INDIVIDUAL DIFFERENCES IN MANAGERIAL DECISION MAKING PROCESSES:

A STUDY OF CONVERSATIONAL COMPUTER SYSTEM USAGE

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Individual Differences in Managerial Decision Making Processes:
A Study of Conversational Computer System Usage

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ABSTRACT

This dissertation seeks to contribute to a theory of individual problem solving processes relevant to understanding the use of Conversational Computer Systems (CCS's) in unstructured tasks. Such a theory is, in turn, seen as a building block in efforts to develop a theory to guide the design and implementation of Decision Support Systems for unstructured tasks.

With this more general objective in mind, the thesis explores the following hypothesis concerning differences in managerial decision making processes in unstructured tasks:

Hypothesis: The Level-of-Information-Processing evident in the decision making processes of managers is positively related to the Integrative Complexity of the manager's relevant conceptual system.

The constructs Level-of-Information-Processing and Integrative Complexity are taken from Complexity Theory which is the main theoretical framework for the study. The components of Level-of-Information-Processing considered are mainly characteristics of the managers use of information: breadth in information source use, volume of information use, and balance in information source use. Integrative Complexity is mainly a function of the number and organization of higher level rules that exist in the relevant conceptual system.

The setting for the research is the Trust department of a large bank where the study focuses on the investment decision making processes of 28 portfolio managers. The managers are supported in their portfolio composition decisions by a recently installed advanced Conversational Computer System (CCS) with graphical display capabilities.

Based on a simple model of the investment task, it was hypothesized that the Integrative Complexity of portfolio and information source perception is positively related to the Level-of-Information-Processing in the investment task. Level-of-Information-Processing is defined within three distinct sets of information sources: personal sources, impersonal sources, and within the latter, the CCS where each function on the system is considered a source of information.
The Role Construct Repertory Interview is used to sample the relevant conceptual systems. There is little evidence of convergent validity in the measurement of Integrative Complexity based on an analysis of four measures of Integrative Complexity and measures of three related characteristics of conceptual systems. Two measures of Integrative Complexity were, however, retained as possibly capturing the construct of interest.

Measures of information source use are based on a system log covering a two month period for the use of the CCS and a sample of three days within the same period for the use of personal and impersonal sources of information. The data suggest that Level-of-Information-Processing does not correlate across all the three sets of information sources considered.

Stringent hypothesis testing is not performed due to the lack of convergent validity in the measures of Integrative Complexity. Rather, the hypothesis is explored at the level of patterns of relationships. There is limited support for the hypothesis in terms of use of personal and impersonal sources. In contrast, there is no support in terms of the use of the CCS.

Insights gained in exploring the unexpected finding about the CCS strengthen the positive findings. It is proposed that the investment process is individual security-oriented, not portfolio-oriented. Data are presented to support this view. The CCS is portfolio-oriented and is used in a structured part of the portfolio manager's task. Task characteristics therefore dominate the use of system functions by the manager.

Two partial explanations of why the managers' decision making process has not changed are proposed. One is specific to the research setting and deals with the nature of the CCS data base. The other is low manager cognizance of the characteristics of the different sources of information available. The managers appear to find it difficult to integrate the data provided by the different sources and to develop new procedures and strategies that take advantage of changes in information processing technology.

The implications of the findings for the development and use of Decision Support Systems relate to the issue of limited managerial capacity for the change required to make use of new information processing technology and to strategies that increase managers' inherent capacity for change and reduce the load on the managers of a desired change.

The implications of the study for further research both on Complexity Theory and Decision Support Systems are reviewed.

Thesis Supervisor: Michael S. Scott Morton
Title: Associate Professor of Management
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Chapter 1: Introduction

Understanding Managerial Use of Information in Unstructured Tasks.

This dissertation is concerned with managerial decision making processes in unstructured or unprogrammable tasks. The research attempts to identify and understand individual differences in how managers utilize information and knowledge in their decision making processes. The primary focus is on how managers use information available on Conversational Computer Systems designed to support their decision making activity. The study explores these issues on the basis of data collected in a field setting where the managers in question had access to an advanced Conversational Computer System.

Why this concern for new management information processing technology and decision making processes in unstructured tasks? The underlying rationale for the research is the belief that new information processing technology, such as Conversational Computer Systems, might increase the effective cognitive capacity of the manager or administrator. Limited cognitive capacity is seen as the cause of the bounded rationality in the present decision making processes of managers (Simon, 1957, pp. 198-199). Any increase in the effective capacity a manager can bring to bear on his task is therefore believed to extend the limits of this bounded rationality -- leading to less satisficing, less uncertainty avoidance, more global search, and, in turn, better decisions.

The step from having a general technological base with a potential for increasing the effective cognitive capacity of managers to the delivery
of such an increase is neither simple nor evident. This seems particularly true for situations involving unstructured tasks where the limitation of the human problem solver is most apparent and where the potential return of any increase of capacity is therefore seen as great. The limited number of systems available, and the apparent limited use of those in existence, suggests that managers and management, at least, have not yet been convinced of the ability to deliver useful and economical systems. In part this reflects the novelty and the early stage of the development of Conversational Computer Systems for managerial applications. The focus of this study is based on a view that it also reflects a lack of understanding of managerial decision making in unstructured tasks. This lack of relevant knowledge, in turn, constrains our ability to design and implement effective systems, and makes it difficult to know what one looks like, even when we see it. The concern for a better understanding of managerial decision making in this study is therefore clearly imbedded within the more overall objective of defining the potential and limitations of Conversational Computer Systems in order to use this knowledge to develop design and implementation strategies for such systems.

