1-1-1975

A methodology for the design of decision-maker oriented information systems.

Gary Martin Grudnitski
University of Massachusetts Amherst

A METHODOLOGY FOR THE DESIGN OF DECISION-MAKER ORIENTED INFORMATION SYSTEMS

A Dissertation Presented

By

GARY M. GRUDNITSKI

Submitted to the Graduate School of the
University of Massachusetts in partial
fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

June 1975

Business Administration

A METHODOLOGY FOR THE DESIGN OF DECISION-MAKER ORIENTED INFORMATION SYSTEMS

A Dissertation

By

Gary M. Grudnitski

Approved as to style and content by:

John G. Burch, Jr., Chairman of Committee

Richard H. Simpson, Member

Peter Park, Member

George S. Odiorne, Dean
School of Business Administration

John T. Conlon, Associate Dean
School of Business Administration

ACKNOWLEDGEMENTS

I would like to express appreciation to the following people, each of whom played a special role in transforming an idea into reality:

John Burch, the chairman of my committee, who invested large amounts of time in thoughtful criticism and guidance,

Dick Simpson and Peter Park, members of my committee, who supplied a wealth of individual expertise,

Dianne Peterson, who skillfully typed the dissertation for an author who never seemed able to make up his mind,

Roger Calantone, a great friend and office mate, who planted the idea, fertilized its development, and, I hope, shared in some of its bounty,

and, my wife, Bonnie, for providing editorial assistance, the amenities of a truly liberated woman, and three of the best years of my life. Thanks, Babe.

A METHODOLOGY FOR THE DESIGN OF
DECISION-MAKER ORIENTED INFORMATION SYSTEMS

June 1975

Gary M. Grudnitski, B. Comm., University of Saskatchewan
M.B.A., University of Saskatchewan
Supervised by: John Burch, Jr.

Abstract

Despite significant technological advancements, many management information systems have failed to achieve their promised potential. A major factor contributing to this phenomenon has been the inability of the analyst to design a management information system that is attuned to the needs of the decision-maker. To remedy this situation, it is essential to develop analytical tools that facilitate the process of defining distinct decision parameters, understandable to the decision-maker, the analyst, and others in the organization.

The primary purpose of the dissertation was to present, develop, and test a methodology for eliciting the information used, or desired to be used, by decision-makers in choice-set environments. Additionally, the methodology attempted to measure the conceptual attribute dimensions of the information.

The kernel of the selected methodology was the Role Construct Repertory Test (Rep Test), developed by George Kelly and applied within a clinical setting, and later adapted to the decision environment by Jarrod Wilcox. Illustrated in Chapter II were the distinct advantages inherent

in this methodology when evaluated against either direct modeling of the decision network or normative choice-set representation.

In Chapter III the experimental design and validation procedures were discussed. An interactive business game, emphasizing managerial planning and control activities, was selected as the trial setting. This particular setting was chosen over other possible trial settings primarily because of the degree of control that could be exercised over the number and types of decisions made. Students, drawn from sections of the undergraduate Managerial Accounting course offered at the University of Massachusetts, served as decision-makers. Nineteen teams were randomly formed from a total of sixty-five individuals.

The data collection procedure consisted of several steps. First, a sixteen item questionnaire was distributed to each participant. The purpose of the questionnaire was to identify the role played by various types and sources of information in the individual's conceptual structure of the decision environment. Second, using the data generated by the questionnaire, information triads were formed. These triads were systematically presented to individuals identified as being most responsible for planning decisions. Presentations took the form of individual, tape recorded interviews. Upon completion of all interviews, the taped protocols were reviewed, and a set of attribute scales for each individual was constructed. Finally, the list of types and sources of information generated from the questionnaire and the set of attribute scales were returned to each individual. The individuals were asked to rank order each type and source of information on each attribute scale. This task was facilitated by having both the information and the attribute scales in the respondents' own vocabulary. Subsequently, individual decision-maker maps were derived using nonmetric, factor analytic methods. The resulting maps consisted of sources and types of information within a reduced attribute space.

Validation of the decision-maker maps was attempted by drawing on the strategic planning framework of Robert Anthony. The working hypothesis generated was that those decision-makers having relatively complex cognitive structures and relying more heavily on external information would outperform, in a planning sense, decision-makers whose cognitive structures and information reliance was otherwise. The basis for the variable of planning performance was forecast error in sales volume; the parameters of cognitive structure and internal-external information reliance were quantified through factor analysis and subjective assessment respectively. The statistical model applied to test the hypothesis was a two-way analysis of variance with interaction.

Presented and analyzed in Chapter IV were the results produced by the methodology. Responses to selected questions (roles) were examined and summarized from the standpoint of feasibility of incorporation into the design of an information system. Next, validation results were reported. While the working hypothesis was statistically supported, unexpected directionality coefficients were obtained for the single, main effect variables. Statistical and behavicral alternatives were offered as explanations for this unexpected finding.

In Chapter V guidelines were suggested for incorporating the methodology into the design of a real-world management information system. Recommendations for related research across a broader spectrum of constituents of management information systems were given.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

In a well known critique of computer-based information systems, John Dearden illustrates the model information systems design:

> The latest vogue in computer information systems is the so-called real-time management information system. The general idea is to have in each executive's office, a remote computer terminal which is connected to a large-scale computer with a data bank containing all of the relevant information in the company. The data bank, updated continuously, can be "interrogated" by the manager at any time. Answers to questions are immediately flashed on a screen in his office. Allegedly, a real-time management information system enables the manager to obtain complete and up-to-the-minute information about everything that is happening within the company. [5, p. 123]

The allure of a bank full of data, instantaneously available on command to the decision-maker, caused many organizations to invest millions of dollars in equipment and human resources to build such a management information system [8]. What followed, was a period of disenchantment, brought about by the widespread failure of these information systems to fulfill their potential [14]. Although many reasons have been advanced as to why management information systems are often profit absorbers, rather than profit producers, Ackoff's explanation appears most cogent. Specifically, Ackoff [1] believes managers:

1. Suffer from an overabundance of irrelevant information.

2. Increase what is already an overload of irrelevant information by not being able to articulate their decision models.

3. Need to know how to use the information now provided.

4. Do not use the information now provided since they do not understand how it was derived.

The thrust of Ackoff's explanation is that management information systems ought to support and facilitate, rather than burden and hinder, management activities. And if one explores the environment of management, it becomes readily apparent that decision-making is the primary function that distinguishes managerial activity from other behaviors [11].

Logically then, the place to begin when designing a better mousetrap is with the mice. Only by careful study of the creatures' habits, can the probability of total failure be reduced. In the case of managers and management information systems, this means the information systems specialist should concentrate on identifying key variables used by managers in decision-making situations.

Mason and Mitroff succinctly define the information specialist's task:

> 1. Managers need 'information' that is geared to THEIR psychology NOT to that of their designers.
> 2. Managers need a method of generating evidence that is geared to THEIR problems NOT those of their designers. [12, p. 475]

While Mason's and Mitroff's guidelines are clear, if not widely practiced, there does appear to be a wide gap between what is being demanded from the analyst, and what is being supplied to him in the form of analytical tools. We are inviting disaster if we expect an analyst, through naive questioning of the manager, to elicit explicit decision parameters that are distinct and understandable to the manager himself, the analyst, and others in the organization [13].

Objective of the Dissertation

The objective of the dissertation is to outline and empirically test a methodology of eliciting the information considered important by individuals for decision-making. The methodology will focus on attempting to make explicit, through measurement, the cognitive decision structure used by individuals in a choice-set environment.

Definition of Terms

To provide a common ground for understanding the terminology used in the dissertation, the following terms are operationally defined:

ACTION SPACE - the identified alternatives (including the null alternative), or courses of action in a selection or choice situation.

ATTRIBUTE - the inherent quality, interpretation, or classification of an object or concept.

COGNITIVE MAP - the structure that allows an individual to process, in an active manner, environmental stimuli. Processing may take the form of responding, naming, discriminating, and analyzing information [6, p. 13].

CONCEPT - the generalization or abstraction of a thing. Movement by auto, railway, or airplane might be generalized under the concept of transportation.

CONSTRUCT - a pattern of relationship between two objects or concepts.

DECISION-MAKING - the process of selecting from identified alternatives.

DIMENSION - the combination of attributes. For example, the attributes of price, quantity, and quality might be functionally combined to form a dimension called value.

FUNCTIONAL FORM - the specific method of combination of items in a set or subset. Some of the more common functional forms are: additive, multiplicative, interactive additive, conjunctive, and disjunctive [9, p. 1394-1397].

MARGINAL RATE OF SUBSTITUTION - the slope of the indifference curve of an individual, at which the individual would be willing to substitute one commodity for another to maintain a given utility level [7, p. 12].

OBJECT - a concrete item, such as a car.

OUTCOME DOMAIN - the set of possible events or states of nature.

PROCESS MODEL - the molar strategy employed by individuals to integrate discrete items of information into a decision. Presently, research paradigms have generally followed a correlational or Bayesian approach [17, p. 16-18].

SOURCE OR TYPE OF INFORMATION - the specific kind, class, origin, or order of information. Examples of information sources might be: other people, past experiences, and resource documents. Examples of types of information might be: past history, statistically summarized data, and financial statements.

UTILITY - the net benefit, satisfaction, or payoff associated with selecting an alternative and having an outcome occur.

Brief Statement of the Research Design

To accomplish the objective outlined the research was designed to examine in detail, decision-makers in a simulated decision-making environment.

Trial setting selected. The trial setting selected was delimited by three considerations. These considerations were: sensitivity of the measurement procedure, stability in the decision-making process, and the ability to identify the decision-makers. Laboratory experimentation was chosen as the method of empirical investigation best able to satisfy the selection considerations. Specifically, an experimental game, emphasizing the planning and control activities of a competitive firm, was adopted as the trial setting to investigate the feasibility of the proposed methodology. This game entailed repetitive decision-making over seven decision periods. In each decision period, arbitrarily defined as simulating the economic events of one month, participants were faced with a number of decision variables. They had to decide on the price of a single, industry-wide, homogeneous product. In support of the selected price, appropriate expenditure levels of promotion and research and development were necessary. To sustain a given level of sales activity, the production resources of cash, raw materials, and labor, were the final decision variables required for each period.

Decisions of each team, in each industry, were then keypunched and entered into a computer-aided, simulation model. The model produced an individual composite of financial statements, as well as a synopsis of industry sales and profits. Based on a careful analysis by each team of its economic condition and the industry synopsis, the same set of decisions was made for the next decision period.

Decision-makers studied. Decision-makers were drawn from sections of the undergraduate Managerial Accounting course, offered at the University of Massachusetts in the Fall semester, 1974. Each of the sixty-five participants was randomly assigned to one of nineteen teams.

Data collection design. Following the third decision period, a list of sixteen questions was distributed to the participants. The purpose of the questionnaire was to elicit the role played by various types or sources of information in the individual's conceptual structure of the decision environment. Six of the questions related to planning decisions, two to control decisions, and the remaining eight, to decision-making in general.

Triads of information sources or types elicited from the questionnaires were then formed. The intent of triad formation was to provide a structure for eliciting attributes that described the information.

Interviews of the participants were subsequently conducted. The dialogue of each interview was tape recorded. From a detailed analysis of the recording, a set of adjective scales was constructed for each participant.

The initial questionnaires and set of adjective scales were returned to each participant, with the request that each type or source of information be ranked on each adjective scale.

Validation procedure. The subject of validating certain physical properties and simple attributes of persons is relatively straightforward and direct. In these situations, there is often a direct analog or close convergence between the object measured and the measurement instrument. Unfortunately, the same cannot be said for validating the cognitive structure of an individual. There are, for instance, no yardsticks to use, no scales with which to weigh the degree of deep-seated personality characteristics, and no clear-cut physical or behavioral traits that point unmistakenly to decision-making style [10, p. 444]. Thus, the whole process of validating an individual's cognitive structure, by its tangential and indirect nature, is likely to create debate rather than provide a clear consensus.

To test the degree to which the proposed methodology captured decision-makers' cognitive maps, the general framework of construct validity was applied. Construct validation, as opposed to predictive, concurrent, or content validation [4, p. 281-283], uniquely links empirical inquiry to theory. That is, construct validation is not simply a matter of validating a methodology. Instead one must additionally validate the theory behind the methodology. Three steps are followed in construct validation: suggesting what attributes account for test performance, deriving hypotheses from the theory involving the attributes and performance, and testing the hypotheses empirically [3, p. 121].

In this dissertation, the derived attributes of decision-maker cognitive complexity and information source usage were empirically tested for their relationship to planning performance; the theory utilized was that of Robert Anthony [2] concerning strategic planning.

Delimitations of the dissertation. There were two major delimitors to the dissertation. First, the methodology proposed directly addresses only the first two issues raised by Ackoff, namely, the overabundance of irrelevant information and the lack of explicit articulation of a decision-maker's conceptual structure. Second, the bent of the methodology is toward ephemeral choice imposed by the environment (descriptive or positive), rather than choice incorporated on a permanent basis, (normative) [13, p. 3].

With regard to the first limitation, there are many individuals [18] [16] [15] who believe that management appreciation, understanding, and involvement are the keys that will ultimately unlock the potential of management information systems. While there is little disagreement on this point, what should be realized is that decision-maker appreciation, understanding, and involvement only begins when acknowledgement is made that the system supports, rather than dictates, the processes of the decision-maker.

Regarding the second limitation, there are those who believe decision-making ought to be constrained within a normative framework. If the decision-maker is not acting in a normative manner, these individuals would contend what is of primary importance is education of that decision-maker. While education may be an appropriate vehicle for the achievement of normative behavior patterns, it appears foolhardy to proceed in that direction without a well-defined point of reference. Would we, for instance, recommend a route to a traveller without first determining the point of departure or the means of transportation available? Furthermore, without a clear descriptive picture of the decision-maker's cognitive structure, it becomes most difficult, if not impossible, to accurately assess and monitor the assimilation of educational input by the decision-maker.

Top management does not have a clear pane of glass through which they can view corporate operations without distortion; instead, they have what is more like a television screen, with those who are supposed to be monitored controlling the cameras; what they do see can be as significant as they do see.

Organization of the Dissertation

This chapter contains the background of the dissertation; the objective of the research; the definition of important terms; a brief description of the research design, including the trial setting selected, the decision-makers studied, an overview of the data collection design, and an introduction to the validation framework chosen; and the delimitations of the dissertation.

Chapter II includes a review of the state of the art in measuring decision-makers' cognitive maps. The review characterizes measurement procedures as following into the broad categories of: normative choice-set representation, direct modeling of the information processing network, and descriptive choice-set representation.

Contained in Chapter III is a detailed discussion of the experimental design and validation procedures employed in the dissertation. In Chapter IV the empirical data generated by the dissertation is presented and analyzed; Chapter V provides a summary of the dissertation, and recommendations for future research that have resulted from the dissertation.

REFERENCES

1. Ackoff, Russell L. "Management Misinformation Systems." Management Science 14 (December 1967): 147-156.

2. Anthony, Robert N.; Dearden, John; and Vancil, Richard F. Management Control Systems. Revised ed. Homewood, Ill.: Richard D. Irwin, Inc., 1972.

3. Cronback, Lee J. Essentials of Psychological Testing. 2nd ed. New York: Harper & Bros., 1960.

4. Cronback, Lee J., and Meehl, Paul E. "Construct Validity in Psychological Tests." Psychological Bulletin 52 (July 1955): 281-302.

5. Dearden, John. "Myth of Real-Time Management Information Systems." Harvard Business Review 44 (May - June 1966): 123-132.

6. Garner, W.R. "To Perceive is to Know." American Psychologist 21 (January 1966): 11-19.

7. Henderson, James M., and Quandt, Richard E. Microeconomic Theory. 2nd ed. New York: McGraw-Hill, 1971.

8. Hershman, Arlene. "A Mess In MIS?" In Computers and Management. Edited by Donald Sanders. New York: McGraw-Hill, 1970.

9. Huber, George P. "Multi-Attribute Utility Models." Management Science 20 (June 1974): 1393-1402.

10. Kerlinger, Fred N. Foundations of Behavioral Research. New York: Holt, Rinehart & Winston, Inc., 1964.

11. Kriebel, Charles H. "The Future MIS." In Computers and Management, 201-208. Edited by Donald Sanders. New York: McGraw-Hill, 1970.

12. Mason, Richard D., and Mitroff, Ian F. "A Program for Research on Management Information Systems." Management Science 19 (January 1973): 475-485.

13. Mattessich, Richard. "The Incorporation and Reduction of Value Judgments in Systems." Management Science 21 (September 1974); 1-19.

14. McKinsey and Company. "Unlocking the Computer's Profit Potential." The McKinsey Quarterly 7 (Fall 1968): 17-31.

15. Montgomery, David B. "The Outlook for MIS." Journal of Advertising Research 13 (June 1973): 5-11.

16. Shewe, C.D.; Wiek, J.L.; and Dann, R. "Advancing Marketing Information Systems: An Empirical Investigation of System Usage Problems." Proceedings of the Sixth Annual American Institute of Decision Sciences. Atlanta: n.p., 1974.

17. Slovic, Paul, and Lichtenstein, Sarah. "Comparison of Bayesian and Regression Approaches to the Study of Information Processing in Judgment." In Human Judgment and Social Interaction. Edited by Leon Rappoport and David Summers. New York: Holt, Rinehart & Winston, Inc., 1973.

18. Swanson, E. Burton. "Management Information Systems: Appreciation and Involvement." Management Science 21 (October 1974): 178-188.

