brain-damaged individual's ability to do
mathematical operations, it was speculated that the property this scale was measuring could be abstract reasoning, and if some scale had been used to measure a person's ability to reason abstractly, the scale would have probably been highly related to decision performance.

These observations led to the present study with its eight objectives and four hypotheses. The objectives were to

1. Review and summarize the present literature which relates personality and binary decision behavior.

2. Review and summarize the present literature which relates personality to information transmission and utilization.

3. Administer three psychological tests, the Minnesota Multiphasic Personality Inventory (MMPI), the Gordon Personal Profile (GPP), and the Gordon Personal Inventory (GPI), to a group of subjects who participate in both the chip and the box experimental designs. This allowed a comparison of the personality factors with subject performance in the experimental designs.

4. Increase the base of psychological tests by including tests of abstract reasoning, in an endeavor to account for a proportion of the decision behavior which is presently unexplained in both the box and the chip designs.

5. Replicate both the box and the chip experiments with a different set of subjects, to test for consistency of findings (17).

6. Perform canonical analysis on the box design, endeavoring to extend and refine the analysis of the data.

7. Perform comparative analysis of the findings of the box design and the chip design, in an endeavor to ascertain what relationships exist
between transmitted information and the utilization of that information in binary decision-making.

8. Identify areas for further research, including possible changes in the metrics used to measure behavior, changes in the experimental designs, and possible biophysiological interfaces with the research.

The four hypotheses for this study were as follows:

1. Replication of the box and the chip research designs will support the original findings that personality, as reflected by a group of psychological scales, is related to decision performance.

2. Abstract reasoning, as defined by the psychological tests, EAS 7 and EAS 10, is related to the quantity of information acquired (box design metric, NS, and chip design metrics, $P_1$, $P_2$, and $P_3$), the quality of the information selected (box design metric, IU), and the utilization of the information for decision-making (box design metric, CS, and chip design metric, PS).

3. The same personality scales which are related to a person's acquisition and utilization in the box design are related to the power and the effectiveness of the search heuristic in the chip design.

4. Canonical analysis is a better analytical technique for the data generated by the box and the chip designs than regression-correlation analysis; and, as a consequence, the coefficient of canonical correlation will be larger than the Pearson Coefficient of Correlation.

Conclusions

1. When the Scarborough-Schkade and Kernan-Mojena studies were replicated, the findings confirmed that there is a significant relationship between personality, as defined in the respective research design,
and the decision-performance metrics, although not necessarily the same psychological scales nor the same order of significance. There was a noticeable difference between the findings of the Kernan-Mojena regression correlation results and those of the present study in that a statistically significant relationship exists between $P_5$, $PS$, and the personality scales at or above the .02 level. As the F-value was not statistically significant on any of the three search heuristic power metrics or the search efficiency metric, $PS$, there does not appear to be a significant difference between the results of regression-correlation analysis on the present study and the original findings reported by Kernan-Mojena.

2. The most unexpected finding of this study was the fact that EAS 7 and EAS 10, which are primarily tests for abstract reasoning, did not prove to be significant predictor variables as had been hypothesized. It would appear that, if abstract reasoning is an important factor, the quality is either being measured better by one or more of the other scales in the predictor sets or that EAS 7 and EAS 10 are very poor measures of abstract reasoning. There are other possible explanations, but all possibilities are beyond the realm of this study.

3. As was hypothesized, the same test scales which were significantly related to the process of information acquisition, selection, and utilization, as reflected in the box research design, were also related to the power and effectiveness of a person's search heuristic, as reflected by the chip research design. The most significant predictor variable for both designs was the Anxiety scale followed by the Caudality scale on the MMPI. Five of the top six predictor variables related to the box decision-performance metrics were contained within the top six
predictor variables related to the chip decision-performance metrics, and ten of the top eleven variables related to the box decision performance metrics were contained within the top fourteen predictor variables related to the chip decision-performance metrics.

To reduce the criticism that the sample size had been overwhelmed by the number of predictor variables, the number of predictor variables used in both the box and the chip designs were systematically reduced until only five predictor variables remained in the predictor set for either of the research designs. Even with this small number of predictor variables, the level of statistical significance between the predictor set and the criterion set for the box design was .001, and the level of statistical significance for the chip design was .01 for PS and $P_1$ or for PS and $P_2$. This statistical relationship with such a small number of predictor variables greatly strengthens the supposition that decision performance is influenced by personality.