Restated from a different perspective, this study is based on a belief that in order to change the world, one first has to understand it; to change and improve managerial decision making processes in unstructured tasks there is a need for a better understanding, at a level somewhat less abstract than the notion of limited cognitive capacity, of the factors that shape and constrain these processes. In terms of what aspect of managerial decision making that needs to be understood, a focus on understanding managerial use of information reflects a concern for the potential of new infor-
mation processing technology.

Exploring these issues in a managerial setting which includes an operational Conversational Computer System is valuable as it ensures that the data and findings are relevant to this class of information processing technology. Furthermore, a Conversational Computer System has an inherent property that gives a new dimension to the study and analysis of managerial decision making processes; the system can be a source of unobstructive measures on its own use.

The specific purpose of the study is to see if characteristics of the individual manager, in other words, dispositional or personality factors, can identify and explain important differences in managerial use of information in unstructured tasks. The dissertation explores a hypothesis concerning individual differences within a theoretical framework that suggests that at intermediate levels of task complexity, individual differences are an important determinant of managerial use of information and the bounded rationality evident in the decision making process.

A brief review of other relevant research efforts is a good way to elaborate somewhat on the nature of this study and put it in perspective. This study represents an attempt in the same vein as the work of Wilensky (1967) on organizational intelligence or the work at the Center for Research on the Utilization of Scientific Knowledge, University of Michigan, (Michael, 1972). However, in contrast with Wilensky, who uses the organization as the unit of analysis and has looked at the relationship between organization structure and information utilization or information pathologies, the main unit of analysis in this study is the individual manager and it looks for personality determinants of information utilization and
decision making processes.

There are a number of other research efforts in progress that also are attempting to determine the relationship between personality characteristics, usually under the label cognitive style, and the use of new informative processing technology (McKenney, 1971, Sackman, 1972, Keen, 1972, Mason and Mitroff, 1973). A main contribution and distinction of this study in relation to these other efforts is the theoretical paradigm used. It represents an attempt to synthesize two distinct, main streams of research and thought. On the one hand, there is the work of the Carnegie School on organizational decision making processes (Simon, 1947, Cyert and March, 1964). On the other hand, there is the work of Schroder et al. (1967) in the area of a personality theory which has been labelled Complexity Theory.

Two aspects distinguish the theoretical framework of the study from the cognitive style paradigm. First, it is formally more comprehensive, integrating characteristics of the task and the decision maker in an attempt to explain and understand differences in problem solving and decision making processes. Secondly, closely linked to the first difference, it does not assume that an individual exhibits the same behavioral patterns over all tasks and situations. Rather, the issue is seen as empirical. Both differences reflect that the theory is more abstract, operating with constructs that are not all at the level of observables. An individual is not characterized as a thinker or a feeler (Mason and Mitroff, 1973). Rather the individual is seen as having a more or less integratively complex conceptual system, which then in turn is seen as the determinant of behavior, under certain conditions, that might be characterized along the
feeling versus thinking dimension.

Finally, this study can be seen as both a continuation and extension of the work of Scott Morton (1967) and Gerrity (1970) on the development and impact of Decision Support Systems or Man-Machine Decision Systems. Decision Support Systems is a label given to designate systems that are designed to be used by managers in unstructured tasks (Gorry and Scott Morton, 1971). The overriding concern of the study is similar to that of these authors: gaining a better understanding of managerial use of Decision Support Systems in order to design and implement more effective systems. The tie is not only conceptual, given that both studies were heavily oriented towards a Simonesque view of organizations and organizational decision making, but also through the research setting of this study (portfolio managers supported by an advanced Conversational Computer System) which is the direct result of Gerrity's work.

To summarize, the principal aim of the research is to make a contribution to the development of a theory of individual decision making processes which is relevant to understanding the use of advanced Conversational Computer Systems in unstructured tasks. Such a theory is, in turn, seen as a building block in efforts to develop a theory to guide the design and implementation of such systems for unstructured tasks. The specific focus of the study is to explore the importance of individual manager characteristics as a determinant of differences in decision making processes.

Outline of Study.

Some of the reasons for the choice of the specific research paradigm
used, Complexity Theory, are first presented in Chapter 2. In the second half of the chapter, the theory and relevant research are reviewed, with particular emphasis on those elements most pertinent to this investigation: individual differences in problem solving processes as a function of conceptual system structure.

A key characteristic of Complexity Theory is that it recognizes that properties of individual decision making behavior might vary across task or problem situations. In order to explore the hypotheses of the theory it is therefore necessary to map the theory into the concrete task studied. In Chapter 3 the specific research setting considered, portfolio management supported by an advanced Conversational Computer System, is described. The research hypotheses of the study are then formulated in Chapter 4.

Chapter 5 presents the measurement of the key independent variable in the study: conceptual system structure. The chapter reviews the problems encountered in the measurement process and the evidence for convergent validity of the measure of the key structural characteristic.

The measurement of process characteristics, the dependent variable of the study, is reviewed in Chapter 6. An analysis of reliability and of whether the construct is unitary, as assumed, is presented.

Given the problems encountered in the measurement of both dependent and independent variables, the analysis of the main hypothesis of the study in Chapter 7 is limited to examining overall patterns of relationship between components of the dependent and independent variables. In Chapter 8 some of the unexpected findings concerning the use of the Conversational Computer System available to the portfolio managers considered are explored. This analysis reveals some of the most important findings of
the study.

Finally, in Chapter 9 some of the major implications of the study and its findings, mostly qualitative and tentative, are explored. The discussion has been divided into issues relevant to the development and managerial use of Decision Support Systems and issues relevant to future research in the area.