19. Wilcox, Jarrod D. A Method for Measuring Decision Assumptions. Cambridge, Mass.: MIT Press, 1972.

CHAPTER II

RESEARCH INTO MEASURING COGNITIVE MAPS

Research into measuring how an individual, within a predefined context, structures sources or types of information, (hereafter referred to as cognitive mapping) and how this structuring influences his decision-making framework, has come from many different areas. One way of categorizing the related measurement literature is under the broad headings of normative choice-set representations, direct models of information processing, and descriptive choice-set representations [28].

Normative Choice-Set Representations

Emanating from the theory of microeconomics, decision alternatives which satisfy one or more constraints are defined as the outcome set. From this outcome set, one or more subsets are formed called indifference sets. These indifference sets are mutually exclusive and completely exhaustive. If the decision-maker conforms to certain axioms [9], he is assumed to be able to supply a complete transitive ordering of the indifference sets. From the most preferred indifference set, the decision-maker can randomly select the specific alternative.

The measurement aspect of this approach deals with the determination of indifference surfaces, both from the point of spatial representation, as well as marginal rates of substitution.

MacCrimmon [14] gives a procedure for obtaining the spatial representation of indifference surfaces for a transportation planning system. In his paper, a hierarchical goal structure and joint attribute set are considered. MacCrimmon uses the following heuristic procedure for determining the slope and convexity of the indifference curve:

1. Identify the direction of preference for the attribute set.

2. Identify the direction of the vector sum of the attribute set.

Along somewhat the same line, Dyer [6] proposes an interactive algorithm designed to determine a decision-maker's marginal rate of substitution. In essence, the decision-maker is requested to indicate how much he would "give up" from one criterion value, to gain a designated increment in another criterion value. To make the task less demanding on the decision-maker, the comparisons need only be done in ordinal form, (e.g., I prefer A to b).

Another more detailed form of mapping has been suggested by Huber [10]. Huber's procedure can be summarized as follows:

Step 1. Obtain the utility for each attribute level on a scale from 0 to 100. A qualitative attribute scale value is obtained by requesting the decision-maker to specify a most and least preferred level and assigning 100 and 0 to these levels, respectively. Using the most and the least preferred levels as a basis, the decision-maker indicates his relative satisfaction for each intermediate level. If the attribute levels are quantitative, a graph, plotting satisfaction against levels of the attribute, is drawn.

Step 2. Internal consistency is checked through ratio relationships. For example, such questions are asked as, "Since your satisfaction with a grade of A is 100% and your satisfaction with a grade of B is 20%, it appears that a grade of A is five times as satisfactory as a grade of B. Is that so?" The utilities are revised where appropriate.

Step 3. The decision-maker ranks the attributes in order of their importance, assigning a weight of 1.0 to the most important attribute, and relative weights to less important attributes.

Step 4. The attribute weights are checked for internal consistency using a procedure similar to Step 2.

Step 5. The levels and importance weights of the attributes are then combined to compute the utility for each attribute.

The scheme proposed by Puglisi, Paretta and Haas [19] is strikingly similar.

The measurement processes described above all suffer from a number of shortcomings. First, these processes are restricted to situations in which all or a very large number of alternatives can be considered and a complete preference ordering established. Consider using this process within a "house-finding" context. It is extremely unlikely for a decision-maker to investigate all available houses for an extended period of time and then "optimize" using one or more criterion values. Instead, he is more likely to use a "satisficing" model, terminating the search activity once an acceptable dwelling is found.

Second, the theory of microeconomics asserts that the preference ordering will go unchanged if the constraints are altered. Considering the example outlined above, this would preclude a shift in strategy (such as the option to rent an apartment), if suddenly, the decision-maker's income were halved.

Finally, even with the contribution of Von Neumann and Morgenstern [26], extreme uncertainty poses a threat to <u>each</u> of the major axioms of microeconomics [9, p. 44-45] and hence, this type of analytical measurement framework.

Direct Models of Information Processing

As noted in the previous section, normative choice-set representations of the decision process can become entangled in problems relating to optimization over the complete choice-set. To overcome many of the problems associated with optimization and imprecise representation of attribute sets, a line of research led by Simon [21] and his associates has concentrated on monitoring the information processing activity itself.

In essence, the source data for the direct modeling approach to measurement is generated by tracking decision-makers as they make real-world decisions. A protocol (record) of the verbalized thoughts and actions of each individual is made as he selects alternatives, and engages in informational search activities. Subsequently, goals, decision-making structure, and support information are formulated, based on a detailed analysis of the protocol.

The work of Cyert, Dill, and March [4], March and Simon [16], and Simon, Cyert, and Trow [22] focused on providing a description of the decision processes and the types of information systems necessary to support such processes within a complex, uncertain, and dynamic environment. The success of the modeling process [3] [25] has led to the development of an ensemble of computer programs which simulate, to a striking degree, the decision process [17].

The benefits obtained from direct modeling have been twofold. One benefit has been the development of an array of conceptual tools for analyzing the managerial decision process. These tools include the notion of "satisficing," heuristics for pruning alternatives, and means-ends decision trees. A second important benefit has been the development of support techniques which stress the processes of information gathering and inter-organizational communication [28].

The basic weakness of the direct modeling approach as a means of measuring or deriving cognitive maps is its feasibility. The method demands a substantial effort by both the analyst and decision-maker under study; a fact that makes it impractical to undertake on a large-scale basis. A subsidiary difficulty is that direct modeling remains, in fact, more an art than a science. In too many real-world situations, the practicing analyst has neither the training nor the temperament to fully exploit the power of the technique.

Descriptive Choice-Set Representations

Simply stated, descriptive choice-set representations of decision processes are obtained by first measuring the alternatives along one or more relevant attributes, and then obtaining the decision-maker's preference for each alternative. The third step in the procedure links the attributes to the preference ordering.

In contrast to normative choice-set representation, descriptive choice-set representation's power lies in its usefulness as a descriptor, rather than a predictor, of the decision process. This is a significant strength, for by shifting the focus, descriptive choice-set representation circumvents two difficulties. First, it is far more forgiving of apparent "irrationalities" in choice-set representation. That is, the derived model does not disintegrate because the decision-maker under study is not risk neutral, or prefers A to B, B to C, and C to A. Second, far less attention must be paid to the functional form of the attribute combination [10] and the process model itself [23], since useful description, not perfect prediction, is the benchmark of viability.

Given any group of decision-makers, their perception of objects may differ in three ways:

1. In the object's position along a common attribute.

2. In the attributes used by the decision-makers to characterize the object.

3. In the relation linking the attributes to the decision-maker's perception of the object. [28, p. 31]

Thus the key issue centers around measuring the <u>relevant</u> attribute dimensions. Two naive methods immediately come to mind. First, there is the technique of direct questioning of the decision-maker. Applying the direct questioning technique, we simply might walk into a corporate executive's office and ask him to articulate all facets of his planning model. This technique has limited effectiveness, as the respondent's decision-making framework may be partly unconscious. Another technique to discover the relevant dimensions is for an independent investigator to list a large number of potentially relevant attributes, and through observation and regression analysis of the preferences, somehow narrow the list. This approach, at best, is inefficient and subject to investigator biases; at worst, it may miss the mark entirely [28, p. 33].

More subtle methods of discovering the relevant dimensions are, therefore, called for. Two such methods are the semantic differential and factor analysis, and the Role Construct Repertory Test.

The semantic differential consists of a set of bipolar scales anchored at each pole by an adjective describing one side of a continuum. An individual is asked to rate an object or concept by placing his check mark at the point on the continuum where he feels the concept or object lies [5, p. 96-98]. For example, if an individual asked to rate the concept PRICE, on a very important/very unimportant scale, placed his mark in the most extreme category, that is, next to the word very important, we might consider that he thinks of this concept as having a semantic connotation of very important. To develop an <u>overall</u> semantic connotation of the concept being considered, many adjectives may be used. The strength of this technique is that it can be used to construct a semantic space for each individual representing our way of measuring how he views the concepts or objects he rates.

The semantic differential has two limitations. First, there is difficulty in making the prespecified set of bipolar adjective scales relevant to the problem at hand for a particular decision-maker. These bipolar scales adjectives may not be understood, or worse yet, misinterpreted if they are not in the decision-maker's own vocabulary. Second, the semantic differential is typical of the categorical rating techniques wherein the individual devising the test, not the decision-maker, determines the form (fineness) of the scale [5, p. 104].

Often used in conjunction with the semantic differential is factor analysis. The objective of factor analysis is to reduce the input set of bipolar adjective scales by forming linear combinations, losing in the process, a minimum amount of the variance [8]. The factors (dimensions) generated from this principal component analysis then can be rotated within the reduced structure, so that the factors more closely relate to the original input set. Finally, the concepts or objects may be rated on each factor.

Factor analysis allows the investigator a good deal of freedom in working, at the outset, with a large set of potentially relevant adjective scales, since he is assured removal of those adjective scales perceived by an individual to be redundant.

In 1955, George Kelly proposed a basic methodology for measuring the psychological space of individuals [11]. The kernel of the methodology was a diagnostic instrument called the Role Construct Repertory Test. The purpose of the Rep Test, as it is commonly called, was to generate a preliminary list of clinical hypotheses.

Methodologically, the Rep Test is an application of the concept-formation test. Unlike traditional concept-formation tests however, the Rep Test dealt with particular items (people), rather than levels of abstraction. The aim of the Rep Test was to develop role constructs [15] or concepts played out in the light of a subject's understanding of a familiar individual.

The procedure used to develop the role constructs for each individual entails in its simplest form, four steps.

First, the individual is requested to designate by name, the person in his realm of experience who best fits a list of role descriptions. The following is a sample from the twenty-four role titles used in the 1955 version of the test:

> An employer, supervisor, or officer under whom you worked or served and whom you found hard to get along with.
> A person with whom you have worked who was easy to get along with.
> A person with whom you have been closely associated recently who appears to dislike you.
> The most interesting person whom you know personally. [11, p. 221-222]

Following the completion by each subject of the role title questionnaire, triads of (groups of three) designated persons are formed by repetitive sorting. Although Kelly suggests a list of thirty-two such triads, he makes the point that substitution, deletion, or addition of triads is within the purview of the examiner.

In the third step of the procedure the examiner elicits similarities and differences for each triad. The examiner says, "Now I would like you to tell me something about these three people. In what important way are two of them alike, but different from the third?"

The examiner records the subject's response, then points to the odd card and says, "How is this person different?"

The examiner records the subject's response to the second question. The remaining sorts are elicited and recorded in the same fashion [11, p. 222].

In the fourth step of the procedure a repertory grid of f persons, c constructs, and f x c intercepts is formed. The subject is asked to check those persons to whom the construct applies. Those persons not checked are assumed to apply to the opposite end of that particular construct.

It is beyond the scope of this dissertation to evaluate the contribution of Kelly's methodology vis-a-vis conventional means of measuring cognitive maps. Within a clinical setting, Kelly's own feelings on the matter can be summarized as follows:

> The simplest, and probably the most clinically useful type of approach to a person's personal constructs, is to ask him to tell us what they are. It is hard to persuade some psychologists that such a guileless approach will work ... A clinician may not want to believe what he hears. He may not be willing to accept the problem in the client's terms. He may want the client to lie down on a Procrustean couch and be "psychoanalyzed." [11, p. 201]

Levy and Dugan [12] demonstrate that the Repertory Grid could be factor analyzed, producing a map of the subject's constructs analogous to Osgood's [18] semantic space. But whereas Osgood's semantic space was ordered by three derived dimensions for all subjects, Kelly's technique gave a unique map of the subject's semantic space in terms of his own dimensions. Because of this characteristic, Bannister [1] suggests that the technique developed by Kelly is extremely flexible. Bannister states:

> Thus although so far as it has been used to investigate constructs about people, there is no reason why the objects sorted by the subject should not be motor cars, political candidates, sexual practices or domestic utensils, thereby allowing a variety of construct subsystems to be investigated. [1, p. 114]

Bieri [2] found that he could isolate groups of subjects into categories of "cognitively simple" and "cognitively complex." Bieri defined a "cognitively simple" person as one who rated other people similarly on supposedly different traits. He adds, parenthetically, that had a factor analytic technique been used to evaluate the responses generated by "cognitively simple" people, few factors would emerge.

Frost [7] uses responses from Rep Test interviews and principal component analysis to develop a semantic differential for collecting attitude ratings of British television programs.

Lunn [13] suggests the Rep Test as a vehicle to determine existing brand attributes and new product ideas. Sampson [19] reports that Rep Test response to brands of drinks is independent of age, sex, or social class.

In the area of decision-making, the most extensive experimentation into the applicability of the Rep Test has been done by Jarrod Wilcox [27] [28]. Specifically, Wilcox investigated Kelly's methodology with respect to measuring assumptions held by market participants (professional investors).

The first step in the research design of Wilcox asks each participant to complete a list of twenty "roles" various stocks play or have played in the participant's conceptual structure and experience. A sample of the questions asked follows:

1. Your present favorite stock.
2. A stock a friend likes which you don't like.
3. A stock whose market action is hard to understand.
4. A stock which you should have waited longer to sell [27, p. 65]

To elicit labels of the important attributes along which the participant perceives the designated stocks, he is presented with triads of stocks and requested to identify what important way two of these stocks are similar with respect to the third stock's difference.

In the third step of the procedure, each participant uses a somewhat reduced list of elicited attribute labels (to make the task less tedious) to scale each designated stock. The instructions read as follows:

> ... For each attribute (a) divide the scale into between 2 and 9 equivalent intervals; (b) place any appropriate stocks into two separately provided categories, "scale not relevant," and "not enough information;" and (c) place the remaining stocks on the attribute scale in their appropriate intervals. [27, p. 57]

Next, a second questionnaire is given to each participant. On the elicited attributes, divided according to the intervals previously obtained, each participant is asked to place a new set of well known stocks. These results are coded and factor analyzed. The intent of the factor analysis is to increase the degrees of freedom for the analysis which follows.

A third questionnaire is now administered. This instrument asks the participants to rate

> ... The new, standardized list in terms of some particular investment objective which he is allowed to select. The subject is free to use any relevant information which he might possess. [27, p. 58]

A multiple regression analysis is performed for each individual, using as the dependent variable the rating of the stocks from the third questionnaire. The independent variables for this analysis come from the factor reduced, attribute set of the second questionnaire. If the squared correlation coefficient (R^2) exceeds that required for statistical acceptance, and if the correlation coefficient is positive, the derived cognitive model is accepted as validated. In fact, only five out of twenty-five could not be accepted using this criterion.

The work of Wilcox is important for many reasons. First, he demonstrated the applicability of a clinical tool within a rather broad, managerial context. Second, Wilcox's measurement procedure offers a viable alternative to imposing preconceived normative models upon the decision-maker. Finally, the efficiency of this procedure is greater than that of direct modeling when evaluated in terms of the time and effort expended on the part of both the investigator and participant.

Wilcox concluded that through the application of this methodology, managerial actions, decisions, objectives, means, assumptions, and relative values can be transformed from an unconscious, inextricably intertwined state to one that is distinct and understandable to the manager as well as others in the organization. [28, p. 230]

Summary

This chapter has provided an outline and a brief description of three rather philosophically distinct methodologies for measuring the decision process. Of the three, particular emphasis was placed on the methodology labeled descriptive choice-set represnetation. Within this methodology, the procedures of Kelly and Wilcox were examined in detail, since these will serve as the direct antecedents of the procedures employed in this dissertation.

REFERENCES

1. Bannister, D. "Personal Construct Theory: A Summary and Experimental Paradigm." Acta Psychologica 20 (1962): 104-120.

2. Bieri, James. "Cognitive Complexity-Simplicity and Predictive Behavior." Journal of Abnormal and Social Psychology 51 (September 1955): 263-268.

3. Clarkson, Geoffrey. Portfolio Selection: A Simulation of Trust Investment. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962.

4. Cyert, R.M.; Dill, W.R.; and March, J.G. "The Role of Expectations in Business Decision-Making." Administrative Science Quarterly 3 (December 1958): 307-340.

5. Dawes, Robyn M. Fundamentals of Attitude Measurement. New York: John Wiley & Sons, 1972.

6. Dyer, James S. "A Time-Sharing Computer Program for the Selection of the Multiple Criteria Problem." Management Science 19 (August 1973): 1379-1383.

7. Frost, W.A.K. "The Development of a Technique for TV Programme Assessment." Journal of the Market Research Society 11 (January 1969): 25-44.

8. Harmon, H. Modern Factor Analysis. 2nd ed. Chicago: University of Chicago Press, 1967.

9. Henderson, James M., and Quandt, Richard E. Microeconomic Theory. 2nd ed. New York: McGraw-Hill, 1971.

10. Huber, George P. "Multi-Attribute Utility Models." Management Science 20 (June 1974): 1393-1402.

11. Kelly, George A. The Psychology of Personal Constructs: A Theory of Personality. Vol. 1. New York: W.W. Norton, 1955.

12. Levy, L.H. and Dugan, R.D. "A Factorial Study of Personal Constructs." Journal of Consulting Psychology 20 (January-February 1956): 53-57.

13. Lunn, J.A. "Prospectives in Attitude Research: Methods and Applications." Journal of the Market Research Society 11 (July 1969): 201-213.

14. MacCrimmon, K.R. Improving the System Design and Evaluation Process by the Use of Trade-Off Information. Santa Monica, Calif.: RAND RM-5877DOT, 1969.

15. Mancuso, James C., ed. Readings for a Cognitive Theory of Personality. New York: Holt, Rinehart & Winston, Inc., 1970.