4. The coefficient of correlation produced by canonical analysis was greater in every instance than the coefficient of correlation produced by multiple regression. The higher coefficient of correlation plus the intercorrelation between the various decision-performance metrics indicates that the metrics were not disjoint or reasonably independent as assumed for regression analysis. As canonical analysis does not require that the criterion or dependent variables be disjoint, canonical analysis appears to be a better analytical tool for this experimental data than multiple regression and correlation analysis.

5. The replication of canonical analysis on the chip data supports the Kerman-Mojena findings that the level of statistical significance is
very sensitive to the formulation (Formula 4, 5, or 6) used to measure the power of the search heuristic. For instance, statistical significance between the efficiency scale, PS, and the three measures of the power of the search heuristic, $\bar{P}_1$, $\bar{P}_2$, and $\bar{P}_3$, varied from .005 for $\bar{P}_3$ to .5 for $\bar{P}_1$. In summary, the results of the present study confirm the findings of both the Scarborough-Schkade and the Kernan-Mojena studies.

6. In an endeavor to determine if a better set of scales could be developed to measure decision performance on the box design, a systematic effort was made to use other parameters and metrics which would improve the relationship between decision performance and the predictor set while retaining some logical basis for the change. Although several metrics were employed, none proved to be as good as the scales originally developed by Schkade. The best of the revised scalings was included in the present study, but these failed to produce a Pearson Coefficient of Correlation or a coefficient of canonical correlation as high as those produced by the original box scaling.

7. The scales of the MMPI are a better reflection of decision performance for the six decision-performance metrics used in this research than the eight scales from the GPI and the GPP.

Research Implications

Although it appears that all of the study's endeavors were remarkably successful with (1) the replication supporting the original findings, (2) the same personality characteristics being important in both the box and the chip designs, and (3) the canonical algorithm providing both stronger relational results between the predictor
variables and the criterion variables and deeper insight into the relative importance of each of the criterion variables to explain decision strategy, the contribution of this research in describing or identifying factors which seem to be related to a person's deviation from the theoretical models must not be overemphasized.

The reason for this caution is the difficulty in explaining what the psychological scales of the MMPI, GPP, and GPI are measuring. The only positive implication of this study is that there is a statistically significant relationship between these selected psychological scales and decision performance as defined by the three decision-performance metrics developed by Kernan-Mojena. Until a better measure of an individual's makeup can be developed, such as perhaps one or more metrics developed from the electroencephalogram scales, this contribution is, at best, a small piece in a large, complex puzzle.

One of the most significant aspects of this study and that of its predecessors is that it represents a first crude step in being able to measure quantitatively characteristics which seem to be related to a person's propensity to behave in a manner other than what would be expected from the major decision-theory models. Through the evolution of time and study, it is quite probable that much better metrics will be developed which should greatly increase knowledge of decision-making and the decision-making process when used with improved metrics designed to measure an individual's "personality" differences.

Much of the work ahead for researchers in endeavoring to measure quantitatively individual differences in decision-making and to identify those factors which are responsible for behavioral deviations rests in
trying to transform the present descriptive models into quantitative formulations. It would appear that, if the many diverse descriptive socio-economic models from the areas of developmental psychology, psychological learning theory, abnormal psychology, social psychology, psychobiology, and others could be coalesced through a systematic model, the quantitative formulations necessary to measure individual differences in decision-making behavior would not be too far into the future. Without a good working systematic model, it is obviously going to require a much longer period of time to be able to talk quantitatively about individual differences in decision-making behavior, and the number of research errors made by workers trying to establish quantitative decision differences will be greater in number.

Although a quantitative model capable of accurately predicting decision behavior does not exist at this time, there are obvious advantages to developing one. First, the ability to describe behavior quantitatively connotes the ability to predict behavior, and the ability to predict behavior implies the ability to analyze closely and to change decision behavior. There are some possible ramifications to the ability to change or control decision patterns, but they will not be discussed in this study. The ability to change or control decision patterns is viewed in the same way as nuclear energy, gene synthesis, abortion, and other areas of research. These processes are not inherently good or bad but depend on who is using them and for what reason they are used. If the knowledge from the above processes is used properly, the quality of life on this planet would be greatly enhanced; it is felt that the researcher almost always has this objective in mind when the actual research is being conducted.
One of the most important contributions envisioned from the ability to identify efficient decision-makers was the ability to filter out objectively those persons going into such professions as medicine, law, politics, and business, to name but a few. It is obvious that society would not want persons entering the medical profession who have a propensity to make inefficient decisions, yet Lee B. Lusted and other researchers who are interested in this area have pointed out that many so-called experts are actually very poor decision-makers (10).