The primary purpose of this chapter is to present the theoretical framework of this investigation, Complexity Theory. First, however, the chapter reviews in more detail the three interdependent issues that the study focuses on: decision making processes, unstructured tasks, and characteristics of the individual manager. The rationale for the choice of Complexity Theory as the paradigm within which to explore these three interdependent issues is then discussed, before the theory is reviewed in detail.

Unstructured Tasks, Characteristics of the Manager, and Decision Making Processes.

In this section the rationale for the decision to explore the importance of individual manager characteristics as a determinant of differences in decision making processes is presented. The choice of the individual manager as the unit of analysis reflects the close relationship between individual and technology inherent in the use of Conversational Computer Systems. The decision to focus on characteristics of the manager, however, is mainly linked to the concern for decision making in unstructured tasks. The discussion therefore begins with an elaboration of the notion of an unstructured or unprogrammable task (Simon, 1960, Soelberg, 1967, Gorry and Scott Morton, 1971).
A number of different paradigms, all relevant to the description and analysis of problem solving and information processing behavior, introduce the notion of degree of structure in a task or problem. One such paradigm views problem solving as a search process through a problem space (Newell and Simon, 1972). The degree of structure is determined by the ease of generating relevant alternative paths through the problem space and by the ease of evaluating these alternative paths as a solution to the problem in question. An extremely ill-structured problem is one where, in addition, there is uncertainty about what is the relevant problem space -- what Newell and Simon call a case where the problem space is not closed (1972, pp. 819-820).

Task predictability is another fashion of looking at the degree of structure in a task. In an unpredictable task it is difficult to predict the consequences of actions one takes. In other words, in the unpredictable task it is difficult to follow through the chain of events from actions to later events and outcomes. For a more organizationally relevant notion of the degree of structure in a task, we can therefore borrow Galbraith's definition of the determinants of task predictability: number of variables that need to be considered, uncertainty, and interdependence between variables (Galbraith, 1969). The more unstructured task has a greater number of variables, a greater uncertainty attached to the estimates of the variables, and a greater interdependency among relevant variables.
A final dimension can be added to the notion of task predictability in Galbraith's model, which is what Steinbruner labels epistemic uncertainty (1968, p. 223): uncertainty about which variables are relevant in the task. It is a concept similar to the distinction between an open and a closed problem space in Newell and Simon's model.

Examples of unstructured tasks are portfolio management, mergers and acquisitions, and new product development in the private sector; examples from the public sector are formulation of social programs, determination of monetary and fiscal policies, and international negotiations. In the case of the task of the generic portfolio manager, the large number of variables that might be relevant and a high degree of uncertainty attached to estimates of critical parameters, is enough to make the task quite unstructured. The portfolio manager deals with two primary classes of variables attached to portfolios and to assets respectively. The manager might be responsible for a large number of portfolios, each containing a large number of different assets. To each portfolio there is attached both variables directly relevant to the assets that it contains, and variables dealing with the characteristics and the objectives of the client for whom the portfolio manager is managing the account. To each asset there are a number of relevant characteristics, some dealing with future and uncertain estimates of asset performance. Finally, although the concept of a portfolio explicitly recognizes the interrelationship between asset characteristics, the exact nature of the interdependence is uncertain.

A key aspect of an unstructured task is that there is room for a large
amount of problem finding activity (Pounds, 1969). This is activity that can be considered as an effort to close the problem space or as an effort to reduce the epistemic uncertainty in the task. In an unstructured task, the individual is not presented with a well defined problem, but rather must define the problem(s) himself on the basis of vague and non-operational overall objectives. The situation is similar to that where Simon suggests that the individual must "...fall back on whatever general capacity it (the individual) has for intelligent, adaptive, problem-oriented action..." (1965, pp. 59-60). In other words, the behavior of the manager might be much more a function of a characteristic of the manager, captured by the notion of a general capacity in Simon's statement, and less a function of the content characteristics of the task which Newell and Simon propose dominate human problem solving behavior in structured tasks (1972, pp. 788-790). This general line of reasoning led to the focus on the potential importance of characteristics of the individual manager.

This study is concerned with managerial decision making and it might seem that organizational variables are equally or more important determinants of process characteristics. However, given the unstructured nature of the task, almost by definition supervisory control is diffuse and limited, and specialization is difficult. An unstructured task, in the terms of Role Theory (Kahn et al, 1964), has inherently quite a lot of role ambiguity. The effect of standard organizational variables on, for example, use of a Conversational Computer System might therefore be quite limited. As noted by Greenstein, "...ambiguous situations leave room for
personal variability to manifest itself..." (1969, p. 50).

The focus on variables that are primarily the characteristics of the individual decision maker is supported by Whisler (1970). In the development of what fashionably could be labelled a contingency theory of the impact of new information processing technology, he suggests that in unstructured tasks, such as research and development or marketing:

"...there is little specialization, the basic task is problem definition, and the organization tends to be "loose" with only modest control devices and arrangements. The time press is not as stringent as in the specialized department; jobs are larger and consist of many bundles of skills. The impact of the computer is quite different. It will be an adjunct to an individual rather than part of the organizational structure..." (1970, p. 52).

The focus of this study is on managerial use of information and, in general, on the dimensions of the bounded rationality evident in managerial decision making processes; outcome or process output characteristics are not considered. This choice of focus obviously reflects a concern for understanding what factors affect managerial use of Conversational Computer Systems. However, it also reflects a belief that this is the feasible and desirable focus for a study of managers in unstructured tasks. In unstructured tasks, both practitioners and researcher are faced with the problem of determining what are the consequences of any action or decision in terms of the goals and objectives of the task. Given the basic uncertainty about what are all the relevant variables, it is, in the language of scientific experiments, difficult to perform controlled experiments. The time lag between decision and relevant outcome is usually long. In portfolio management it can involve a time span of several years. Under such conditions, attempts to monitor decision making in outcome terms only will not
provide much knowledge or feedback, as it is difficult to determine and separate out all relevant factors. Rather, monitoring and understanding decision making should consider the mediating variable of how decisions are made; in other words, the decision making process. The yardstick against which the process can be compared is normative, task specific models and, at the level of this study, general notions of rational decision making. As noted in the introductory chapter, the fundamental concern of this study is precisely the potential use of Conversational Computer Systems to extend the limits of the bounded rationality in managerial decision making processes.