16. March, James G., and Simon, H.A. Organizations. New York: John Wiley & Sons, 1958.

17. Newell, Allen, and Simon, H.A. "Simulation of Human Thought." In Computer Simulation of Human Behavior. Edited by John Dutton and William Starbuck. New York: John Wiley & Sons, 1971.

18. Osgood, C.E.; Suci, G.J.; and Tannenbaum, P.H. The Measurement of Meaning. Urbana, Ill.: University of Illinois Press, 1957.

19. Puglisi, D.J.; Poretta, R.L.; and Haas, K.C. "A Decision Making Model for Resource Allocation in the Criminal Justice System." Proceedings of the 4th Annual Meeting of the Southeastern American Institute of Decision Sciences. Atlanta: n.p., 1974.

20. Sampson, Peter. "Using the Repertory Grid Test." Journal of Marketing Research 9 (February 1972): 78-81.

21. Simon, H.A. "A Behavioral Model of Rational Choice." Quarterly Journal of Economics 69 (February 1955): 99-118.

22. Simon, H.A.; Cyert, R.M.; and Trow, D.B. "Observation of a Business Decision." Journal of Business 29 (October 1956): 237-248.

23. Simon, H.A. "Theories of Decision-Making in Economics and Behavioral Science." American Economic Review 49 (June 1959): 253-283.

24. Slovic, Paul, and Lichtenstein, Sarah. "Comparision of Bayesian and Regression Approaches to the Study of Information Processing in Judgment." In Human Judgment and Social Interaction. Edited by Leon Rappoport and David Summers. New York: Holt, Rinehart & Winston, Inc., 1973.

25. Smith, R., and Greenlaw, P.S. "Simulation of a Psychological Decision Process." Management Science 13 (April 1967): 409-419.

26. Von Neumann, John, and Morgenstern, Oscar. Theory of Games and Economic Behavior. Princeton, N.J.: Princeton University Press, 1947.

27. Wilcox, Jarrod W. "Market Participant Cognitive Maps for Individual Common Stocks." Ph.D. dissertation, MIT, 1970.

28. Wilcox, Jarrod W. A Method for Measuring Decision Assumptions. Cambridge, Mass.: MIT Press, 1972.

CHAPTER III

EXPERIMENTAL DESIGN AND VALIDATION PROCEDURES.

Discussed in this chapter are the selection of a trial setting, the composition of the experimental sample, and the data collection design followed. Furthermore, an outline of the procedure for validation of the derived cognitive maps is given. Again, the principal aim of this dissertation is to make a contribution toward detecting the types of information used by decision-makers, as well as assessing the reasons for the importance of this information. Although decision-making is embedded within a planning context, the methodology is thought to be flexible and, therefore, applicable to a wide range of decision situations.

Selection of a Trial Setting

There were many possibilities studied in the selection of a trial setting. Initially, likely candidates ranged in form from complex, real-world organizations to highly contrived, stimulus-response situations. Ultimately, selection of a trial setting was delimited by three overriding considerations.

First, there was the matter of the inherent sensitivity of the proposed measurement procedure. While a claim can be made concerning the flexibility and adaptability of the measurement procedure, far less assurance can be given for its ability to causually link attributes to objects in environments where the outcome domain and action space are ill-defined. It should be pointed out, however, a limited action space and a well-defined outcome boundary does not preclude lack of outcome variety [16]. Thus a setting where the decision-maker has a large number of relatively simple choices within a well-defined outcome boundary, became the first consideration in the selection of a trial setting.

A second desired feature of the trial setting was stability in the decision-making process, since stability in the decision-making process and probability of successful validation of the decision process are directly related. Stability is best attained when learning effects are minimal but the decision-making process has not, as yet, become mundane. Operationally, this meant examining only the outcomes from the middle decision periods of a multi-period, decision environment.

A third consideration was that the decision-maker be readily identifiable and have explicit decision objectives. In the real-world, those decision-makers charged with the responsibility of making the decision often merely "rubber stamp" what passes before them. Furthermore, the hidden objectives of a decision-maker are sometimes diametrically opposed to the formal objectives of the organization [11]. Although these are important problems that demand attention in the exploration of the decision-making process, by isolating their influence, confounding of results can be minimized.

With these considerations in mind, the four methods of empirical research identified by VanHorn [22] were investigated.

The case study method, as exemplified by the studies of Gerrity [14], Morton [20], Ferguson and Jones [12], and Dunlop [10], attempts to capture the complexity of the situation through the use of narrative descriptions. It is difficult, however, to transfer the findings of one study to other settings, since cause and effect relationships remain relatively unestablished, and experimental design and controls are not employed.

A number of field studies [4] [8] have been conducted employing an experimental design framework to isolate the effects of certain variables. Unfortunately, these studies concentrate on managerial problems created by the proliferation of information systems, rather than offering experimental evidence to extend information systems analysis.

Field tests study one or more organizations within a controlled environment. By systematically altering variable levels, the investigator attempts to assess the impact on the aspect of concern. For example, the field test of Bariff and Lusk [2] examined the effect on employee resistance to change by varying the levels of report summarization. The setting for this field test was a community nursing home. Although field tests offer a vehicle for potentially useful isolation and identification of variables as they relate to the informational support problem, few field tests have been conducted where the operating procedures have not overridden the test considerations, and the interpretation of results has not been loaded with large amounts of subjectivity [9].

Finally, in laboratory experiments, especially those involving experimental gaming, a simulator is used to define specific decision variables and a specific level of complexity, within a specific type of decision environment. Of prime advantage is the degree of control which may be exercised. In fact, the simulator can be designed with those characteristics congruent with the objectives of the investigator [19].

Of the four methods described above, laboratory experimentation was selected as the alternative best able to meet the previously stated, selection considerations. The consideration of stability in decision-making performance was met by having the participants make decisions for seven periods in total, but examining only the middle four periods (3, 4, 5, and 6). With regard to fulfilling the criterion of explicit decision-maker objectives, each participant was given prior to the first decision period, the twofold objective of maximizing profit and minimizing planning inaccuracy against which his performance would be evaluated. Debriefing, subsequent to the completion of the experiment, clearly indicated the incorporation of this experimenter induced objective into the participants' decision-making framework. The final consideration of establishing a decision setting which had a restricted action set, but allowed for a wide range of outcomes, was achieved by adopting an experimental game that emphasized the planning and control activities of a competitive firm (see APPENDIX A). A discussion concerning the reasons for adoption of this particular type of simulation game appears in the section labeled "Validation Procedures."

Composition of the Experimental Sample

The participants for the experiment were drawn from three sections of the undergraduate Managerial Accounting course offered at the University of Massachusetts in the Fall semester, 1974. Of the sixty-five participants, 17% were seniors, 67% were juniors, and 16% were sophomores. Each of the nineteen teams comprised either three or four students. The actual makeup of each team was done through random assignment by the investigator.

There are important points concerning the composition of the sample which need amplification. First, there is the matter of studying students as decision-makers. While it is recognized that evidence exists as to the appropriateness of using students as surrogates [6] [13] [21] [23], it should be clearly understood that what is being investigated is not how managers perform in planning situations, but instead, the sources and types of information used by individuals in a specific context. In this regard, validation of the derived decision-makers' models was made on a relative rather than an absolute basis. That is, although performance by students may fall short of that which could be or would be attained by a professional manager, the primary concern was the difference between outcomes instead of measurement against some norm.

Second, to lessen the number and mitigate the ramifications of situations involving extreme unsophistication on the part of some of the participants, as well as enrich the variety of informational sources to which the participants were exposed, decision-making was designed to be a group process. Critics may feel this provision makes the decision-making environment illusionary. However, it should be noted that in real-life, it is often the case that a decision-maker seeks consultation from a number of individuals. For example, it is not uncommon for a decision-maker to seek advice and utilize the information provided by peers, subordinates, superiors, predecessors, and other less direct sources. Though he alone makes the decision and is held accountable, the process itself may more aptly be characterized as one of group consensus.

Data Collection Design

The data collection design consisted of five steps:

1. Following the third decision period, a questionnaire was distributed to all participants. The intent of the questionnaire was to elicit the role played by various types or sources of information in the decision-maker's conceptual structure of the simulation environment. In total, sixteen questions were asked (see Table III-1). The questions broadly parallel those asked by Kelly and Wilcox. Six of the questions relate to planning decisions, two to control decisions, and the remaining eight, to a more general nature.

On the reverse side of the questionnaire, each participant was asked to identify the team member most responsible for planning decisions. If there was a consensus in response to this question, the individual identified became the sole subject of further investigation. For those cases where a consensus did not exist, further investigation proceeded with all identified members of that team.

2. From the questionnaire of the identified individual or questionnaires of the identified group, a limited number of triads of information sources were formed, (see Table III-2). The intent of

TABLE III-1

INFORMATION SOURCE ROLE LIST

1. The source of information you used to make a decision that resulted in a substantial profit.

2. The source of information you used to make a decision that resulted in a substantial loss.

3. The source of information which at first was not crucial to your control decisions but now is.

4. The source of information most strongly debated by your team.

5. The source of information you consider crucial to the planning process.

6. A source of information which you favor but your team does not.

7. A source of information you consider important to the control process.

8. The source of information which at first was not important to your planning decisions but now is.

9. A source of information you feel you understand well.

10. A source of information recommended by the instructor for planning decisions which you should have used but did not.

11. A source of information provided in the game instructions which proved valuable to planning decisions.

12. A source of information you feel is difficult to understand.

13. A source of information recommended by your instructor which you found wasn't important.

14. A source of information you feel would be of value to the planning process but could not obtain.

15. A source of information which if changed from its present form would contribute materially to your planning decisions.

16. A source of information you consider misleading.

TABLE III-2

LIST OF TRIADS

1.	13-2-14	9.	10-4-11
2.	16-13-3	10.	7-14-15
3.	5-6-9	11.	13-8-12
4.	9-4-8	12.	1-11-5
5.	16-3-9	13.	10-15-16
6.	1-4-12	14.	12-11-2
7.	8-7-3	15.	15-1-6
8.	10-6-14	16.	2-5-7

triad formation was to elicit, for differing combinations of information sources, a pattern of relationship which was similarity (construct), or dissimilarity (contrast) based. Each information source appeared in exactly three triads. Although the choice of three was somewhat arbitrary, it was influenced by the trade off of participant fatigue versus adequate comparison exposure of each of the information sources. Triad order of presentation was done on a random basis. Similarly, both the ordering of information sources within the triads, and triad formation itself were randomized, with the sole consideration that no two information sources appear in more than one triad.

3. Each individual or group was then interviewed. In the interview, the examiner attempted to elicit similarities and differences for each triad of information sources. He asked, "I would like you to tell me something about these information sources. Which two are most alike, and in what important way are they alike?"

For the third information source, he asked, "How is this information source different?"

He then repeated this process for each of the remaining triads.

The dialogue of each interview was tape recorded. In most instances the interviews lasted from 25-40 minutes. The length of these interviews was largely a function of the degree of response specificity which could be obtained. For example, if a response was given such as, "Both are hard to understand," when identifying a construct for a pair of information sources, the interviewer would be required to engage in a series of probing questions. He might ask, "Is there something about their being hard to understand which seems to be alike?"

4. Upon completion of all interviews, the tapes were reviewed and adjective scales formed for each construct. It should be noted that constructs concerning multiple triads were often repeated; likewise, but on a less frequent basis, more than one construct was generated for a single triad. For this reason, a yield ratio of adjective scales to triads of less than one was achieved.

5. The initial questionnaires and sets of adjective scales were returned to the individuals with the request that each information source be ranked on each adjective scale. For those information sources inappropriate to a specific adjective scale, a category labeled "Scale does not apply," was provided.

Validation Procedures

Once the decision makers' information sources and adjective scales that appeared to make these information sources relevant were elicited, the question that must then be asked is, how well have we captured the decision-maker's conceptual structure? One way to answer this question would be to present the decision-maker with his derived conceptual structure and request a response from the decision-maker as to its appropriateness. Validation using this approach is less than satisfactory since an individual may be unwilling to admit to a structure which is highly simplistic, or, as is more likely the case, be unaware on a conscious level of many of its aspects.

A more fruitful approach would be to compare the decisions expected from decision-makers who have a particular conceptual structure against those decisions actually made. If there is no significant difference, we could assume our methodology used to derive a decision-maker's conceptual structure, captures, in essence, many of the important aspects.

In practice, this approach can follow two paths. The first path relies on the ability of one set of data to predict the results generated by other sets of data. That is, the initial data are used to build a structure from which predictions on the manner of new stimuli handling can be made. This was the path followed by Wilcox [24]. The implicit assumption here is that both data sets are relatively homogeneous, and that decision-maker models are insensitive, over time, to learning or environmental effects.

The second path, and the one adopted here, concentrates on a single data set, thereby freeing itself from reliance on the above assumption. What is necessary, however, is an a priori, hypothesized structure for evaluation. Clearly, the strength of this path is a direct function of the validity and generality of the hypothesized structure being the true state of nature.

In the area of planning and control systems, Robert Anthony [1] has proposed a framework which consists of three elements: strategic planning, management control and operational control.

> Strategic planning is the process of deciding on the objectives of the organization, on changes in these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these strategies. [1, p. 7]

On the other hand, the purpose of management and operational control is the effective and efficient application of resources to achieve the organization's objectives.

Although these elements or subsystems are clearly related, because each has a different purpose and set of characteristics, a distinctive way of thinking about each is required. Specifically, Anthony proposes distinguishing the two elements on the characteristics of complexity and nature of information relied on. He feels that strategic planning involves the consideration of many variables. This can be contrasted to management and operational control activities, which entail far fewer variables, and hence, can be considered a less complex process. Likewise, Anthony suggests that strategic planning relies heavily on external information collected from outside the operating department, or internally generated information that has been recast to fit the needs of the problem being analyzed. [1, p. 8-9]

This dissertation draws on these two distinctions to generate the following hypothesis:

Those decision-makers having more complex cognitive maps, and relying more heavily on externally generated data or internally trnasformed data will outperform, in a planning sense, those decision-makers having less complex cognitive maps, and relying less on externally generated data or internally transformed data.

By stating the above hypothesis in this form does not imply the existence of a converse. The converse, in this case, would be that decision-makers having less complex cognitive maps, and relying more heavily on internal data sources will outperform, in a control sense, those decision-makers whose maps and data source reliance is otherwise. In fact, the conditions necessary to test the converse would be: a) strict independence of the planning and control activities, and b) intentional measurement of control performance.

A type or source of externally generated information is defined as one that does not emanate from the game explanation, game printout of financial statement data and competitors' selling price and sales volume, or another member of the decision-maker's team. Data that has its origins in the game explanation or printout, but has been transformed by some means (e.g. regression analysis), is defined as internally transformed data. Complexity is defined as the number of nonredundant (orthogonal) attributes or dimensions related to the set of information sources or types. It should be noted that this definition of complexity is consistent with Bieri's [3] definition.

While determination of the internal versus external nature of the information sources or types can be done by subjective evaluation of each decision-maker's set, assessment of the degree of complexity of each of the decision maker's models was not as straightforward. Because the data resulting from the second questionnaire were less than intervally scaled, an algorithm capable of reducing an arbitrary matrix to Gramian form of equal rank is called for. Such an algorithm and accompanying program (SSA-III), has been proposed by Lingoes and Guttman [17].

The SSA-III procedure addresses itself to representing the ordering of derived measures, (in this case a correlation matrix) with a minimum number of parameters, (in this case dimensions). Three principles are involved in obtaining a solution: a) the iterative method of refactoring for a fixed number of dimensions using orthogonal transformations to improve communality estimates; b) linear transformations on an Euclidean coordinate system, ($XX'=\theta$) to maximize the predictability of the correlation matrix R; and, c) rank-image cell-wise permutations of the θ matrix [17, p. 488-489]. By rank-image is meant a matrix θ whose rank order value is identical to the correlation matrix R. When a perfect nonmetric fit is obtained, each pair of coefficients ($r_{ij} \geq r_{kl}$) from R, monotonically corresponds to a pair of coefficients ($\theta_{ij} \geq \theta_{kl}$) from θ.

The dependent variable of team planning performance was quantified by adopting a measure proposed by Daily [7], and used, in modified form, by McDonald [18], and Clark and Elgers [5]. Daily, in essence, casts planning performance in standard deviation terms. He, first, defines accuracy as:

$$\text{Accuracy} = \frac{\text{Forecasted results}}{\text{Actual results}} \times 100$$

and then, measures precision as:

$$\text{Precision} = \sqrt{\frac{\sum_{i=1}^{N} \left(\text{Accuracy}_i - \left(\frac{\Sigma \text{ Accuracy}}{N} \right) \right)^2}{N}}$$

where N is the number of observations [7, p. 687]. A value of zero represents perfect precision; a value greater than zero, measures the degree of imprecision.

It should be noted that here, precision more appropriately means consistency of forecast accuracy. That is, a precision value of zero represents complete or perfect consistency of forecast error; a value greater than zero represents the degree of inconsistency of forecast error.

A simple example may serve to clarify this point. Suppose a forecast of 105 is made for two consecutive periods. Suppose further that 100 was the actual result achieved for both periods. While average accuracy would be 105, precision would be zero. That is, although the forecaster errored by 5%, his error was perfectly consistent.

While we are, no doubt, interested in quantifying planning performance in terms of the consistency of forecast errors, of equal concern is the exactness attained in planning performance. While Daily's accuracy measure appears, at first glance, to satisfy this need, further inspection clearly shows its inadequacy as measure of forecasting exactness.

If, for example, forecast accuracy of 105 and 95 were achieved in two periods, the average amount of inexactness in the forecasts would be 5%. However, by averaging the forecast accuracy over the two periods, Daily's measure shows zero inexactness (100 is perfect accuracy)!