It is quite possible that, if an accurate model of decision behavior could be developed, instead of certain persons being refused entrance into certain professions, those who have a propensity to make incorrect decisions could be taught to make more efficient ones.

The ability to identify efficient decision-makers is also important to business and to people with business interests. In an extensive study conducted by W. G. Baker, it was found that it was relatively easy to identify successful and nonsuccessful stock brokers by administering a specially designed psychological test. Baker contended that the obvious difference between the stock brokers who were able to invest and make money for their clients successfully and those who were unsuccessful in investing and making money for their clients was that an unsuccessful stock broker "tends to be uncertain when he is making decisions" (1).

It is logical that this criterion of success and failure equally applies to the business manager. The successful manager is the one who can successfully invest another person's money and bring about a transaction which will return the investor a profit. Likewise, the unsuccessful manager is an individual who is unable to invest another
person's money and bring about a transaction which will return a profit. If this analogy between the stock broker and the consultant-manager is an acceptable one, it also seems probable that the unsuccessful manager is the one who seems "uncertain when he is making decisions."

Another area of business in which the present study appears to make a significant contribution is in the area of market research. Bert Blake found that there is a significant relationship between dogmatism and the acceptance of new products, and John Robertson asserts that new products can be made successful if the "innovator" or trend leaders can be identified. It appears that an underlying characteristic of the market innovator is his disregard for the possibility that a new product may not be accepted (2, 14). If these people can be identified, then a message can be developed which will have particular appeal for them. The market innovator seems to be willing to accept the risk of being stuck with a product which few people want or which may even lead to his being ridiculed for its purchase. The Edsel automobile is an example. It appears that the decision inclination of the market innovator is closely akin to what could be called risk assumption (2). If this is an accurate hypothesis, the results from the Scarborough-Schkade research, the Kernan-Mojena research, and the present research could be used to assess a person's risk assumption-risk aversion propensity which appears to be related to his market innovating proclivity (9, 15).

In a cross-cultural replication of this extended design, conducted by Schkade and others, the relationship between personality and decision performance has been statistically significant in every case, although
different sets of predictor variables have emerged. This suggests that, if a firm is marketing its products multiculturally, the advertising should be designed in such a way as to have appeal to a particular culture, or possibly, the advertising message should be changed for each subculture market within a single country. It is also conceivable that the present metrics or others can be employed by market research specialists to compare quantitatively the effectiveness of different advertising messages in appealing to the different subcultures.

A field of study in which the findings of quantitative behavioral decision theory has possibly the most to offer is economics. It has been accepted for several years that game-theoretic models are not capable of explaining decision-making patterns (13). Recognition of the present problems in economic theory has led to a major rebuilding of economic theory which recognizes economic variables as being subject to stochastic laws. Ultimately, decision-making is done according to probabilistic distribution which is affected by both the quality and quantity of information available to the decision-maker about the possible outcomes.

The reformulation of economic theory to take account of stochastic components is certainly one of the most important areas of economic research. Path-breaking work is underway in reformulating the theory of the firm under conditions of uncertainty, in assessing the role of information in general equilibrium theory, in integrating uncertainty with welfare economics, and in designing measures of uncertainty possessing both theoretical appeal and practical importance (12, pp. 403-404).

This suggests the possibility of developing a new theory in economics which is not only based on stochastic models but is also based on the entropy of the available information at the time of
decision-making. Such a theory recognizes that, in reality, a person must make decisions on the basis of less than perfect information, and for this reason, the quality of decision-making, the economic decisions of the firm, and ultimately, the collective economic decisions which affect the entire economy are all functions of both the quality and the quantity of information available at decision time.

Finance is another important area where the present research has important implications. In finance, the decision-maker has a multitude of alternatives to discriminate between when making a decision. For example, if a financial officer is trying to determine the best source of new funds needed for expansion, he must determine if these funds can be raised internally or if the funds must come from the outside (3, 4). If it is decided that the funds must come from the outside, the financial officer must decide whether it will be best for the company to market additional stock (common or preferred), borrow short-term money from the bank, borrow long-term funds through the sale of bonds, a combination of the above, or use some less popular means, such as selling receivables (3).