To summarize, from a focus on unstructured tasks flows the concern in this study both for managerial decision making processes and the possible importance of individual manager characteristics as a key determinant of individual differences in these processes.

Choice of Paradigm.

There are a number of different ways of looking at the individual manager and his decision making behavior. Given a concern for the use and impact of new information processing technology, it seems natural to choose a paradigm for the analysis of individual characteristics and behavior that is particularly relevant to information processing behavior. The view of the individual problem solver and decision maker as an information processing organism (Newell & Simon, 1972, Reitman, 1965, Schroder et al., 1967, Simon, 1960) addresses directly the issues relating decision making
behavior to information use. In a sense, the focus on individuals as problem solving and decision making entities implies a paradigm with the individual as an information processing organism.

With the choice of an information processing based paradigm there still remains the issue of what constructs, or level of abstraction, one should choose in the description and analysis of the problem solving processes. This choice must consider the ability of the constructs or theoretical language to describe important individual differences in processes, this without becoming completely bogged down in detail and without using a task specific representation.

Simon's Intelligence, Design, and Choice model of the decision making process (1960) has been used successfully in some of the initial studies of the impact of Conversational Computer Systems (Scott Morton, 1967, Hedberg, 1970). However, it is a model that emphasizes the similarities in problem solving processes across individuals. It therefore does not seem as an appropriate base for research concerned with the importance of individual differences

On the other hand, Newell and Simon or Artificial Intelligence-like models (Newell & Simon, 1972), which generate what Bettman calls idiosyncratic models of the individual problem solver and his behavior (Bettman, 1972), are based on a detailed representation of the individual's problem space. Newell and Simon call it a content-oriented theory (1972, pp. 9-13). It is highly task dependent (e.g., see Clarkson's model [1960]). Although it might be fruitful to follow Bettman's suggestion for categorizing such models in a task independent fashion (Bettman, 1971), the problem of detail or size remains tremendous in unstructured tasks. Even more important, the
view that the problem space is not closed or bounded in unstructured tasks
suggests that such a model ignores a critical dimension of the task.

From this discussion, it would seem that there is a need for a
theoretical framework with constructs that deal with problem solving
processes at a level of abstraction intermediate between the Artificial
Intelligence models and the Intelligence, Design, and Choice model.
Schroder, Driver and Streufert's Complexity Theory (Schroder et al., 1967)
furnish such a framework. The theory relates characteristics of the whole
of an individual's conceptual system (equivalent to the whole of Newell
& Simon's notion of the internal problem space representation), it's
Integrative Complexity, to general characteristics of the problem solving
and decision making process of the individual, such as number of information
sources used, number of alternatives considered, and number of integrations
performed over problem situations. Of equal importance is the contingent
nature of the theory. The behavior that results from structural pro-
perties of the individual's concepts is viewed as being dependent on
structural properties of the task, it's complexity (where task complexity
is a notion similar to the previously discussed notion of task structure).

Complexity Theory, therefore, focuses on information processing
behavior as it varies both between individuals within a specific task, and
for an individual between tasks. The applicability of such a theory to
the research issues of interest here is obvious. It allows the use and
impact of a Conversational Computer System to be analyzed relatively
independently of the specific task considered, as the constructs of the
theory are not expressed in task specific or content terms. Furthermore,
the theory characterizes the information processing behavior in terms that
directly refer to the use of different sources of information. At the same time, this pattern of information use is connected to characteristics that capture some of the dimensions of bounded rationality in decision making. Finally, given that the theory integrates characteristics of the task and environment within which the decision maker operates with characteristics of the individual, it represents a framework for broader research issues than those explored in this specific study. Having the study embedded within a larger framework that can generate, for example, interesting hypotheses concerning longitudinal shifts in managerial decision making processes resulting from the introduction of new information processing technology, would seemingly increase the value of a detailed investigation of a specific hypothesis derived from the paradigm.

To summarize, the considerations mentioned above suggested that Complexity Theory was an interesting and useful theoretical framework and led to its use in this study. The more detailed review of the theory in the section that follows will help to make the logic of this choice more apparent.

Complexity Theory.

The basic underlying paradigm of Complexity Theory (or Conceptual Systems Theory [Karlins, 1967]) is the view of individuals interacting with their environment as active information processing systems. Furthermore, the theory emphasizes "cognitive structuring as the important organismic variable in behavior analysis" (Karlins, 1967). Cognitive structuring is seen as the way a person combines information -- as a
characteristic of the whole conceptual system of the individual. This concern for structural variables is contrasted with a concern for content variables such as "the acquisition, direction, and magnitude of responses, attitudes, norms, needs, and so on ..." (Schroder et al., 1967, p.4).

Within Complexity Theory there are two central ideas plus one consequent notion that are important to understand within the context of this study. These are (1) the distinction between concrete and abstract structures and (2) the notion of the interdependence between environmental complexity and information processing behavior. Following from (1) and (2), is (3) the notion of domain specificity. First a look at the concrete-abstract distinction.

Abstract versus Concrete Structures.