This deficiency in Daily's measure of exactness can be remedied by considering forecast accuracy as an absolute quantity. A measure of exactness than becomes,

$$\text{Mean absolute accuracy} = \frac{\sum_{i=1}^{N}\left(\left|\frac{\text{Forecasted result}}{\text{Actual result}} - 1\right| \times 100\right)}{N}$$

As such, the measurement of average absolute accuracy was adopted as a second qualifier of planning performance.

Daily goes on to discuss the notion of materiality, (limits at which information becomes important). As he correctly detects, his measure of accuracy becomes misleading in certain situations. Suppose a border zone of 10% is adopted for identifying material forecast deviations. Then, if Daily's accuracy measure produces a value greater than 110 or less than 90, the forecast error would be considered material. Now, consider the example of a medium sized company that forecasts income of $3,000, but earns only $1,000. The forecast accuracy would be 300, though the amount of dollar deviation is trivial.

Clark and Elgers illustrate the problem even more succinctly.

> The machinery firm, for example, over the five years covered, functioned close to breakeven. In this case study, an accuracy criteria of 10% for predicted net income would have led to an average 0.005 restriction on the sales error. Under the like circumstances in the other studies, to stipulate a 10% to 15% standard for profit prediction would elevate sales forecasting to the status of an exact science. (Emphasis theirs) [5, p. 670]

A trial run on my data, using net income to compute accuracy, produced accuracy extremes of -1,588 to 622. As a result, another trial run was performed, this time, substituting sales volume for net income in the accuracy formula. For this trial, accuracy extremes of 93 to 126 were found. Since these extremes were more reasonable than those previously obtained, the variable of forecasted to actual sales volume became the surrogate measure for planning performance.

A measure of the complexity of the cognitive structure was obtained from the factor analysis in the following way:

1. Selected from the initial factoring process, were those factors with eigenvalues larger than one.

2. A ratio was formed that consisted of the number of selected factors divided by the number of input adjective scales. A ratio of one meant that a decision-maker perceived each adjective scale to be unique; a ratio near zero meant that a decision-maker perceived the set of adjective scales as entirely redundant. Thus, the inference was made that the higher the ratio, the higher the cognitive complexity of the decision-maker.

3. This ratio was then multiplied by the inverse of the percentage of variance attributable to the selected factors. The rationale for this step can be explained by the following example. Assume that two decision-makers (A and B), each rate an equal number of adjective scales. Suppose that only a single factor is derived, in both cases, by our factor analytic solution. From step 2, an identical ratio would be computed for both decision-makers. Now suppose that the eigenvalue for the derived factor of decision-maker A was twice that of the eigenvalue for the derived factor of decision-maker B. While an equivalent redundancy could be inferred for both decision-makers' derived cognitive maps, the strength of the redundancy surely lacks inferential equivalency. Thus, redundancy (the ratio compiled in step 2) was weighted by the strength of the redundancy (the inverse of the variance attributable to the selected factors).

4. Finally, the resultant measures were rank ordered.

This rather involved procedure was necessary because of the varying number, among teams, of information sources and adjective sets.

From the subjective evaluation of information sources, a proportion measure of external-internal information source was computed for each team. The form of the measure was as follows:

$$\text{Proportion of external sources} = \frac{\text{Number of external sources}}{\text{Total number of sources}}$$

Using a mean split on the explanatory variable of external-internal information sources, and a midrank split on the explanatory variable of complexity, the formal model to statistically test conceptual structure was formulated as a two-way analysis of variance with interaction. Since estimating the parameters of the relationship between the explanatory variables and the planning performance measure was of interest, a dummy variable, regression model [15, ch. 8] of the following form was used:

$$y = B_0X_0 + B_1X_1 + B_2X_2 + B_3X_3 + e$$

Where y = the measure of planning precision for each team.

X_0 = 1 for all observations

$$X_1 = \begin{cases} 1 \text{ for those teams with high complexity} \\ 0 \text{ otherwise} \end{cases}$$

$$X_2 = \begin{cases} 1 \text{ for those teams with high external information source reliance} \\ 0 \text{ otherwise} \end{cases}$$

$$X_3 = \begin{cases} 1 \text{ for those teams with high complexity and high external information source reliance} \\ 0 \text{ otherwise} \end{cases}$$

e = the disturbance, which is spherical normal.

Summary

The purpose of this chapter was to outline the research design and validation procedures employed.

In the selection of a specific trial setting, certain desirable criteria were specified and a variety of settings explored. From various settings, the method of laboratory experimentation was chosen. One subset of laboratory experimentation, namely that of experimental gaming, was viewed as most closely conforming to the selection considerations of internal control, investigator induced objectives, and repetitive decision-making.

Participants for the experiment were drawn from undergraduate Accounting sections. Each student was randomly assigned to a team, where decision-making was a group rather than an individual process.

The data collection design consisted of five steps:

1. Completion of, by each participant, a questionnaire consisting of sixteen information source roles.

2. Triad formation of the information sources based on the responses generated from the questionnaire.

3. Taping of the interviews in which constructs were elicited.

4. Forming adjective scales by review of the taped interviews.

5. Ranking, by the participants, of all informational sources from the first questionnaire on each of the adjective scales.

As a proposed validation procedure of the derived cognitive maps, first, Anthony's framework concerning strategic planning was adopted. Next, using derived measures of cognitive complexity and reliance on external information sources as explanatory variables, the hypothesis was formulated that decision-makers, whose cognitive maps exhibit high cognitive complexity and rely more heavily on external information sources, would outperform in a planning sense, those decision-makers whose cognitive maps were otherwise. Methods for the assessment of the degree of external versus internal information source reliance, cognitive complexity, and planning performance were defined. Finally, a formal model for statistical analysis was specified.

REFERENCES

1. Anthony, Robert N.; Dearden, John; and Vancil, Richard E. Management Control System. Revised ed. Homewood, Ill.: Richard D. Irwin, Inc., 1972.

2. Bariff, Martin L., and Lusk, Edward J. "A Study of the Utilization of Cognitive and Personality Tests for the Design of Management Information Systems." Working Paper, The Wharton School, University of Pennsylvania, April 1974.

3. Bieri, James. "Cognitive Complexity-Simplicity and Predictive Behavior." Journal of Abnormal and Social Psychology 51 (September 1955): 263-268.

4. Churchill, N.C.; Kempster, J.H.; and Uretsky, M. Computer Based Information Systems for Management: A Survey. New York: National Association of Accountants, 1969.

5. Clark, John J., and Elgers, Peter. "Forecasted Income Statements." The Accounting Review 48 (October 1973): 668-678.

6. Copeland, Ronald; Francia, Arthur; and Strawser, Robert. "Students as Subjects in Behavioral Business Research." The Accounting Review 48 (April 1973): 365-372.

7. Daily, R.A. "The Feasibility of Reporting Forecasted Information." The Accounting Review 46 (October 1971): 686-692.

8. Dean, Neil J. "The Computer Comes of Age." Harvard Business Review 46 (January - February 1968): 83-91.

9. Dickson, G.W., and Senn, J.A. "Research in Management Information Decision Systems: The Minnesota Experiments." Paper presented at the 6th Annual Meeting of the American Institute of Decision Sciences, Atlanta, 1974.

10. Dunlop, R.A. "Some Empirical Observations on the Man-Machine Interface Question." In Management Information Systems: Process and Perspectives. Edited by C.H. Kriebal et al. Pittsburg: Carnegie Press, 1971.

11. Ellis, Robert C. "The Need for a Measure of Relative Importance of Top Level Objectives." Proceedings of the 4th Annual Meeting of the Southeastern American Institute of Decision Sciences. Atlanta, n.p., 1974.

12. Ferguson, R.L., and Jones, O.H. "A Computer Aided Decision System." Management Science 15 (June 1969): B550-561.

13. Fleming, J.E. "Managers as Subjects in Business Decision Research." Academy of Management Journal 12 (March 1969): 550-561.

14. Gerrity, T.P. "The Design of Man-Machine Decision Systems." Ph.D. dissertation, MIT, 1970.

15. Goldberger, Arthur S. Econometric Theory. New York: John Wiley & Sons, 1964.

16. Hare, Van Court, Jr. System Analysis: A Diagnostic Approach. New York: Harcourt, Brace & World, Inc., 1967.

17. Lingoes, James C., and Guttman, Louis, "Nonmetric Factor Analysis: A Rank Reducing Alternative to Linear Factor Analysis." Multivariate Behavioral Research 14 (October 1967): 485-505.

18. McDonald, Charles L. "An Empirical Examination of the Reliability of Published Predictions of Future Earnings." The Accounting Review 48 (July 1973): 502-510.

19. Moch, Ted. "Learning Patterns, Decision Approach and Value of Information." Journal of Accounting Research 10 (Spring 1972): 123-153.

20. Morton, M.S.S. Management Decision Systems. Boston: Division of Research, Harvard Business School, 1971.

21. Moskowitz, Herbert. "Managers as Partners in Business Decision Research." Academy of Management Journal 14 (September 1971): 317-325.

22. Van Horn, R.L. "Empirical Studies of Management Information Systems." Data Base 5 (Winter 1973): 172-180.

23. Watson, David. "Students as Subjects in Behavioral Business Research: Some Comments." The Accounting Review 49 (July 1974): 534-537.

24. Wilcox, Jarrod W. A Method for Measuring Decision Assumptions. Cambridge, Mass.: MIT Press, 1972.

CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

In this chapter the data obtained from the information source role questionnaire are presented and analyzed; the results of quantification of cognitive complexity and information source usage are presented; the planning performance of each team is assessed; and the statistical validation of the derived, decision-makers' cognitive maps is illustrated.

Information Source Role Questionnaire

One way to communicate to the reader the types and sources of information considered relevant by decision-makers for planning, control, and more general purposes, would be to list all responses by question. This approach, however, places an extremely heavy burden on the reader who merely wants an overall flavor of role perceptions. To satisfy the reader of this type, only a selected summary of responses are discussed in the text which follows. For the reader wishing a more detailed exposition of the output generated by the information source role questionnaire, reference should be made to APPENDIX B.

Response frequency to the questions. The number of information sources or types elicited from the information source role questionnaire varied from twelve to sixteen, (see Table IV-1). Of the sixteen questions, two had a high, nonresponse rate, (see Table IV-2). Both of these questions (10 and 13), pertained to the utilization of instructor input. One might speculate that students were especially susceptible to what

TABLE IV-1

INFORMATION SOURCES ELICITED

Number of Sources	Number of Teams	Percentage
16	11	.58
15	2	.11
14	3	.16
13	1	.05
12	2	.11
Total	19	1.00

Mean Number of Sources = 15

TABLE IV-2

RESPONSE FREQUENCY BY QUESTION

QUESTION	PERCENTAGE	QUESTION	PERCENTAGE
1	100	9	100
2	95	10	63
3	100	11	95
4	95	12	100
5	100	13	68
6	95	14	89
7	100	15	100
8	95	16	95

might be termed "expert" advice. That is, advice given by an expert, in this case the instructor, was considered to be of value and therefore, less often ignored than information obtained from other sources. Whether a valid analogy can be drawn to real-world managers' perceptions of consultants, is a matter of conjecture. As such, the relative usefulness of the responses in the design of an information system is questionable.

Planning decisions. The types or sources of information most often mentioned as important to planning decisions were sales estimation, or estimation of some component that influenced sales. This response was not unexpected, since an accurate sales forecast is regarded as the cornerstone of effective planning.

The methods used by decision-makers in determining sales estimates were: intuitive analysis and extrapolation of past results, charting, and regression analysis. Once a sales forecast was agreed on, its impact was propogated to the other functions (production, purchasing, etc.) within the "paper" organization, by means of budgets and Pro Forma statements. The budgets and Pro Forma statements, in turn, provided a basis for evaluation and possible reassessment of the initial sales estimate.

The two sources or types of information considered crucial to the planning process were ending cash and finished goods inventory. The availability of both these resources dictated, to a large extent, the upper bound on sales volume for the next decision period.

The two sources or types of information, considered to be of value to the planning process, but unobtainable, were accurate estimates of industry demand, and inventory quantities of competitors. As a requisite of a viable planning information system, these sources are key ingredients.

The response was mixed to the question that asked which source of information, if changed in form, would contribute materially to planning decisions. Responses included: costs of production, sales trends, financial statement detail, and cost of labor. Apparently, different individuals perceived different information sources with varying degrees of clarity.

Control decisions. Not surprisingly, the factors considered important to control decisions can be characterized as relating to either penalty costs or marginal returns from expenditures. Penalty costs, on one hand, were incurred if material had to be "rush" ordered, loans were "forced" rather than planned, and overtime was necessary. On the other hand, costs were incurred if an excess amount of raw material was carried, funds were left uninvested, and labor resources were not fully utilized. Fundamental to the design of a control system, would be the parameterization of a function to provide for the analytic evaluation of these trade offs.

The other factor considered important to control decisions was the return per dollar expenditure. Control, in this sense, can be thought of as putting the cap on the bottle of ever increasing expenditure outflows that were unmatched by concomitant revenue inflows. Often, many decision-makers must have asked the classical question, "Is the amount I am spending on promotion and research and development generating sufficient revenue to justify this level of expenditures?" Accordingly, an information system should attempt to provide answers to this question through some form of sensitivity analysis.

General roles. Only two questions are examined in this subsection. Both questions relate to those types of information lacking clarity.

The types of information decision-makers found difficult to understand were ending inventory charges on finished goods, and the effect of research and development expenditures on sales potential. While ending inventory charges on finished goods might be further delineated to aid comprehension, little can be done to facilitate understanding of the relationship between research and development expenditures and sales potential.

Candidates for the most misleading type of information were numerous. The type of information most frequently mentioned was ending cash balance. Decision-makers consistently attempted to relate (equate) ending cash balance with profits. They falsely assumed that as profits increased, cash balances would increase at an equivalent rate. What they failed to realize was that disbursements were on cash basis but receipts were partially accrued. As such, if sales volume constantly increased, cash receipts lagged cash disbursements: if sales volume was constant, but the level of production increased, a net cash disbursement resulted. Confusion might have been considerably reduced if the information system produced a funds flow statement on a working capital basis.

Quantification of Cognitive
Complexity and Information Source Usage

As mentioned in Chapter III, the quantification of cognitive complexity of the factor analytic derived decision-maker maps, (see APPENDIX C for details) consisted of the following four steps:

1. Factors with eigenvalues larger than one were selected from the initial factoring process.

2. A ratio (Table IV-3, col. 4) was formed by dividing the number of input adjective scales (col. 3) into the number of selected factors (col. 2).

3. The ratio was then multiplied by the inverse of the percentage of variance attributable to the selected factors (col. 5). The resultant measure (col. 6), if small, was equated to a simple cognitive structure.

4. Finally, the resultant measures were rank ordered (col. 7).

Two things need be mentioned at this point. First, the following descriptive statistic was applied as a criterion for determining minimum dimensionality:

$$K = 1 - (r_{r\theta}^{\ 2}/r_{\theta\theta}^{\ 2})$$

The value K, permitted an evaluation of the lack of monotonicity (bending) of the Shepard diagram. In this instance, the Shepard diagram related R to θ for $i \neq j$. Drawing on the experience of Lingoes and Guttman [6, p. 493], dimension reduction was terminated when $K > 0.05$.

Second, in a number of instances, information sources were placed in the category, "Scale does not apply." The net effect of placing information sources in this category was to create missing data. To handle data of this type, the following procedure was adopted:

TABLE IV-3

QUANTIFYING COGNITIVE COMPLEXITY

(1) Team Number	(2) Number of Eigenvalues > 1.	(3) Total Adjective Scales	(4) 2 ÷ 3	(5) % Variance	(6) 4 ÷ 5	(7) Rank Order
1	4	9	.444	.79	.5620	7
2	4	11	.364	.65	.5600	8
3	2	7	.286	.60	.4767	15
4	4	10	.400	.70	.5714	5
5	4	12	.333	.65	.5123	14
6	6	14	.429	.77	.5571	9
7	3	6	.500	.77	.6494	1
8	3	7	.429	.76	.5645	6
9	2	8	.250	.62	.4033	19
10	3	10	.300	.69	.4348	18
11	4	11	.364	.70	.5200	13
12	3	10	.300	.65	.4615	16
13	3	8	.375	.70	.5281	11
14	3	10	.300	.67	.4478	17
15	3	7	.429	.74	.5797	4
16	4	9	.444	.75	.5920	3
17	3	8	.375	.72	.5208	12
18	2	6	.333	.63	.5282	10
19	3	7	.429	.67	.6403	2
Average	3.3	8.9	.371	.70	.5302	

1. If more than 40% of the information sources were placed in the category "Scale does not apply," the adjective scale was considered vague or irrelevant, and deleted from the input adjective set. In total, 22 out of 191 (11.5%), adjective scales were removed from further consideration for this reason.

2. For those adjective scales that had less than 40% of the information sources designated as "Scale does not apply," the midrank of the ordered information sources was computed. The information sources placed in the category "Scale does not apply," were then assigned the midrank value. For example, if twelve information sources were ordered on an adjective scale, and two information sources were placed in the category "Scale does not apply," then these two information sources were each assigned a midrank value of 6.5. The net effect of midrank assignment, was to neutralize the missing data [10, p. 144].

A midrank <u>split</u> on the ranking of cognitive complexity yielded a classification structure as shown in Table IV-4. Notice that due to sample division on the midrank, team 18 was not included in either split half. Also, this classification structure produced a difference between split half means, using a one-way analysis of variance, that was statistically significant at the 0.05 level.