From among these various alternatives, there will be those decisions which from an objective point of view are deemed acceptable, those decisions which are deemed unacceptable, and one or more decisions which will provide optimum results. The criterion normally used to determine the effectiveness of a financial officer is predicated upon the quality of his decision-making (propensity to choose one of the better decisions) when viewed in retrospect. This capacity of a financial officer to choose better decision alternatives comes from his ability to assimilate and
review the available data, and, on the basis of this data, select one of
the better decisions (4).

This problem as outlined seems to be analogous to the problem facing
a physician, accountant, stock broker, general manager, market researcher,
or any other decision-maker. There are some financial officers who have
a propensity for making the right decision and others who seem to acquire
more information and still select one of the poorer alternatives.

The one inexorable function of all the business endeavors presented--
i.e., the market researcher, the stock broker, the manager, the economist,
or the housewife--is that each of these persons is a decision-maker who
must choose between alternatives (make decisions) which entail varying
degrees of uncertainty. The literature points out that certain of these
decision-makers are effective and others are ineffective. The problem
lies in being able to determine what characteristics differentiate an
efficient decision-maker from an inefficient decision-maker (1, 8, 9, 12).

From this study and its two predecessors, it appears that decision-
making efficiency can be predicted on the basis of certain personality
scales. If this is a valid assumption, which it appears to be on the
basis of the research findings, it would appear that it is possible to
choose better decision-makers on the basis of certain "personality"
scoring and that it may be possible to devise some technique for changing
a person's decision-making efficiency by devising a technique or envi-
ronmental program capable of changing the personality profile.

As tempting as it is to make these kind of extrapolations, it
is very risky to do so on the basis of trying to equate a binary-
laboratory decision situation with that of a multidimensional-object
system decision situation faced by decision-makers. It is felt that the present research makes some contributions, but it is also felt that the real significance of these findings cannot objectively and decisively be evaluated at this point in time.

Areas for Further Research

Because of the ambiguity inherent in psychological tests, the results of this study could possibly be strengthened by substituting the movement of the brain waves for one or more of the twenty-one psychological scales in the predictor space or by adding the brain rhythms to the predictor space. One observation suggesting that this substitution might be meaningful is the fact that the Anxiety scale was the most important predictor variable for both the chip and the box models. What makes this significant is the observed relationship between anxiety and the alpha wave. Grey Walters suggests that persons who are particularly anxious have almost no perceptible alpha rhythm, while persons who are low in manifest anxiety have strong alpha patterns (18). If there exists a strong relationship between the alpha wave and anxiety and if the Anxiety scale on the MMPI psychological test is a true reflection of anxiety, there should be a strong relationship between the alpha pattern and the chip and the box decision-performance metrics. If this relationship could be established, present technology would allow for a much more precise measurement of the predictor scales than is possible using psychological tests.

A second important extension of the present study would be to develop some type of metric capable of measuring the amount of empirical information that a person employs in the decision-making process.
Statistical learning theory has shown that past stimulus-response reinforcement is an important factor in determining how a person will respond to a stimulus in an iterative decision situation \((5, 6, 16)\). A factor which would cast new light on the decision process is the changing of the experimental apparatus or experimental design to allow the decision-maker to buy access to his past purchase of information, to base his decision upon that information, and to determine the accuracy of his decision. It has been shown that all decision-makers have a limited channel capacity \((11)\); hence, from this information, it may be possible to determine the psychological characteristics of those decision-makers who can recode the available information on a pending decision in order to increase the number of bits of information which they are able to employ effectively in the decision-making process.

There are several possible findings which could result from the analysis of this additional metric. Better information processors might acquire more empirical data and efficiently employ it as a consequence of their codifying process, or an efficient information processor could possibly codify the information as he is exposed to the data. If a person is capable of codifying the data as he is exposed to it, he should acquire very little empirical information with the exception of possibly checking his mental code periodically. It is also obviously possible that something quite afield from either of these two proposed findings could be found upon analysis of the data.

Although the present research has many weaknesses, it is still believed to represent a significant step forward in the behavioral maze which explains why people behave the way they do when cast into a
decision-making situation. The relationship between the inherent self, or the self that cannot be seen, and a person's overt, quasimeasurable behavior seems to provide significant insight for future research in the area of decision theory.
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