Let us review a simple model of a conceptual system in order to facilitate the understanding of the term "structure" of a conceptual

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Figure 2.1 Two Conceptual Systems.
system. In the simple model, conceptual systems are built up of two main components: 1) dimensions or attributes of objects; 2) rules for transforming or combining dimensions, or other rules. Figure 2.1 shows two conceptual systems with different structures (Schroder et al., 1967, pp. 15-22). Note that there is a strong analogy between the notion of the structure of a conceptual system and the notion of the structure of an organization.

Now we can discuss the distinction between concrete and abstract structures. Concrete structures are simple structures (Figure 2.1 A), while abstract structures are higher level or complex structures (Figure 2.1 B). The level of a structure, or the integration index, is mainly determined by two interdependent aspects: the parts or dimensions; the integrating rules. The higher level or more abstract structures, primarily a function of the number and nature of the integrating rules, are the more integratively complex structures:

Low integration index is roughly synonymous with a hierarchical form of integration, in which rules or programs are fixed. Schemata for organizing alternate sets of rules are not present... High integration index structures have more connections between rules; that is, they have more schemata for forming new hierarchies, which are generated as alternate perceptions or further rules for comparing outcomes. High integration structures contain more degrees of freedom (Schroder et al., 1967, p.7).

From another point of view, using terms developed in Artificial Intelligence, simple or concrete conceptual systems have a hierarchical structure while complex or abstract conceptual systems have a more heterarchical structure (Minsky & Papert, 1972).
Finally, a third perspective on the distinction between concrete and abstract structures using a model that is more formal and explicit, but that does not capture the notion of rules or programs as elements of conceptual systems. Scott (1969) proposes a model where images or concepts of objects are represented as points in a multidimensional space composed of the different attributes of the conceptual system. Figure 2.2 presents an example of such a model, where A1, A2, and A3 are the attributes or dimensions of the conceptual system, and O1, O2, and O3 are the image of three objects relevant to the system.

![Figure 2.2](image)

**Figure 2.2** A two dimensional representation of a three dimensional conceptual space.

For our purposes, the interesting properties of a conceptual system within this model are the dimensionality, the articulation, and the centrality of the system and its component attributes. Dimensionality is a notion similar to differentiation and is the number of dimensions or attributes in the space. In the example of Figure 2.2, the dimensionality is three. Articulation of an attribute is defined as the number of reliable distinctions among objects that are made on an attribute. For attribute A1 in Figure 2.2 the articulation is two, as the attribute
is dichotomous or is capable of differentiating objects into one of two categories. Centrality is a function of the proportion of images that have explicit projections on an attribute; in other words, the number of objects that the attribute is seen as relevant to. Attribute A2 has a higher centrality than either attribute A1 or A3 in Figure 2.2. Within this model of a conceptual system, a more abstract conceptual system has greater dimensionality, has a greater articulation of the attributes, and does not have a wide disparity in the centrality of the different attributes.

In summary, the distinction between concrete and abstract structures is both a function of the nature and the interrelationship of the different components of a conceptual system. In terms of Complexity Theory, the central determinant of the process characteristics of interest is the nature and interrelationship of higher order rules or programs, the Integrative Complexity of the conceptual system. However, this characteristic is clearly related to the other structural characteristics such as the dimensionality, the centrality, and the articulation of the system, although the nature of this relationship is vague. It is primarily these latter related, but less abstract characteristics of conceptual systems that are well defined. Integrative Complexity is defined mainly in terms of behavioral consequences, and not in terms of a formal, explicit model of a conceptual system.
Resultant Process Differences.

In terms of impact on the problem solving processes, the single most important consequence of increasing integrative complexity in a conceptual system is the increasing ability and tendency to generate alternate interpretations of given stimuli. From this hypothesis Complexity Theory postulates that the more integratively complex individual will perceive more uncertainty and ambiguity in his environment and will, therefore, seek more information from the environment to resolve this uncertainty. Furthermore, there will be a tendency to link the information from a wide number of information sources as the individual is able to generate perspectives that can integrate such a diversity of information. Thus, the integratively complex individual is not only seen as using more information, but also taking this information from a number of different sources and sampling information more evenly from these sources (Karlins, 1967, pp. 268 - 270). This characteristic of the problem solving process -- use of information -- is one element of what Schroder et al. term the Level-of-Information-Processing. Another aspect of Level-of-Information-Processing is the number of integrations of knowledge gained across problem situations. An integration is defined operationally as the integration of feedback from an action or decision in a subsequent decision (Schroder et al., 1967, p.116); it's relation to integrative complexity stems from the view that the concrete or integratively simple individual tends to compartmentalize his environment, experiencing each new situation as unique. The concrete individual is therefore hypothesized to be less cognizant of the relevance of past experience in problem situations.
On another dimension the integratively simple person is seen as having a greater tendency to anchor his behavior in external conditions. He looks to his environment for the rules to guide his behavior. The integratively more complex individual, on the other hand, is seen as relying more on internal generation of conditions and rules. This internal-external distinction can be seen as similar to a distinction between a problem-guided decision making process and an opportunity-guided process. The individual who anchors his behavior in external conditions can be seen as letting the external environment define the problems he should deal with. On the other hand, the individual who anchors his behavior in internal processing might be more likely to initiate behavior that results from his determination of an opportunity in the environment.

Finally, although Schroder et al. do not test this directly in their work, a parallel dimension to the external-internal distinction should be the number of alternatives considered in a decision making process. The theory suggests that the more integratively complex, the more alternatives considered.

The hypothesized relationship between degree of integrative complexity and the different components of Level-of-Information-Processing has been shown in a number of studies (for a review, see Schroder et al, 1967, Karlins, 1967, Schroder and Suedfeld, 1971). To the knowledge of this investigator, however, all the studies involved experimental tasks and did not deal with the problem solving behavior of individuals in a natural task environment. A good example of the kind of study performed and one that is of particular interest in this study, is Karlins research (1967). It
is therefore briefly reviewed in what follows.