Presented in Tables IV-5 (a) (b) (c) are the information types or sources subjectively evaluated to be external or internally recast by decision-makers. Additionally, Tables IV-5 (a) (b) (c) contain the proportion of these kinds of information types or sources to total information sources or types. Using the overall mean proportion (.2380), the total

TABLE IV-4

SPLIT HALVES BASED
ON DERIVED COMPLEXITY

Complex

Team	Rank		Complexity
1	7		.5620
2	8		.5600
4	5		.5714
6	9		.5571
7	1		.6494
8	6		.5645
15	4		.5797
16	3		.5920
19	2		.6403
		Average*	.5863

Simple

Team	Rank		Complexity
3	15		.4767
5	14		.5123
9	19		.4033
10	18		.4348
11	13		.5200
12	16		.4615
13	11		.5281
14	17		.4478
17	12		.5208
		Average*	.4784

* $F_{1,16} = 7.758$, significant at $p < 0.05$

TABLE IV-5 (a)

EXTERNAL OR INTERNALLY RECAST INFORMATION

Team	External or Internally Recast Information	Total Sources	Percent of Total
1	-competitor's inventory - pro forma statements - purchase budget	16	.1875
2	- estimator of demand curve - cash budget - master budget - obtaining printout of other firms	12	.3333
3	- effect of seasonality - budgeting - estimating future sales - estimating total market demand	15	.2667
4	- information on other teams - labor budget - variance analysis - estimate line of credit	16	.2500
5	- improving budget procedure - demand estimation - forecasting pricing strategy of others - estimating period sales	16	.2500
6	- charting price changes - comprehensive budget - graphing projected industry demand - determining sensitivity of price - analyzing market share	16	.3125
7	- budgets - sales/promotion relationship - information on competitors	15	.2000

TABLE IV-5(b)

EXTERNAL OR INTERNALLY RECAST INFORMATION

Team	External or Internally Recast Information	Total Sources	Percent of Total
8	- determining effects of competition - estimating the demand curve	12	.1667
9	- price/promotion relationship - estimating the demand curve - other firms' printouts	14	.2143
10	- sales forecast - knowledge of other players - past players of the game - budgeting - determining sales function	16	.3125
11	- employment of alternative strategies - budgets - reliable sales forecasts	14	.2143
12	- past participants - sales forecasts - profit projections - weight of variables (price, promotion, R & D) in demand equation	16	.2500
13	- projections of sales volume - price elasticity of demand	13	.1538

TABLE IV-5(c)

EXTERNAL OR INTERNALLY RECAST INFORMATION

Team	External or Internally Recast Information	Total Sources	Percent of Total
14	- estimation of sales - role of competition - cash budget - product demand equation	16	.2500
15	- sales forecast - regression analysis - estimate of competitor's price and advertising - correlation analysis of R & D and sales	14	.2857
16	- word of mouth - price vs. demand relationship - cost/effectiveness of R & D - marginal advertising effect - other teams' forecasts	16	.3125
17	- effect of seasonality	16	.0625
18	- intuition - advanced accounting students - course material - budget process - friend	16	.3125
19	- estimating sales potential - graphing demand equation - determining inputs to the demand equation	16	.1875
	Average	15	.2380

sample was divided into two subsamples. These subsamples are shown in Table IV-6. Again, a one-way analysis of variance was performed on the proportion means of the subsamples. The difference between proportion means was statistically significant at the 0.01 level.

The final step in categorizing the validation structure was to form a 2 x 2 matrix. The elements of the matrix, as shown in Table IV-7, were cognitive complexity and internal-external source usage. Taken from this matrix were the following values for the hypothesis validation vector:

1. Simple-internal cell: $X_0=1$, $X_1=0$, $X_2=0$, $X_3=0$.
2. Simple-external cell: $X_0=1$, $X_1=1$, $X_2=0$, $X_3=0$.
3. Complex-internal cell: $X_0=1$, $X_1=0$, $X_2=1$, $X_3=0$.
4. Complex-external cell: $X_0=1$, $X_1=1$, $X_2=1$, $X_3=1$.

Validation Results

Table IV-8 lists forecasted and actual sales volume, by team, for the four periods under inspection. Additionally, Table IV-8 includes average absolute accuracy and average precision for each team.

Before examining the test results of validation, methods are discussed and results are presented concerning aspects of stability and sensitization.

To test for stability in planning performance, as measured by absolute accuracy, a one-way analysis of variance was performed on the data. The hypotheses for this test were formulated as follows:

TABLE IV-6

EXTERNAL AND INTERNAL
SOURCE USAGE

External

Team		Percent
2		.3333
3		.2667
4		.2500
5		.2500
6		.3125
10		.3125
12		.2500
14		.2500
15		.2857
16		.3125
18		.3125
	Average*	.2852

Internal

Team		Percent
1		.1875
7		.2000
8		.1667
9		.2143
11		.2143
13		.1538
17		.0625
19		.1875
	Average*	.1733

* $F_{1,17} = 8.088$, significant at $p < 0.01$

TABLE IV-7

VALIDATION STRUCTURE

Information Source Usage		Cognitive Complexity: Simple	Cognitive Complexity: Complex
	Internal	Teams 9 11 13 17	Teams 1 7 8 19
	External	Teams 3 5 10 12 14	Teams 2 4 6 15 16

TABLE IV-8

FORECASTED AND ACTUAL SALES VOLUME (000 OMITTED)

Team Number	Period 1		Period 2		Period 3		Period 4		Average Absolute Accuracy	Precision
	F	A	F	A	F	A	F	A		
1	190	195.2	190	166.9	190	159.5	190	223.6	.126634	13.5261
2	150	178.7	185	161	180	156.6	170	167.8	.118052	12.7294
3	156	159.7	165	147.7	150	140.9	150	170.5	.081279	9.0162
4	125	112.5	175	163.5	160	164.1	165	185.2	.078876	8.5516
5	165	179	189	140.7	190	153.4	170	203.4	.190083	19.3037
6	137	140	189	178.5	215	206.9	252	237.9	.044668	3.2991
7	175	173.7	175	189.9	195	173.7	160	115.6	.148164	17.4144
8	160	144.5	180	140.8	170	211.7	180	133	.234009	21.1680
9	160	138.4	180	179.6	216	206.1	220.6	242.4	.074066	8.8559
10	150	117.3	150	157	175	146.9	175	229.4	.187946	20.2275
11	200.2	169.4	200.2	177.9	185	166.8	171	236	.172503	18.0640
12	180	177	195	187.4	200	216	250	205.6	.086883	10.5019
13	175	152.2	175	150.9	150	170	169	169	.106790	11.4658
14	149	118.1	175	150	175	156.8	160	171.6	.148761	11.4932
15	169	173.8	164.5	157.8	190	179.2	180	176.8	.037111	3.2970
16	140	146.9	165	159.3	164	164.3	250	239.1	.032542	3.6411
17	150	142.8	155	152.3	160	179.3	200	184.8	.064883	7.2639
18	170	157.9	170	168.6	175	221.3	200	237.9	.113366	11.7246
19	170	159.1	170	150.5	175	197.3	250	197.6	.144072	13.5934
	Average Absolute Accuracy	.096536		.102257		.114592		.147811	.115300	Average Precision .115299

$H_0 \quad \mu 1=\mu 2=\mu 3=\mu 4$

$H_1 \quad \mu 1 \neq \mu 2 \neq \mu 3 \neq \mu 4$

$$\text{where } X_i = \frac{\sum_{j=1}^{19} \text{Absolute Accuracy}_{ij}}{19} \quad \text{for } i=1, 2, 3, 4$$

The resulting F statistic was not statistically significant at the 0.25 level, (see Table IV-9). As such, the null hypothesis was not rejected: accordingly, the lack of stability in planning performance, for the periods sampled, could not be inferred.

To determine if the individuals responding to the information source role questionnaire were sensitized to the issues of information source usage, a paradigm of the following form [4, ch. 17] was employed:

BEFORE AND AFTER CONTROL-GROUP DESIGN

Y_b	X	Y_a	(Experimental)
Y_b	$(\sim X)$	Y_a	(Control)

The experimental group was made up of the nineteen teams previously defined: the control group consisted of seven teams drawn from another section of the same Managerial Accounting course. The notation Y_a, X, and Y_b refer, respectively, to the average absolute accuracy for the decision period prior to the completion of the questionnaire, the questionnaire treatment ($\sim X$ means the null treatment), and the average absolute accuracy for the decision period immediately following the completion of the questionnaire.

The significance of the difference between the scores $(Y_b - Y_a)$ of the experimental and control groups was analyzed by means of a one-way

TABLE IV-9

ANALYSIS OF VARIANCE TEST
FOR STABILITY

Component	Sum of Squares	D.F.	Mean Square	F*
Between Periods	.030	3	.0100	1.282
Within Periods	.558	72	.0078	
Total	.588	75		

* $F_{3,72} = 1.282$, significant at $p > 0.25$

analysis of variance. The results of the analysis, (see Table IV-10) indicate no marked sensitization of the individuals responding to the questionnaire.

Applying the classification structure of cognitive complexity and information source usage, and adopting average absolute accuracy as a surrogate for planning performance, a two-way analysis of variance with interaction was performed. The results of the analysis are shown in Table IV-11 and Table IV-12.

From Table IV-11, the overall classification structure was statistically significant at the 0.028 level. What is far more illuminating, however, was the functional form of the regression equation, (refer to Table IV-12). The interaction term had, as expected, a negative coefficient. That is, for those decision-makers designed as having complex cognitive maps, and using a proportionally greater amount of external information sources, average absolute <u>inaccuracy was reduced</u>. Unexpected, on the other hand, were the positive coefficients for the main effects of cognitive complexity and external source usage. Positive coefficients here meant that decision-makers designated as having a complex cognitive structure and using internal information sources, or having a simple cognitive structure and using external information sources, were <u>more inaccurate</u> than those decision-makers designated as having a simple cognitive structure and using internal information sources.

Two plausible explanations can be advanced to explain this rather counterintuitive result. First, the coefficients of complexity and external-internal source usage did not display a high degree of statistical

TABLE IV-10

ANALYSIS OF VARIANCE
FOR SENSITIZING EFFECTS

Component	Sum of Squares	D.F.	Mean Square	F*
Between Groups	.00041	1	.000410	1.385
Within Groups	.00651	22	.000296	
Total	.00692	23		

* $F_{1,23}$ = 1.385, significant at $p > 0.25$

TABLE IV-11

ANALYSIS OF VARIANCE USING AVERAGE ABSOLUTE ACCURACY

Component	Sum of Squares	D.F.	Mean Square	F*
Between Teams	.02652	3	.00884	4.068
Within Teams	.03043	14	.00217	
Total	.05695			

* $F_{3,14} = 4.068$, significant at $p < 0.028$

TABLE IV-12

REGRESSION EQUATION USING
AVERAGE ABSOLUTE ACCURACY*

Variable	B	Std. Error of B	F	Significance
Constant	.105	.023	20.119	.001
External-Internal	.059	.033	3.166	.097
Complexity	.034	.031	1.212	.290
Interaction	-.135	.044	9.372	.008

* R^2 = .46571

significance. This may mean the magnitude and, perhaps, the signs of these coefficients are, in fact, spurious. Second, the analogy of a "fish out of water," may be drawn. Given either a complex or simple structure, a decision-maker using a noncompatible type of information may become ineffective, and as such, make relatively poorer decisions.

But why, for example, would a decision-maker with a simple cognitive structure use external information sources, if he feels uncomfortable in doing so? One explanation for this behavior lies in the research area of small group dynamics. For instance, it has been shown that group problem solving is influenced by group leadership [8] [9], heterogeneity of group membership [2] [3], relative status of the group members [7], and dependence of an individual on the majority [1].

Although decisions were made by individuals, often, the pooling of group resources and knowledge may have substantially altered the decision alternative selected. This would especially be the case if a decision-maker were prone to group pressure or committed to the achievement of a harmonious group relationship [5].

Of the two explanations advanced to explain the unexpected outcome produced by the validation model, I find the latter line of reasoning the more compelling of the two. Of course, final resolution could best be attained by replication of the study within a group dynamics paradigm.

A second two-way analysis of variance with interaction was performed. The same classification structure was used, except this time, precision of sales volume forecasts was the surrogate measure of planning performance. Again, while absolute accuracy measures the amount of forecast error, precision measures the consistency of forecast error. A precision value of zero tells us the forecast error was uniform for all periods.

From Table IV-13, the overall classification structure was statistically significant at the 0.025 level. The regression results, (see Table IV-14) where precision was the dependent variable, conformed to those results obtained using absolute accuracy as the dependent variable. However, because of the increased standard error of the coefficients of external-internal information source usage and cognitive complexity, the likelihood of spurious signs increased in probability.

Summary

The purpose of the chapter was to present, analyze, and validate the data produced by the adapted Role Repertory methodology.

Toward this end, the responses elicited by the information source role questionnaire were selectively analyzed, with regard to the manner of incorporation of these information sources into the design of a management information system.

Next, decision-makers (teams) were categorized into a validation structure. The parameters defining the validation structure were derived cognitive complexity and external-internal information source usage.

As a prelude to validation, stability in planning performance and possible sensitizing effects from the initial questionnaire were tested. Both tests were performed using a one-way analysis of variance on the

TABLE IV-13

ANALYSIS OF VARIANCE
USING PRECISION

Component	Sum of Squares	D.F.	Mean Square	F*
Between Teams	263.760	3	87.920	4.242
Within Teams	290.170	14	20.726	
Total	553.930	17		

* $F_{3,14} = 4.242$, significant at $p < 0.025$

TABLE IV-14

REGRESSION EQUATION
USING PRECISION*

Variable	B	Std. Error of B	F	Significance
Constant	11.423	2.276	25.184	.001
External-Internal	5.002	3.219	2.414	.143
Complexity	2.685	3.054	.773	.394
Interaction	-12.807	4.319	8.792	.010

* $R^2 = .47616$

absolute accuracy of forecasted sales volume. It was concluded that significant instability or sensitization was not present.

Finally, validation, of the degree to which the methodology captured decision-makers' cognitive maps, was attempted. Statistically significant results were found for both surrogate measures (accuracy and precision) of planning performance. As a side issue, an explanation was advanced concerning the rather counterintuitive signs of the cognitive complexity and external-internal information source parameters.

REFERENCES

1. Cohen, B.P. Conflict and Conformity. Cambridge, Mass.: MIT Press, 1963.

2. Hoffman, L.R. "Homogeneity of Group Members' Personality and Its Effect on Group Problem Solving." Journal of Abnormal and Social Psychology 58 (January 1959): 27-32.

3. Hoffman, L.R., and Maier, N.R.F. "Quality and Acceptance of Problem Solution by Members of Homogeneous and Heterogeneous Groups." Journal of Abnormal and Social Psychology 62 (September 1961): 401-407.

4. Kerlinger, Fred N. Foundations of Behavioral Research. New York: Holt, Rinehart & Winston, Inc., 1964.

5. Kessel, Colin. "Effects of Group Pressure and Commitment on Conflict, Adaptability and Cognitive Change." In Human Judgment and Social Interaction. Edited by Leon Rappoport and David Summers. New York: Holt, Rinehart & Winston, Inc., 1973.

6. Lingoes, James C., and Guttman, Louis. "Nonmetric Factor Analysis: A Rank Reducing Alternative to Linear Factor Analysis." Multivariate Behavioral Research 14 (October 1967): 485-505.

7. Raven, B.H., and Rietsma, J. "The Effects of Varied Clarity of Group Goal and Group Path Upon the Individual and His Relationship to His Group." Human Relations 10 (1957) 29-45.

8. Shaw, M.E. "Some Effects of Problem-Solving Complexity Upon Problem Solution Efficiency in Different Communication Sets." Journal of Experimental Psychology 48 (September 1954): 211-217.

9. Shaw, M.E. "Communication Networks." In Advances in Experimental Social Psychology. Edited by L. Berkowitz. New York: Academic Press, 1964.

10. Tryon, B.C., and Bailey, D.E. Cluster Analysis. New York: McGraw-Hill, 1970.

CHAPTER V

SUMMARY

In recent years, there has been a growing concern over the inability of management information systems to fulfill their promised potential. Technological advancements in management information systems have been unmatched by concomitant gains by the constituents of management information systems. This shortfall is especially true where management information systems play an integral role in supporting decision-making.

Purpose of the Dissertation

It was the primary purpose of the dissertation to present, develop, and test a methodology for eliciting types and sources of information used, or desired to be used, for decision-making purposes. Additionally, the methodology attempted to identify the conceptual dimensions on which these types and sources of information were perceived by decision-makers.

Review of the Literature

A review of the literature revealed serious shortcomings in some of the more traditional methods of measuring how a decision-maker, within a specific context, structures information. As a result, the appropriateness of a novel methodology, called the Role Construct Repertory Test (Rep Test), was explored. It was argued that the Rep Test methodology, which develops cognitive maps of decision-makers in terms of information and attributes of that information, overcomes the shortcomings of lack of practicality embodied in direct modeling of the decision network, and degree of unfeasibility inherent in normative choice-set representation.

Experimental Design and Validation Procedure

Trial setting selected. The trial setting selected to apply and validate the proposed methodology was a business game emphasizing the aspects of managerial planning and control in a competitive environment. This specific trial setting was chosen over other possible trial settings for three reasons. First, validation required a number of decision observations. Second, a commonality of objectives among decision-makers was desired. Finally, to increase the probability of being able to link the values generated by the measurement procedure to decision outcomes, a restricted action space was deemed essential.

Composition of the experimental sample. The experimental sample comprised sixty-five students enrolled in the undergraduate Managerial Accounting course offered at the University of Massachusetts in the Fall semester of 1974. From this sample, nineteen teams, of either three or four students, were randomly formed.

Data collection design. The data collection design consisted of five steps. First, the types or sources of information used by decision-makers were elicited by means of a sixteen item questionnaire. Second, triads of the elicited information responses were formed. Third, those individuals identified as being most responsible for planning decisions were interviewed. All interviews were tape recorded. Fourth, adjectives scales were constructed by reviewing the tape recording. Finally, the responses from the initial questionnaire were returned to the identified individuals along with the set of adjective scales. These individuals were requested to order the types and sources of information elicited from the initial questionnaire on each adjective scale of the set.

Validation procedure. To determine whether or not the proposed methodology captured, in essence, decision-makers' cognitive maps, a validation procedure was devised based on the analytical framework of Robert Anthony. Anthony suggests that strategic planning is a distinct function of management, distinguishable by the nature of information, as well as the structural complexity of the information. Using Anthony's framework, it was hypothesized that those decision-makers having more complex cognitive maps, and relying more heavily on external information would outperform, in a planning sense, decision-makers having less complex cognitive maps and relying less on external information.

To empirically test the hypothesis, it was necessary to quantify the variables of cognitive complexity, reliance on external information, and planning performance, and to propose a statistical validation model.

The variable of cognitive complexity was quantified in the following manner:

1. From a factor analysis of the set of adjective scales, factors with eigenvalues of more than one were identified.

2. The number of identified factors as a percentage of total input scales was then divided by the variation, within the original structure, attributable to the identified factors.

3. The resultant values were then rank ordered.

The degree of external source reliance was quantified by calculating the percent of external sources or types of information (as subjectively assessed), to total information sources or types.

Initially, forecasted to actual net income was proposed as a planning performance surrogate. Net income, in this case, was found to be an unsatisfactory surrogate because of the large number of teams that operated near the breakeven point. To achieve a relatively common and uniform numerical base, forecasted and actual sales volume, for the four periods under consideration, was adopted as the planning performance surrogate. For each team, two values were calculated. The first value measured the absolute accuracy (forecast error) achieved by each team: the second value measured the consistency of forecast deviation from actual sales volume.

The statistical model applied to test the hypothesis was a two-way analysis of variance (ANOVA) with interaction. The main effects were the quantified variables of external-internal information reliance and cognitive complexity.

Review of the Results

Overall, the results supported the classification structure hypothesized. The magnitude and inconsistency of forecast error was less for those decision-makers assessed as having relatively complex cognitive structures and relying on a proportionally greater number of external types or sources of information. As such, the notion concerning the ability of the methodology to elicit and generate meaningful cognitive maps of information sources was confirmed.

On a more detailed level, no strong statistical evidence could be found for treating each of the main effects as a separate classifier. In fact, an examination of the signs of the coefficients of the dummy variable, multiple regression equations (the actual form of the ANOVA), revealed unanticipated directionality. This meant the magnitude and inconsistency of forecast error was estimated to be larger for those decision-makers assessed as having relatively simple structures, and relying on a proportionally greater number of external types or sources of information. A similar result was found for those decision-makers assessed as having relatively complex cognitive structures, and relying to a greater extent on internal sources or types of information.

Two explanations were advanced for this finding. First, as previously mentioned, the coefficients did not display a high degree of statistical significance. Since this lack of statistical significance is directly reflected by the size of the standard error of the coefficient, the sign of the coefficient may be, in fact, spurious.

Second, an alternative analysis, emanating from the research on small group dynamics, was advanced to explain the unexpected directionality of the signs of the main effect coefficients. Prior research in the area of small group dynamics has illustrated that often an individual's behavior is dramatically influenced by other individuals with whom he has direct contact. If a decision-maker were prone to group pressure, or committed to the attainment of an harmonious group relationship, he might have selected a decision alternative (forecast) which was the group's rather than his own. Thus we would be, on one hand, measuring by this methodology the individual's cognitive structure, while, on the other hand, observing the planning performance of the group.

Recommendations for Operationalizing the Methodology

Based on the results of this dissertation, the application of the Rep Test methodology in a real-world setting is strongly encouraged. A design process of the following form is contemplated:

1. Since many real-world decision-makers cannot articulate what should be the objective or objectives of the information system, the Rep Test methodology could be applied here as a valuable analytical tool. By eliciting a preliminary list of types and sources of information deemed by the decision-maker to be essential, benchmarks for evaluating the performance of the information system are revealed. From the examination of the evaluative criteria, insight is provided into the nature of the objectives of the information system [5, p. 430-431].

2. Given a consensus can be reached on what are the objectives of the information system, the degree to which the present information system meets these objectives can be determined. By this assessment process, the strengths and weaknesses of the present information system should be delineated, thereby providing guidelines for either enhancement of the present system, or evolution of a dramatically different information system.

3. Drawing on the preliminary list of types and sources of information, as well as the reasons a decision-maker considers this information to be of importance, an indepth investigation of the attributes of the types and sources of information should be carried out. This indepth investigation should focus on such salient information attributes as: timeliness, level of detail, degree of summarization, accuracy, certainty, degree of quantification, and accessibility [1, p. 34].

Each type and source of information from the preliminary list, together with other information that the decision-maker may have, at first, overlooked should be scaled (rank ordered) on the attributes elicited by means of the triad comparison exercise, as well as the additional information attributes identified above.

4. A joint space should then be constructed consisting of information types and sources and information attributes. Although nonmetric factor analysis (SSA-III) was used in this dissertation, I believe a better picture of the joint space could be developed if the techniques of multidimensional scaling (MDS) were used. (For those unfamiliar with MDS as a research tool, see the article by Krampf and Williams [6]). A nonmetric MDS algorithm [9] can be applied to the preference input data to formulate a geometric space in n dimensions, and locate the sources and types of information in this space; a nonmetric unfolding algorithm [2] can be used to derive (identify) the underlying dimensions of the reduced space.

5. Following the completion of the systems design and implementation phase, and after some specified period of hands-on experience with the

operational information system, the decision-maker should be revisited by the analyst. The decision-maker should be requested to rescale the types and sources of information on each of the attributes. The resulting data should be resubmitted to the MDS and unfolding programs.

6. The output from the initial and follow-up analysis can now be compared. This comparison should reveal differences in the location of sources and types of information. The direction and amount of change in location of these information sources and types, represent (estimate) the degree of perceptual change experienced by the decision-maker over the time period from system analysis to the present. If the change, from the standpoint of the decision-maker, is in an undesired direction and significant, two alternatives are available. First, the analyst may attempt to convince and/or educate the decision-maker as to the merits of this deviation. Second, it may be necessary for the analyst to retune the system to conform to the decision-maker's needs.

A final recommendation concerns the somewhat Utopian notion that management information systems will eventually evolve to the state of being cost-effective on an individual basis. If information is produced for aggregated decision-makers, rather than merely basing aggregation on function, location in the organization, and level of decision-making (strategic, tactical, or operational), another dimension of aggregation ought to be considered. This additional facet entails classification of decision-makers on the basis of sources and types of information, as well as the attributes that make the information useful. Operationally then, decision-makers, classified on a multiple criteria basis, might be grouped by means of a cluster analysis [4].

Recommendations for Related Research

An implicit purpose of the dissertation is to suggest to those who follow, certain fruitful areas of investigation.

The data gathered in the dissertation provided information on one group of decision-makers. Further research needs to be undertaken across a broader spectrum of constituents of management information systems. Specifically, these constituents include management, shareholders and prospective shareholders, consumers, suppliers of production factors, governmental agencies, and commentators (e.g. financial analysts, academics, credit rating organizations, etc.) [7].

For example, the Committee on Accounting for Corporate Social Performance, headed by Robert Beyer, has suggested that corporate entities have a social as well as economic impact. As such, to more appropriately measure total corporate performance, net income reporting ought to be supplemented by measures of social effort and the impact these efforts have, and will have, upon society [3].

One major area under which social performance is considered, concerns product or service contributions. Product or service contributions reflect the concerns of an entity for generating and perpetuating customer goodwill over and above that of a "caveat emptor" attitude [3, p. 40].

In proposing a Rep Test methodology to define the informational requirements of a product or service contribution information system, the following is a sample of the questions that might be asked of monitoring groups:

1. What source of information allows you to assess adherence to warranty provisions?

2. What source of information would be valuable in assessing product quality, but is now unobtainable?

3. What source of information do you consider misleading?

4. What source of information was not at first crucial to your assessment of responsiveness to customer complaints, but is now?

5. What source of information did you use to make a judgment concerning adequacy of customer eduction?

6. What source of information concerning product safety do you consider difficult to understand?

Scales that might define the attributes of the elicited product or service contribution information sources include: completeness, clarity, timeliness, adherence, uniformity, and injuriousness.

Another example of an area ripe in research potential concerns the interface between external accounting reports and the investor. The Study Group on the Objectives of Financial Statements has stated that users of financial statements need both factual and interpretive information about events and transactions to enable them to make predictive, comparative, and evaluative assessments of an enterprise's earning power [8, p. 33-34]. To determine whether or not accounting reports are useful or could be altered to be made more useful, it is imperative that an accurate resolution be made of how accounting statement information is presently being used by investors. This resolution may be greatly facilitated by the application of the Rep Test methodology. For instance, the information sources that influence trading decisions might be sought. A field or experimental setting could be adopted, depending upon whether we wish to study current cognitive structures of investors, or changes in cognitive structures of investors related to changes in the informational content of accounting data, over classes of investors and time.

REFERENCES

1. Burch, John G., Jr. and Strater, Felix R. Information Systems: Theory and Practice. Santa Barbara, Calif.: Hamilton Publishing Co., 1974.

2. Carroll, J.D., and Cheng, C.D. "Relating Preference Data to Multidimensional Scaling Solutions via a Generalization of Coombs Unfolding Model." In Multidimensional Scaling, Vol. 1, Theory. Edited by Roger Shepard et al. New York: Seminar Press, 1973.

3. Committee on Accounting for Corporate Social Performance. "Accounting for Corporate Social Performance." Management Accounting 55 (February 1974): 39-41.

4. Grudnitski, Gary, and Calantone, Roger. "A Guide to the Use of Selected Nonmetric Multivariate Programs." Working Paper, University of Massachusetts, 1974.

5. Ijiri, Yuji; Jaedicke, Robert; and Knight, Kenneth. "The Effects of Accounting Alternatives on Management Decisions." In Information for Decision Making. Edited by Alfred Rappaport. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1970.

6. Krampf, Robert F., and Williams J.D. "Multidimensional Scaling as a Research Tool: An Explanation and Application." Journal of Business Research 2 (April 1974): 157-175.

7. Prakash, Prem, and Rappaport, Alfred. "Informational Interdependencies: A Perspective for Accounting." Evanston, Ill., 1974. (mimeographed.)

8. Study Group on the Objectives of Financial Statements. Objectives of Financial Statements. New York: AICPA, 1973.

9. Young. F.W., and Torgerson, W.S. "TORSCA, A FORTRAN IV Program for Shepard-Kruskal Multidimensional Scaling Analysis." Behavioral Science 12 (November 1967): 498-503.

APPENDICES

APPENDIX A -- GAME EXPLANATION

APPENDIX A

GAME EXPLANATION

INTRODUCTION

This handout is designed to introduce you to the mythical Agelclap Industry (a spinoff of the very prosperous widget industry).

Herein you will find only a cursory report on the industry and the firm you have been hired to help manage. A greater knowledge will come to you as you participate in running your firm. Experience is the best teacher.

INDUSTRY AND FIRM DEMAND

The total industry demand for Agelclaps appears to be a function of price, promotion, and research and development. In addition, industry demand seems to vary seasonally (see Appendix). Throughout the industry, it is felt that the total industry demand curve has the general configuration appearing in Figure I. It is also felt that money spent on promotion and R&D causes lateral shifts of the curve; promotion because it makes more potential consumers aware of the product and because it provides persuasion, and R&D because it results in refinements of the product which make the product adaptable to a larger variety of uses. Table I provides some historical data which may help you to formulate hypotheses concerning the effects the four variables mentioned above have upon demand.

Because of the relatively small number of firms in the industry, the sales potential of any individual firm is affected not only by its decisions, but by the actions of its competitors as well.

The products produced by each of the firms in this industry are relatively homogeneous with respect to quality, design, and other technical features. Because of this, consumers' perceptions of differences among the various brands of Agelclaps are influenced primarily by the advertising of the various firms.

Research and development is important in that no firm can allow another to gain a technological advantage. It is felt throughout the industry that a technological innovation introduced by one company that could not be matched by the other companies would give the introducing company a recognizable competitive advantage.

(A simplifying assumption made in this game is that the quality of advertising and R&D is the same for every firm in the industry so that variations in the quantity of these two items becomes the relevant variables.)

THE PRODUCTION FUNCTION

Due to the comparative youth of this industry and industry-wide bargaining by labor unions, all the firms face the same variable cost structure in producing goods for sale.

The union contract has established the following:

Monthly contract wages for production workers (including direct fringe benefits)	$1,200
Length of the regular work week	40 hours
Maximum overtime for each worker	2 hours/day
Overtime pay rate	$11.25/hour
Standard production units per hour	3 units/hour
Severance pay	$1,200

In addition, the companies in the industry have established the fact that it costs $400 to train a newly-hired production worker.

(Another simplifying assumption of the game is that workers may be hired and fired only at the beginning of a month.)

The raw materials used in making Agelclaps have a unit cost of $6.00. One unit of raw material is needed in the production of one Agelclap. Normally, there is a month lag between the time materials are ordered and when they are ready to go into production. That is, goods ordered in month one cannot be used until month two, etc. However, should the need arise, it is possible to rush-order raw materials by paying a 20% premium above the $6.00 unit cost. Materials rush-ordered are available for use in the month in which they are ordered.

There are three inventory costs that companies face. The ordering cost for raw materials (5%of the value of the order), the storage cost for raw materials ($0.20 per unit per month), and the storage cost for finished goods ($0.30 per unit per month). These three costs are accumulated by the month and considered as production overhead for that month.

The plant and equipment of your firm had a $12 million price tag when it was new. The estimated useful life of these physical assets is 15 years with a salvage value at the end of that period of $3 million. As the game starts, the net value of the plant and equipment (purchase price less accumulated depreciation) is $6 million. Depreciation is computed according to the straight line method.

COMPANY CASH FLOW

In general, the convention in the industry is to pay cash for all purchases so that there are no accounts payable at month's end. The payroll obligations of the firms are also met at month's end so that there are no wages payable carried from month to month.

On occasion, this cash basis policy necessitates the borrowing of money to meet obligations. All the firms in the industry have access to lines of credit at local banks which allow them to borrow money on very short notice at a current interest rate of 12% per year. Any money borrowed in this fashion must be kept for one month. Also, all the firms have the ability to borrow money by issuing one month notes. These notes currently carry an interest rate of 8% per year and cannot be redeemed before their maturity date. If a firm should wish to prolong paying off the notes, it may do so by issuing a new note on the due date of the old note. Even is the note is renewed, however, the company must pay the interest of the original note on the original due date.

Although the firms all purchase on a cash basis, they do allow credit sales. Accounts receivable normally average 35% of the sales for the month and are usually collected the next month.

Very often, when they have extra cash, the firm invests the idle money in one month certificates of deposit which have a current interest rate of 6-1/2% per year. These are renewable each month if the company should so desire.

MISCELLANEOUS MATTERS

Each company begins the competition with the same financial statements.

The maximum capacity of the plant is 300,000 units/month

Administration costs not only include the costs of hiring and dismissing production employees, but also 343,400 at present levels. These are the costs of supervision, social security contributions, payroll preparation costs, and other similar expenses. It is felt that the incremental monthly administrative cost per employee is $200.

DECISION MAKING

Each firm makes nine decisions which affect the financial performance of their firm. These decisions include:

1. Price of product.
2. Promotional expenditures.
3. Research and development expenditures.
4. Production schedule in units.
5. Purchase orders in units (both normal and rush orders).
6. Number of new employees hired.
7. Number of old employees layed off.
8. Amount of short-term (one month) loans.
9. Investment of idle cash.

These decisions and their implications are explained more fully below.

Price - The price of your product affects the total units sold, the total revenue and the net profit of your firm. In setting a price, your team should consider the economic situation, the competitors, the influence of promotion and R&D on sales, and the impact of different prices on demand.

Promotion - Promotion expenditures influence team sales. However, too much promotion results in wasted effort, too little may hurt sales volume.

Research and Development - R&D affects sales in much the same way as promotion but its impact does not appear to be as immediate as that of promotion.

Production Schedule - The number of units produced should be a function of the sales forecasts for the upcoming months. Consider the following questions. Do you need to work overtime in order to meet forecasts of sales? Can you avoid overtime by building larger inventories? Are larger inventories too costly? Perhaps overtime is cheaper.

Purchases - Keep in mind that normally, purchases cannot be used until the month after they have been made. For this reason, normal purchases are related to production in future periods rather than to production this month. Relying on rush orders can be quite costly, as was outlined above. Another consideration should be the fact that there are storage costs associated with inventory. Effort should be made to hold the total costs of raw material to a minimum.

New Hires - The output of the plant in any given month is limited by the number of men available for work assignments. If your sales volume is rising, you had better consider adding additional men to your work force. (See production decision above.)

Layoffs - As sales volume falls, it may be cheaper to incur severance expenses than to use the labor force at a lower productivity rate.

Loans - By preparing a cash schedule, you should be able to forecast your need for money in order to pay your operating expenses. It is cheaper to plan your borrowing than to rely on your line of credit.