The purpose of Karlins study was not limited to testing hypotheses about Complexity Theory, but was also an attempt to compare the theory with another "...theory of creativity relevant to the study of complex human problem solving..." (Karlins, 1967, p. 264): Mednick's theory (1962) of remote associative proficiency. Of particular relevance here, however, is the methods used to categorize and capture the behavior of interest. The investigation presented subjects with an experimental task involving a complex inductive interpersonal problem -- the Community Development Exercise. Through information search the subject was expected to learn about an unfamiliar South Seas Island culture -- asking enough questions about the island and its inhabitants to find the best possible way to get native approval and cooperation in building a needed hospital. In order to solve the problem, the subjects were presented an information base organized into 57 fixed categories of card decks. Each deck contained between 10 and 30 pieces of information. Each information element was, in turn, expressed in a sentence between 40 and 65 characters long.

The basic measures of behavior involved how the subject sampled the information base available. One measure was breadth of search, in other words, the number of different card decks sampled in the course of the problem solving session. Another measure used was evenness and breadth in search based on the uncertainty measure H -- a measure designed to capture how evenly the subjects sampled the different card decks. Both measures were hypothesized and found to have a positive relation to the Integrative Complexity of the subjects.
To summarize the discussion so far, Complexity Theory proposes a link between a characteristic of the structure of an individual's conceptual system, the degree of integrative complexity, and characteristics of the individual's problem solving processes that have been labelled Level-of-Information-Processing. Some of the components of Level-of-Information-Processing, such as volume, breadth, and evenness of information source use deal directly with the individual's sampling of his information environment. The other components, such as number of integrations over problem situations, number of alternatives considered, and degree of opportunity guided decision making deal with more complex aspects of the individual's problem solving and decision making process.

Environmental Complexity.

An important characteristic of Karlin's study reviewed above is that it was looking at the relation between Integrative Complexity and Level-of-Information-Processing within a specific task. Complexity Theory, however, has an added dimension that suggests that differences in Level-of-Information-Processing are not only a function of differences in the Integrative Complexity of individuals. The theory hypothesizes that environmental complexity, a notion similar to the concept of task structure, is a determinant of process differences. Specifically, it is proposed that there is an inverted U relationship between environmental complexity and Level-of-Information-Processing (Schroder et al., 1967, pp. 29-41). With either low or high environmental complexity, Level-of-Information-Processing is hypothesized to be relatively low and
the differences between individuals differing in Integrative Complexity is small. The highest Level-of-Information-Processing, and the largest individual differences are hypothesized to be apparent at an intermediate level of environmental complexity. Simply stated, this hypothesis rests on the view that at the low end of environmental complexity, there are few possible alternate interpretations of the relevant stimuli -- the specific task in question dominates behavior. For the high end of environmental complexity, on the other hand, the individual is overwhelmed by the complexity of the task.

In short, Complexity Theory suggests that variations in Level-of-Information-Processing are both a function of characteristics of the individual and characteristics of the task in question. This brings us to the third point concerning Complexity Theory which deals with whether the relevant characteristic of the individual, Integrative Complexity, is a global property of all his conceptual systems, or rather a local property that varies across the conceptual systems relevant to specific tasks. This is the issue of domain specificity.

Domain Specificity.

From the point of view of Complexity Theory, the issue of whether the concrete-abstract distinction might vary across tasks or conceptual domains is empirical and not theoretical. The theory, in other words, does not preclude that, for example, a scientist might have a very integra-
tively complex structure relevant to his scientific speciality, while he may have an integratively simple structure relevant to his dealing with his children. That Integrative Complexity might be a domain specific characteristic is indicated by findings that a number of common measures of conceptual system structure from different domains do not correlate (Vannoy, 1965, Scott, 1969, Riesing, 1972).

However, the issue of cognitive domain has not been addressed explicitly in much of the research done in Complexity Theory. As far as is known, except for a limited number of studies (such as Karlins, 1967), most of the research has measured the Integrative Complexity of one domain and attempted to relate this measure to characteristics of information processing behavior in another domain. An example of this is Sieber and Lanzetta's study (1964) where they relate performance in a figure recognition task with Integrative Complexity measured using the Sentence Completion Test. The Sentence Completion Test can be considered mainly an instrument relevant to "interpersonal behavior in social and group task oriented activities" (Schroder et al., 1967, p.190).

What is lacking is an explicit model of the task being studied. Such a model would enable one to define more clearly which conceptual system(s) should be used to measure the relevant Integrative Complexity and which information processing behavior one should attempt to relate to this measure of Integrative Complexity. Stated somewhat differently, a model of the task used to investigate hypotheses from Complexity Theory enables one to map the more abstract theory into the concrete setting in question.
The recognition of possible cognitive domain specific characteristics of individual problem solving and decision making behavior is one central difference between Complexity Theory and a number of other theories or paradigms of human problem solving behavior. In particular, the position that the generalizable nature of certain behavioral patterns is an empirical issue rather than an issue not recognized by the paradigm and therefore a theoretical issue separates Complexity Theory from most cognitive style paradigms. In part this implies that Complexity Theory is a more abstract theory with constructs not only dealing with observables.

Summary.

1. Complexity Theory has been proposed as a paradigm that both deals with aspects of individual decision making behavior that seem particularly relevant to studying the use and impact of Conversational Computer Systems and as a basis for understanding individual differences along these dimensions.