Investment - The cash schedule you make should also reveal any idle funds you have. Perhaps you should consider investing this money in certificates of deposit.

Rush Purchases - See discussion under "Purchases."

FEEDBACK

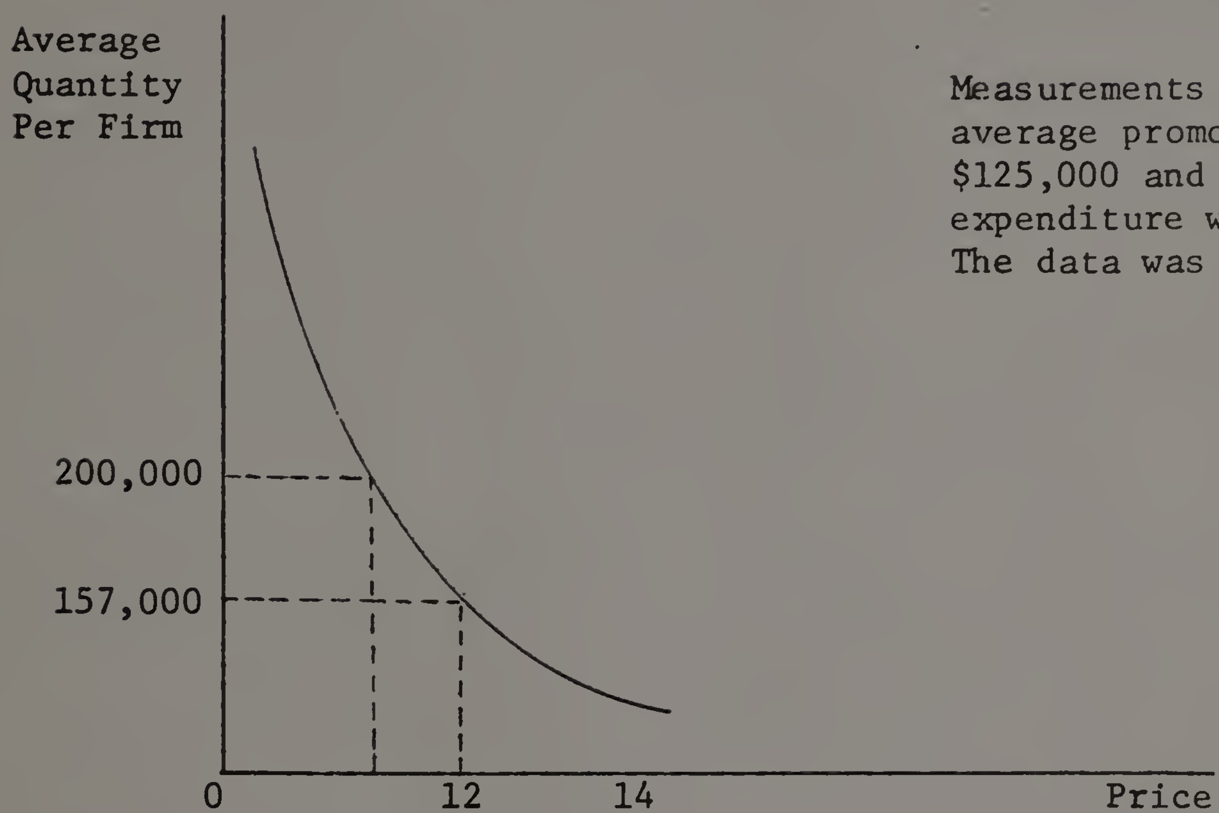
The decisions of all firms are used as inputs to a computer simulation model whose structure has been outlined in the discussion above. The model determines the total industry demand, the allocation of sales to competing firms, and the financial results for each firm. The information returned to each team at the completion of each period of play consists of financial statements for the team's firm and the other miscellaneous data on the industry.

COMMENT

Remember, you are playing this game to learn something about managerial accounting. You should attempt to justify all your decisions based upon their affect on your company's profitability. Decisions which are not well thought out in terms of their affects on costs and revenues are not good decisions.

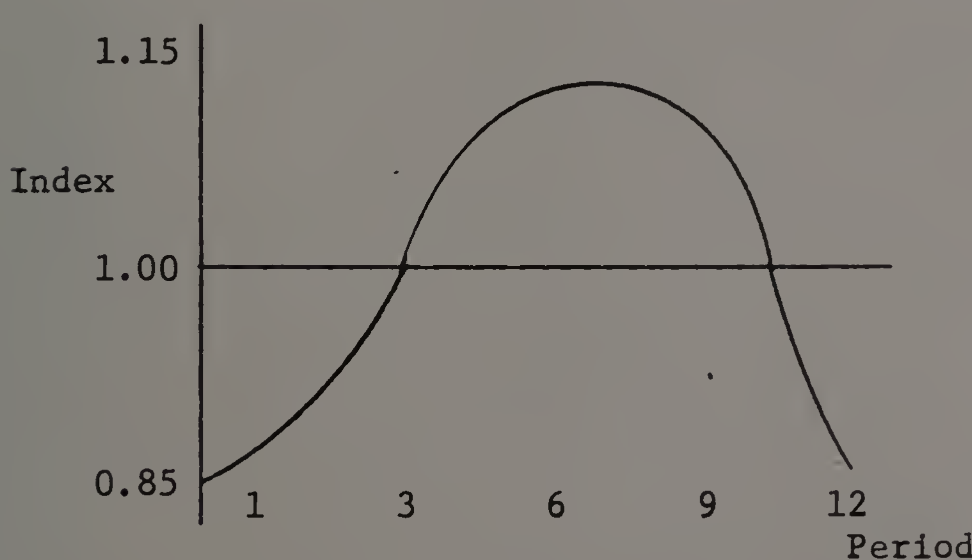
APPENDIX

Figure I - Agelclap Demand Statistics (Courtesy Agelclap Trade Association)



Measurements were taken when the average promotion per firm was $125,000 and the average R & D expenditure was $25,000 per firm. The data was adjusted for seasonality.

Figure II - Agelclap Demand Seasonality



APPENDIX

Table I - Historical Operating Data

Until recently, company record keeping was usefully inadequate. Below, howver, is some data from the last 6 months that you might find useful.

Month	-5	-4	-3	-2	-1	0
Company price	$12.00	$12.50	$13.00	$13.00	$13.00	$14.00
Company advertising	$10,000	50,000	50,000	100,000	75,000	125,000
Company R&D	$ 1,000	1,000	10,000	10,000	20,000	25,000
Company sales volume*	147,340 units	152,197	140,642	157,226	139,137	133,495
Average price of competitors	$13.00	$13.00	$13.50	$13.50	$13.50	$14.00
Total industry sales volume*	490,936 units	491,733	527,615	546,635	575,043	533,980

*Sales volume figures are seasonally adjusted.

APPENDIX B -- TYPES AND SOURCES OF INFORMATION

APPENDIX B

TYPES AND SOURCES OF INFORMATION

Team 1	Team 2
1. Handout	1. Estimator of demand
2. Production quantity	2. ---
3. Labor input	3. Promotion
4. Keeping production constant	4. Price
5. Pricing policy	5. Handout
6. R&D	6. ---
7. Promotion	7. Cash budget
8. Ending cash	8. Master budget
9. Past sales	9. Production
10. Long run planning	10. ---
11. Loan repayment	11. Past sales of firm
12. Purchase budget	12. Past sales of the industry
13. Ending inventory	13. ---
14. Competitor's inventory	14. Printout of other firms
15. Production costs	15. R&D
16. Pro Forma statements	16. Output

Team 3

1. Relative product price
2. Labor force
3. R&D
4. Sales quantity
5. Production quantity
6. Effect of lowering price
7. Effect of seasonality
8. Promotion
9. Labor force
10. ---
11. Budgeting
12. Estimating future sales
13. Carrying costs
14. Estimating total market demand
15. Raw materials inventory
16. Loan acceptance

Team 4

1. Game handout
2. Labor budget
3. Promotion
4. Price
5. Team interaction
6. Balance sheet
7. Cash
8. Variance analysis
9. Budget explanation
10. Loans and payments
11. Miscellaneous matters
12. Calculating inventory
13. Line of credit
14. Information on other teams
15. Printout
16. Holding cost

Team 5

1. Handout
2. Transcription error
3. Forecasting others pricing strategy
4. Own price policy
5. Past sales
6. Promotion
7. Demand index
8. Labor input
9. Layoffs and idle cash
10. Improving budget procedure
11. Income statement
12. Demand estimation
13. Team interaction
14. R&D
15. Estimating period sales
16. Seasonal adjustment factor

Team 6

1. Charting price changes
2. Analyzing market share
3. Carrying costs
4. Price
5. Printout
6. R&D
7. Industry sales
8. Investment of idle cash
9. Loans
10. Comprehensive budget
11. Graphing projected industry demand
12. Inventory costs
13. Previous six month's history
14. Accuracy of industry demand figures
15. Costs of production
16. Determining sensitivity of price

Team 7

1. Historical data
2. Transcription error
3. Paying loans
4. Price and profit
5. Timeliness of feedback
6. R&D
7. Production
8. Loans payable
9. Budgets
10. Information on competitors
11. Balance sheet
12. Calculating ending inventory
13. Sales/promotion relationship
14. ---
15. Seasonal index
16. Purchases

Team 8

1. Determining effect of competition
2. Loans
3. Hiring - firing costs
4. Price
5. Cash
6. R&D
7. Promotion
8. ---
9. Levels of production
10. ---
11. Penalty costs
12. Ending inventory
13. Sales volume
14. ---
15. Estimating the demand curve
16. ---

Team 9

1. Printouts
2. Price/promotion relationship
3. Promotion
4. Level of production
5. Carrying costs
6. Holding market share
7. Borrowing charges
8. Idle costs
9. Estimating the demand curve
10. ---
11. Handout
12. R&D
13. ---
14. Other teams' printouts
15. More detail on balance sheet
16. Sales

Team 10

1. Luck
2. R&D
3. Printouts
4. Promotion
5. Sales forecast
6. Production costs
7. Knowledge of other players
8. Production levels
9. Budgeting
10. Cash balances
11. Labor force
12. Loans
13. Pricing
14. Determining sales function
15. Handout
16. Past players of the game

Team 11

1. Employment of alternate strategy
2. Ending inventory
3. Profits of other teams
4. Idle costs
5. Holding costs
6. R&D
7. Sales volume (ours)
8. Production
9. Budgets
10. Total industry sales
11. ---
12. Inventory charges
13. ---
14. Reliable sales forecasts
15. Promotion
16. Profit

Team 12

1. Price
2. Inventory of raw material
3. Inventory of finished goods
4. Purchases
5. Past participants
6. Notes payable
7. Production
8. R&D
9. Sales revenue
10. Holding costs
11. Sales forecasts
12. Handout
13. Profit projections
14. Weight of variables (price, promotion, and R&D) in demand equation
15. Cost of labor
16. Cash

Team 13

1. Team interaction
2. Sales volume
3. R&D
4. Ending inventory of raw materials
5. Projections of sales volume
6. Securities
7. Price
8. Finished goods inventory
9. Changes in demand
10. Idle costs
11. Raw material cost
12. Cash
13. Firing cost
14. Price elasticity of demand
15. Profit level
16. Hiring costs

Team 14

1. Size of inventory
2. Layoffs
3. Estimation of sales
4. Promotion
5. Price per unit
6. Role of competition
7. Cash budget
8. R&D
9. Special material cost
10. Handout
11. Product demand equation
12. Cash
13. Income statement
14. Opponent's price
15. Current sales
16. Firing costs

Team 15

1. Handouts
2. Previous decisions
3. Inventory of finished goods
4. High inventory costs vs. firing costs
5. Sales forecast
6. Historical operational data
7. Quantity of raw materials
8. Price
9. Regression analysis
10. ---
11. Promotion
12. Cost of inventory
13. ---
14. Estimate of competitors' price and advertising
15. Correlation analysis of R&D and sales
16. Seasonal graph

Team 16

1. Word of mouth
2. Historical information about the firm
3. Price
4. Price vs. demand relationship
5. Printouts
6. Promotional expenditures
7. Production function
8. Inventory of finished goods
9. Raw materials inventory
10. Loans and notes
11. Income statement - balance sheet
12. Cost/effectiveness of R&D
13. Securities/cash
14. Marginal advertising effect
15. Forecasts of other teams
16. Historical data

Team 17

1. Prices of other teams
2. Production
3. Inventory
4. Promotion
5. Sales
6. Holding cost of inventory
7. Cash inflow
8. Loans
9. Our price of product
10. Handout
11. Income calculation
12. Layoffs
13. R&D
14. Where my planned cash went
15. Hiring costs
16. Effect of seasonality on sales

Team 18

1. Intuition
2. Balance sheet
3. Advanced accounting students
4. Inventory
5. Advertising
6. Course material
7. Ending inventory of raw materials
8. Previous decision results
9. Handouts
10. Friend
11. Budget process
12. R&D
13. Loans
14. Printouts
15. Labor costs
16. Beginning information on game

Team 19

1. Handout
2. Team members
3. Inventory
4. Promotion
5. Printouts
6. Hiring costs
7. Idle time
8. Inventory control
9. Production
10. Cash control
11. Planned loans
12. Estimating sales potential
13. R&D
14. Determining inputs to demand equation
15. Price
16. Graphing demand equation

APPENDIX C -- FACTOR ANALYTIC DIMENSIONS

APPENDIX C

FACTOR ANALYTIC DIMENSIONS

What follows, is the derived factor analytic results for each of the nineteen teams. Only those factors with an eigenvalue of greater than one are listed; only loadings that are either greater than or equal to 0.50 or less than or equal to -0.50 are shown.

Team 1 -- Total scales 9

Factor 1 E=2.98

.81 kept constant -- varied

.73 variables important to the budget process -- variables determined by the budget process

.63 long run -- short run

.61 data not available -- data available

.55 mechanical decision variable -- more art than science

Factor 2 E=1.72

.60 benefits realized in future periods -- not so

-.55 predictable results -- vague results

Factor 3 E=1.31

.58 predictable results -- vague results

Factor 4 E=1.06

-.54 not enough information given -- sufficient information given

Team 2 -- Total scales 11

Factor 1 E=3.05

.84 relative to competition -- not affected by competition

.81 easy to determine effect on sales -- difficult to determine effect on sales

.70 fits together -- not so

.67 increases profitability -- decreases profitability

-.61 gives you an overall picture -- gives you only part of the picture

.60 impacts on cash -- not so

Factor 2 E=1.85

.60 information you would pay for -- not so

.56 not enough information -- sufficient information

.54 past data to rely on -- not so

Factor 3 E=1.13

.52 increases profitability -- not so

Factor 4 E=1.12

.50 changes each time through -- relatively constant

Team 3 -- Total scales 7

Factor 1 E=2.84

.83 important to doing well -- not that important to doing well

-.82 largely ignored -- most often heeded

-.55 had little understanding of -- understood well

-.54 paid little attention to but should of -- not so

Factor 2 E=1.38

-.55 determines production -- determines sales

-.51 kept constant -- had to vary

Team 4 -- Total scales 10

Factor 1 E=2.60

-.91 depends on team interaction -- not so

-.66 depends on what others do -- not so

-.63 helps to determine production -- not so

Factor 2 E=1.60

-.97 team decision -- mechanical

Factor 3 E=1.40

-.76 affects idle cost -- not so

-.57 easy to determine -- guess

.56 not easily understood -- easy to understand

Factor 4 E=1.36

-.96 determines how much cash is necessary -- not so

Team 5 -- Total scales 12

Factor 1 E=2.92

.77 hard to understand -- easy to understand

.77 misleading -- not misleading

-.72 sufficient information provided -- insufficient information provided

.55 after the fact variable -- before the fact variable

.51 should be presented in a different form (e.g. histogram) -- okay as now presented

Factor 2 E=1.92

.61 important decision input -- important decision output

.59 should be presented in a different form (e.g. histogram) -- okay as now presented

Factor 3 E=1.58

.59 an offensive variable -- a defensive variable

.58 controllable -- uncontrollable

Factor 4 E=1.37

.53 external source -- internal source

Team 6 -- Total scales 14

Factor 1 E=3.09

-.91 not relevant -- relevant

.87 tracked over time and compared -- not so

.84 a mistake in one leads to problems in others -- not so

.63 effective in determining results -- not effective in determining results

Factor 2 E=2.15

-.89 ballpark figures -- specific values

.76 experimented with -- held constant

Factor 3 E=1.65

-.88 easy to misinterpret -- not easily misinterpretable

-.58 feel provided for variable by historical data -- not so

.57 predicated on sales -- not so

Factor 4 E=1.40

-.82 planning variable -- control variable

<u>Factor 5</u> E=1.36

.83 prediction variable -- mechanical variable

.61 results in penalty -- results in reward

<u>Factor 6</u> E=1.35

.92 variables you work backward from -- variables you work forward to

-.51 misleading or vague -- not so

<u>Team 7</u> -- Total scales 6

<u>Factor 1</u> E=1.80

-.76 paid little attention to -- paid a great deal of attention to

-.73 related to competition -- internal

<u>Factor 2</u> E= 1.45

.79 related to contribution margin -- indirectly related to contribution margin

.61 reason for budgeting -- no need for budgeting

<u>Factor 3</u> E=1.37

-.75 input to the decision process -- output from the decision process

-.68 constant level -- varied considerably

<u>Team 8</u> -- Total scales 7

<u>Factor 1</u> E=2.37

-.98 something that happens to you -- something that you cause

.92 controllable -- uncontrollable

.60 helps to understand demand for product -- not so

Factor 2 E=2.08

.81 affects production -- does not affect production

.67 easily determined -- not easily determined

-.57 help to understand demand for product -- not so

-.54 related to sales volume -- unrelated to sales volume

Factor 3 E=1.04

-.76 depends on competition -- not so

.54 easily determined -- not easily determined

Team 9 -- Total scales 8

Factor 1 E=3.25

.86 profit producer -- not a profit producer

.74 a key decision variable -- not so

.71 has tangible benefits -- benefits are less tangible

-.61 easy to estimate -- hard to estimate

.61 variables interrelated -- variables unrelated

Factor 2 E=1.75

.90 variable should be de-emphasized -- proper emphasis given to variable

Team 10 -- Total scales 10

Factor 1 E=4.65

.87 less tangible cause and effect relationship -- more tangible relationship

.83 sources that decrease in value as the game is played -- sources that retain their value

-.83 time consuming -- take little time

-.80 part of the budget procedure -- not so

-.78 planned -- not so

-.75 related to competition -- not so

-.72 well understood -- not understandable

Factor 2 E=1.16

-.85 value of information depends on situation -- not so

Factor 3 E=1.07

.78 shows you how you went wrong -- does not tell you how you went wrong

Team 11 -- Total scales 11

Factor 1 E=2.71

.74 internally important -- externally important

.71 a variable that relates to safe decisions -- a variable that relates to risky decisions

.52 dependent on another variable -- not dependent on another variable

.51 able to assess impact -- unable to assess impact

Factor 2 E=1.86

.70 variable influenced by other teams -- not so

.66 important gauge on your progress -- not an important gauge on your progress

Factor 3 E=1.56

.62 short term effect -- long term effect

-.55 internally important -- externally important

Factor 4 E=1.37

.59 has substantial impact on sales -- not so

Team 12 -- Total scales 10

Factor 1 E=2.96

-.88 variables related -- distinct variables

-.70 comes off a common schedule -- not so

-.67 major decision variable -- minor decision variable

-.61 best to keep constant -- best to vary

-.58 short term results -- long term results

-.53 influences profits greatly -- has little effect on profits

Factor 2 E=2.50

-.80 difficult to determine impact -- not so

-.77 could use more information -- enough information provided

-.74 little consideration given to -- much consideration given to

.72 short term results -- long term results

Factor 3 E=1.05

.60 misleading -- reliable

-.56 major decision variable -- minor decision variable

Team 13 -- Total scales 8

Factor 1 E=2.64

.65 relates to sales -- not so

.63 time dependent -- not so

.58 important decision variable -- not an important decision variable

.57 environmental issure -- internal issue

.55 variable to be considered in a growing market -- not so

<u>Factor 2</u> E=1.50

.70 applicable to a going concern -- not so

<u>Factor 3</u> E=1.40

.53 affects how consumers see your product -- not so

<u>Team 14</u> -- Total scales 8

<u>Factor 1</u> E=4.34

.89 directly determined -- indirectly determined

-.82 had large impact on sales -- had little impact on sales

-.82 directly affects sales -- does not directly affect sales

-.77 crucial decision variable -- not so

.73 mechanical -- not so

-.70 outcomes of budgeting process -- free variable

-.66 difficult to understand -- easy to understand

-.60 dictated by competition -- not dependent on competition

<u>Factor 2</u> E=1.20

-.65 reaction variable -- not so

<u>Factor 3</u> E=1.17

-.83 influences costs -- not so

<u>Team 15</u> -- Total scales 7

<u>Factor 1</u> E=2.21

-.92 based on previous decisions -- not so

.82 less affected by historical data -- affected by historical data

<u>Factor 2</u> E=1.97

.80 not used in decision-making -- used or important in decsion-making

-.72 important in peak seasons -- not as important in peak seasons

.52 less affected by historical data -- affected by historical data

<u>Factor 3</u> E=1.03

.76 can be analyzed externally -- not analyzed externally

<u>Team 16</u> -- Total scales 9

<u>Factor 1</u> E=2.87

.94 affects cost structure -- not so

.91 concrete -- nebulous

.58 historical data based -- not so

<u>Factor 2</u> E=1.55

.72 results in substantial impact -- results in minimal impact

-.58 after the fact variable -- not so

<u>Factor 3</u> E=1.22

.54 placed in equation form -- not so

<u>Factor 4</u> E=1.12

.59 competitive reaction variable -- a variable that you do not react to

<u>Team 17</u> -- Total scales 8

<u>Factor 1</u> E=2.41

.67 dependent on competitors -- internally decided upon

.52 short-run decision variable -- long run decision variable

.51 important to the decision process -- not so

.51 control variable -- planning variable

<u>Factor 2</u> E=1.74

.61 short run decision variable -- long run decision variable

-.51 related to many variables -- related to few variables

<u>Factor 3</u> E=1.62

.57 variables that changed in importance over time -- not so

.52 variables not easily determined -- variables easily determined

<u>Team 18</u> -- Total scales 6

<u>Factor 1</u> E=3.68

.94 a poor feedback information source -- a good feedback source

-.89 practice run experience - not so

-.86 little or no impact on income outcome -- not so

-.86 used extensively -- used little

<u>Factor 2</u> E=1.05

-.84 helpful in setting production -- not so

<u>Team 19</u> -- Total scales 7

<u>Factor 1</u> E=1.90

-.78 monetary -- nonmonetary

.67 only one aspect -- many components

<u>Factor 2</u> E=1.61

.64 control variable -- planning variable

.63 well explained -- not well explained

<u>Factor 3</u> E=1.56

.64 clear indication of impact -- vague idea of impact

BIBLIOGRAPHY

Ackoff, Russell L. "Management Misinformation Systems." Management Science 14 (December 1967): 147-156.

Anthony, Robert N.; Dearden, John; and Vancil, Richard F. Management Control Systems. Revised ed. Homewood, Ill.: Richard D. Irwin, Inc., 1972.

Bannister, D. "Personal Construct Theory: A Summary and Experimental Paradigm." Acta Psychologica 20 (1962): 104-120.

Bariff, Martin L., and Lusk, Edward J. "A Study of the Utilization of Cognitive and Personality Tests for the Design of Management Information Systems." Working Paper, The Wharton School, University of Pennsylvania, April 1974.

Bieri, James. "Cognitive Complexity-Simplicity and Predictive Behavior." Journal of Abnormal and Social Psychology 51 (September 1955): 263-268.

Burch, John G., Jr. and Strater, Felix R. Information Systems: Theory and Practice. Santa Barbara, Calif.: Hamilton Publishing Co., 1974.

Carroll, J.D., and Cheng, C.D. "Relating Preference Data to Multidimensional Scaling Solutions via a Generalization of Coombs Unfolding Model." In Multidimensional Scaling, Vol. 1, Theory. Edited by Roger Shepard et al. New York: Seminar Press, 1973.

Churchill, N.C.; Kempster, J.H.; and Uretsky, M. Computer Based Information Systems for Management: A Survey. New York: National Association of Accountants, 1969.

Clark, John J., and Elgers, Peter "Forecasted Income Statements." The Accounting Review 48 (October 1973): 668-678.

Clarkson, Geoffrey. Portfolio Selection: A Simulation of Trust Investment. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1962.

Cohen, B.P. Conflict and Conformity. Cambridge, Mass.: MIT Press, 1963.

Committee on Accounting for Corporate Social Performance. "Accounting for Corporate Social Performance." Management Accounting 55 (February 1974): 39-41.

Copeland, Ronald; Francia, Arthur; and Strawser, Robert. "Students as Subjects in Behavioral Business Research." The Accounting Review 48 (April 1973): 365-372.

Cronback, Lee J. Essentials of Psychological Testing. 2nd ed. New York: Harper & Bros., 1960.

________, and Meehl, Paul E. "Construct Validity in Psychological Tests." Psychological Bulletin 52 (July 1955): 281-302.

Cyert, R.M.; Dill, W.R.; and March, J.G. "The Role of Expectations in Business Decision-Making." Administrative Science Quarterly 3 (December 1958): 307-340.

Daily, R.A. "The Feasibility of Reporting Forecasted Information." The Accounting Review 46 (October 1971): 686-692.

Dawes, Robyn M. Fundamentals of Attitude Measurement. New York: John Wiley & Sons, 1972.

Dean, Neil J. "The Computer Comes of Age." Harvard Business Review 46 (January - February 1968): 83-91.

Dearden, John. "Myth of Real-Time Management Information Systems." Harvard Business Review 44 (May - June 1966): 123-132.

Dickson, G.W., and Senn, J.A. "Research in Management Information Decision Systems: The Minnesota Experiments." Paper presented at the 6th Annual Meeting of the American Institute of Decision Sciences, Atlanta, 1974.

Dunlop, R.A. "Some Empirical Observations on the Man-Machine Interface Question." In Management Information Systems: Process and Perspectives. Edited by C.H. Kriebal et al. Pittsburg: Carnegie Press, 1971.

Dyer, James S. "A Time-Sharing Computer Program for the Selection of the Multiple Criteria Problem." Management Science 19 (August 1973): 1379-1383.

Ellis, Robert C. "The Need for a Measure of Relative Importance of Top Level Objectives." Proceedings of the 4th Annual Meeting of the Southeastern American Institute of Decision Sciences. Atlanta, n.p., 1974.

Ferguson, R.L., and Jones, O.H. "A Computer Aided Decision System." Management Science 15 (June 1969): B550-561.

Fleming, J.E. "Managers as Subjects in Business Decision Research." Academy of Management Journal 12 (March 1969): 550-561.

Frost, W.A.K. "The Development of a Technique for TV Programme Assessment." Journal of the Market Research Society 11 (January 1969): 25-44.

Garner, W.R. "To Perceive is to Know." American Psychologist 21 (January 1966): 11-19.

Gerrity, T.P. "The Design of Man-Machine Decision Systems." Ph.D. dissertation, MIT, 1970.

Goldberger, Arthur S. Econometric Theory. New York: John Wiley & Sons, 1964.

Grudnitski, Gary, and Calantone, Roger. "A Guide to the Use of Selected Nonmetric Multivariate Programs." Working Paper, University of Massachusetts, 1974.

Hare, Van Court, Jr. Systems Analysis: A Diagnostic Approach. New York: Harcourt, Brace & World, Inc., 1967.

Harmon, H. Modern Factor Analysis. 2nd ed. Chicago: University of Chicago Press, 1967.

Henderson, James M., and Quandt, Richard E. Microeconomic Theory. 2nd ed. New York: McGraw-Hill, 1971.

Hershman, Arlene. "A Mess in MIS?" In Computers and Management. Edited by Donald Sanders. New York: McGraw-Hill, 1970.

Hoffman, L.R. "Homogeneity of Group Members' Personality and Its Effect on Group Problem Solving." Journal of Abnormal and Social Psychology 58 (January 1959): 27-32.

________, and Maier, N.R.F. "Quality and Acceptance of Problem Solution by Members of Homogeneous and Heterogeneous Groups." Journal of Abnormal and Social Psychology 62 (September 1961): 401-407.

Huber, George P. "Multi-Attribute Utility Models," Management Science 20 (June 1974): 1393-1402.

Ijiri, Yuji; Jaedicke, Robert; and Knight, Kenneth. "The Effects of Accounting Alternatives on Management Decisions." In Information for Decision Making. Edited by Alfred Rappaport, Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1970.

Kelly, George A. The Psychology of Personal Constructs: A Theory of Personality. Vol. 1. New York: W.W. Norton, 1955.

Kerlinger, Fred N. Foundations of Behavioral Research. New York: Holt, Rinehart & Winston, Inc., 1964.

Kessel, Colin. "Effects of Group Pressure and Commitment on Conflict, Adaptability and Cognitive Change." In Human Judgment and Social Interaction. Edited by Leon Rappoport and David Summers. New York: Holt, Rinehart & Winston, Inc., 1973.

Krampf, Robert F., and Williams, J.D. "Multidimensional Scaling as a Research Tool: An Explanation and Application." Journal of Business Research 2 (April 1974): 157-175.

Kriebel, Charles H. "The Future MIS." In Computers and Management, 201-208. Edited by Donald Sanders. New York: McGraw-Hill, 1970.

Levy, L.H. and Dugan, R.D. "A Factorial Study of Personal Constructs." Journal of Consulting Psychology 20 (January-February, 1956): 53-57.

Lingoes, James C., and Guttman, Louis. "Nonmetric Factor Analysis: A Rank Reducing Alternative to Linear Factor Analysis." Multivariate Behavioral Research 14 (October 1967): 485-505.

Lunn, J.A. "Prospectives in Attitude Research: Methods and Applications." Journal of the Market Research Society 11 (July 1969): 201-213.

MacCrimmon, K.R. Improving the System Design and Evaluation Process by the Use of Trade-Off Information. Santa Monica, Calif.: RAND RM-5877DOT, 1969.

McDonald, Charles L. "An Empirical Examination of the Reliability of Published Predictions of Future Earnings." The Accounting Review 48 (July 1973): 502-510.

McKinsey and Company. "Unlocking the Computer's Profit Potential." The McKinsey Quarterly 7 (Fall 1968): 17-31.

Mancuso, James C., ed. Readings for a Cognitive Theory of Personality. New York: Holt, Rinehart & Winston, Inc., 1970.

March, James G., and Simon, H.A. Organizations. New York: John Wiley & Sons, 1958.

Mason, Richard D., and Mitroff, Ian F. "A Program for Research on Management Information Systems." Management Science 19 (January 1973): 475-485.

Mattessich, Richard. "The Incorporation and Reduction of Value Judgments in Systems." Management Science 21 (September 1974); 1-19.

Moch, Ted. "Learning Patterns, Decision Approach and Value of Information." Journal of Accounting Research 10 (Spring 1972): 123-153.

Montgomery, David B. "The Outlook for MIS." Journal of Advertising Research 13 (June 1973): 5-11.

Morton, M.S.S. Management Decision Systems. Boston: Division of Research, Harvard Business School, 1971.

Moskowitz, Herbert. "Managers as Partners in Business Decision Research." Academy of Management Journal 14 (September 1971): 317-325.

Newell, Allen, and Simon, H.A. "Simulation of Human Thought." In Computer Simulation of Human Behavior. Edited by John Dutton and William Starbuck. New York: John Wiley & Sons, 1971.

Osgood, C.E.; Suci, G.J.; and Tannenbaum, P.H. The Measurement of Meaning. Urbana, Ill.: University of Illinois Press, 1957.

Prakash, Prem, and Rappaport, Alfred. "Informational Interdependencies: A Perspective for Accounting." Evanston, Ill., 1974. (mimeographed).

Puglisi, D.J.; Poretta, R.L.; and Haas, K.C. "A Decision Making Model for Resource Allocation in the Criminal Justice System." Proceedings of the 4th Annual Meeting of the Southeastern American Institute of Decision Sciences. Atlanta: n.p., 1974.

Raven, B.H., and Rietsma, J. "The Effects of Varied Clarity of Group Goal and Group Path Upon the Individual and His Relationship to His Group." Human Relations 10 (1957) 29-45.

Sampson, Peter. "Using the Repertory Grid Test." Journal of Marketing Research 9 (February 1972): 78-81.

Schewe, C.D.; Wiek, J.L.; and Dann, R. "Advancing Marketing Information Systems: An Empirical Investigation of System Usage Problems." Proceedings of the Sixth Annual American Institute of Decision Sciences. Atlanta: n.p., 1974.

Shaw, M.E. "Some Effects of Problem-Solving Complexity Upon Problem Solution Efficiency in Different Communication Sets." Journal of Experimental Psychology 48 (September 1954): 211-217.

________. "Communication Networks." In Advances in Experimental Social Psychology. Edited by L. Berkowitz. New York: Academic Press, 1964.

Simon, H.A. "A Behavioral Model of Rational Choice." Quarterly Journal of Economics 69 (February 1955): 99-118.

________. "Theories of Decision-Making in Economics and Behavioral Science." American Economic Review 49 (June 1959): 253-283.

________; Cyert, R M.; and Trow, D.B. "Observation of a Business Decision." Journal of Business 29 (October 1956): 237-248.

Slovic, Paul, and Lichtenstein, Sarah. "Comparison of Bayesian and Regression Approaches to the Study of Information Processing in Judgment." In Human Judgment and Social Interaction. Edited by Leon Rappoport and David Summers New York: Holt, Rinehart & Winston, Inc., 1973.

Smith, R., and Greenlaw, P.S. "Simulation of a Psychological Decision Process." Management Science 13 (April 1967): 409-419.

Study Group on the Objectives of Financial Statements. Objectives of Financial Statements. New York: AICPA, 1973.

Swanson, E. Burton. "Management Information Systems: Appreciation and Involvement." Management Science 21 (October 1974): 178-188.

Tryon, B.C., and Bailey, D.C. Cluster Analysis. New York: McGraw-Hill, 1970.

Van Horn, R.L. "Empirical Studies of Management Information Systems." Data Base 5 (Winter 1973): 172-180.

Von Neumann, John, and Morgenstern, Oscar. Theory of Games and Economic Behavior. Princeton, N.J.: Princeton University Press, 1947.

Watson, David. "Students as Subjects in Behavioral Business Research: Some Comments." The Accounting Review 49 (July 1974): 534-537.

Wilcox, Jarrod W. "Market Participant Cognitive Maps for Individual Common Stocks." Ph.D. dissertation, MIT, 1970.

________. A Method for Measuring Decision Assumptions. Cambridge, Mass.: MIT Press, 1972.

Young, F.W., and Torgerson, W.S. "TORSCA, A FORTRAN IV Program for Shepard-Kruskal Multidimensional Scaling Analysis." Behavioral Science 12 (November 1967): 498-503.