2. Complexity Theory suggests that certain differences in problem solving process characteristics, or Level-of-Information-Processing are due to differences in the Integrative Complexity of the individual problem solvers relevant conceptual system and the complexity of the environment in which he is operating. Level-of-Information-Processing covers a number of aspects of the individual's problem solving processes, such as breadth in information source use, evenness in source use, number of alternatives considered, and number of integrations performed over problem situations.
Integrative Complexity is mainly a function of the number and organization of higher level rules in a conceptual system.

3. The theory implies that the extent to which the problem solving behavior of an individual has the same pattern over a number of tasks and environments dealing with different objects and content is an empirical issue. It was suggested here that a model of the task investigated is required to map the more abstract constructs of the theory into operational measures for a specific research setting. In the next chapter, the concrete setting of this study is reviewed in order to develop such a model of the task investigated.

The primary purpose of this chapter is to set the stage for an operationalization of Complexity Theory in task specific terms by presenting the research setting of the study. The operationalization, together with the specific research hypotheses of this study, are developed in chapter 4.

The chapter is organized as follows. First a general overview of the organizational setting of the study, the Trust department of a large bank, is presented. In the second half of the chapter, the different dimensions of the task of the portfolio managers are reviewed and the particular sub-task which this investigation focuses on is identified.

Organizational Setting.

The setting for the study is the Trust Department of a large Midwestern bank (see Gerrity, 1970, and Landau, 1972, for another perspective on the same research setting). As of the early 1970's the market value of the more than 3,000 accounts for which the bank had investment responsibility totalled approximately $6.2 billion. The primary responsibility for the management of these accounts rests with a group of approximately thirty portfolio managers, the managers with which this study is concerned.

The portfolio managers are organized into three main product groups that reflect the nature of the accounts they manage. Of the total $6.2 billion assets managed, $4 billion were in the Retirement and Endowment Group as pension, profit sharing, and endowment funds. This group had nine
portfolio managers. Of the remaining $2.2 billion, $1.8 billion were in personal trust funds and in probate funds, managed by fourteen portfolio managers that comprised the Personal Trust Group. The Investment Advisory Group, responsible for the remaining $400 million in investment advisory accounts consists of seven portfolio managers.

From this brief review it follows that the managers in the different product groups are responsible for somewhat different mixes or portfolios of accounts. Table 3.1 presents some more detailed statistics concerning the load on the average manager in the Trust Department as a whole, and how these figures look for the average portfolio manager in each product group.

<table>
<thead>
<tr>
<th>Product Groups</th>
<th>Trust Department</th>
<th>Personal Trust</th>
<th>Investment Advisory</th>
<th>Retirement &amp; Endowment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Accounts per manager</td>
<td>145</td>
<td>242</td>
<td>107</td>
<td>41</td>
</tr>
<tr>
<td>Total $ Value of Accounts per manager (in $ mil.)</td>
<td>177</td>
<td>156</td>
<td>78</td>
<td>281</td>
</tr>
</tbody>
</table>

The most distinctive feature of these figures is that the Personal Trust portfolio manager is responsible for a large number of relatively small accounts, while his counterpart in Retirement and Endowment manages a relatively small number of large accounts. What these figures do now show is that the Investment Advisory accounts are discretionary and aggressive, the Retirement and Endowment accounts are discretionary and very performance sensitive, while there is less discretion combined with more prudent objectives for Personal Trust accounts.
The portfolio managers of the Trust department represent a professional and well educated group of managers. All of the twenty-two managers presently in the department for which data are available have an undergraduate degree. Most have degrees in finance, business, accounting, or economics. There are two managers with an engineering background and one with an AB in mathematics. Twelve of the twenty-two managers have graduate degrees, eleven of them MBA's.

The average age of the portfolio managers is 35, where on the average they entered the bank at the age of 27 and became portfolio managers three years later. Most of the managers spent part of their training period in the bank working as analysts in the Investment Research department that the Trust department maintains as part of the functions that support the portfolio managers in the management of accounts.

The entry of the Trust department into the pension, profit sharing and retirement fund business is a rather recent event. Twenty years ago the Trust business was very much in the image of the Prudent Man rule, managing trust funds where preservation of capital rather than total return was the primary objective. The industry was not very competitive. This has now changed with the entry into the pension and retirement fund business. Competition comes no longer from other trust departments, but from the investment and asset management industry in general. The competitive environment, together with the bear markets of recent years, has led to strong pressures on the Trust department. One effect of such a turbulent and competitive environment has been constant re-organizations in the Trust department.
Another result of competitive pressures, although somewhat less direct, was the design and implementation of an advanced Conversational Computer System to support the portfolio managers in the Trust department. The existence of this system, available to individual portfolio managers, was the reason for the choice of both portfolio management and this specific Trust department as a setting to study managerial decision making. Obviously the choice of the specific setting reflects equally the willingness of both manager and management to make such a research effort possible.

The Conversational Computer System available to the portfolio managers, designated the Portfolio Composition System, will be presented in more detail in the context of the other support functions available to the portfolio managers. This description is partly taken from Gerrity (1970, pp. 207 - 209). Figure 3.1 presents the entities that interface with or support the portfolio manager. The most important entities of the figure are described below:

1. Investment Research is the "intelligence" function of the department. It consists primarily of security analysts who are responsible for monitoring, adding, or deleting securities from the approximately 350 common stocks making up the Common Stock List. Common Stock List securities are authorized for investment by the portfolio manager -- this is his "universe" of investment opportunities. Another list maintained by the analysts is the Stock Recommendation List which is a subset of the securities on the Common Stock List that the analyst proposes are currently attractive trades. In other words, the Stock Recommendation List is a more volatile list than the Common Stock List.
Figure 3.1 The Portfolio Management Environment
The analysts supply the managers with a vast amount of background information that relates to the stocks on the Common Stock List. This includes Industry Reviews, Company Reviews, notes from field trips, and analyses that deal with specific issues such as reports during the late fall of 1973 on the possible impact of the energy crisis.

In all, based on a sample taken for the period covering November 15 to December 15, 1973, the portfolio managers received 114 different documents from the Investment Research function, representing in total 396 pages of written material.

2. The Committee Structure is responsible for reviewing all changes in status of the Common Stock List and the Stock Recommendation List, setting portfolio management policy guidelines, and reviewing portfolios on a regular basis.

3. The Traders are part of a specialized trading group responsible for execution of all portfolio management trading decisions. They are a source of information on very short term market conditions and are actively involved in setting up large block trades.

4. Administrative Services support the portfolio managers in processing the large amount of clerical work, not only in terms of trades but also in terms of handling in- and out-flow of funds to clients, and in terms of documents that have to be prepared for control and legal purposes. In a pre-Portfolio Composition System world, the administrative services furnished the portfolio managers with periodic reports on portfolio holdings. This was the only source of such information, other than the personal files maintained by
the individual portfolio manager.

5. **Management Information Services** is the central data processing facilities of the bank that provide the portfolio manager with regular computer generated reports such as demand note balances, overdrafts, cash position, and in a pre-Portfolio Composition System world, reports on which accounts held a particular security. These last reports were generated on request.

6. **Outside Sources** are the direct contacts that the portfolio manager has with investment related information from outside the Trust department. It includes the Quotron, a terminal that gives real-time security prices, newspapers such as the *Wall Street Journal*, and reports from brokerage houses and other investment service firms.

7. **The Client** which in the case of both Personal Trust and Investment Advisory most often is an individual investor. In the case of the Retirement and Endowment group the client is a company, typically represented by the treasurer or a committee.

8. **The Portfolio Composition System** is an interactive, graphical terminal based computer system designed to support the portfolio managers in their portfolio composition decisions. The initial effort that led to the development of the system started in the end of 1967 and the first operational version of the system was made available to the portfolio managers in the beginning of the summer of 1972. The development proceeded through several stages; the first stage was the design and experimental use of a prototype system done as part of a thesis effort (Gerrity, 1970, 1971). The operational system finally implemented, although closely linked to the proto-
type system in terms of design concepts, represented a completely new system based on different technological components and with functions that were successively implemented in a phased approach. Presently most managers share a terminal on a Lazy-Susan with a colleague. The system is operational from 8:00 a.m. to 5:00 p.m.

The present (fall 1973) version of the system, released in the early spring of 1973, has ten different functions or commands that give the portfolio managers access to a data base that contains two main components: the **account file** that basically contains account specific information on which assets an account holds, organized by accounts; the **asset file** which contains historical, current (in most cases, as of the closing prices of the previous day), and future or predicted data on individual assets, organized by asset. Most of the functions on the system present information, some in graphical format, relevant to the content and distribution of assets in a specific account. Figure 3.2 shows a simplified version of a report generated using one of the graphical functions available on the system — the HISTOGRAM report — which in the example shown gives the percentage of an account in different asset categories. One function presents information relevant to the holding or non-holding of a specific asset across all accounts of a manager (the RUN function). Finally, one function presents information on accounts across all accounts of a manager (the DIRECTORY function).

The most striking characteristic of this overview of the organizational context of the portfolio manager is the vast number of information sources
and the vast quantity of information that the manager needs to deal with. Slovic's comment on the nature of the security analysis seems even more applicable to the portfolio manager task:

"...Just as the stock market has been described as "The Money Game", security analysis, whether by expert or novice, might aptly be labeled "The Information Game". In no other realm are such vast quantities of information from such diverse sources brought to bear on so many important decisions. Careful accumulation and skilled interpretation of this information is said to be the *sine qua non* of accurate evaluation of securities..." (1972, p. 779).

In normative portfolio theory (Sharp, 1970), the task of the portfolio manager is quite constrained and structured. The manager makes portfolio composition decision, consistent with account objectives, based on a couple of summary statistics for individual securities: the beta or volatility of the security returns, and the expected return of the security relative to the market. The main information processing task is located in the analyst function, both responsible for estimates of the relevant individual security data, and for estimates of overall market performance. However, the portfolio manager in actual fact is constantly second guessing the analyst -- using the raw data provided rather than relying on the data that summarizes the work of the analysts. The reasons for this rejection of a clear division of effort are numerous; the most important reason probably is that the portfolio managers have the final responsibility for the performance of the accounts they manage and are therefore reluctant to rely totally on the work of somebody who does not directly have the same concern. Other reasons are that the portfolio managers have to communicate and justify their decisions to their clients; the credibility of the analysts is not always good, some of them having much less experience than the portfolio
managers who to a large extent are ex-analysts themselves. In a sense, the duplication of effort reflects the unstructured nature of the portfolio management task where the division of labor and specialization that the normative theory prescribes is difficult to implement. The lack of clear feedback on the outcome of decisions and the existence of multiple and not necessarily consistent objectives is another dimension of the unstructured nature of the portfolio manager task. The same conclusion seems evident from a closer look at the different sub-tasks that the portfolio manager task can be decomposed into, the topic of the next section.

The Components of the Portfolio Manager Task.

Slightly simplified, the portfolio management task can be considered as consisting of three different, although overlapping sub-tasks: a client relations sub-task, an administrative sub-task, and an investment sub-task (see Figure 3.3).

Figure 3.3: The Components of the Portfolio Management Task
The primary concern of the client relations sub-task is obviously on an overall basis, to maintain the client base of the Trust department. More specifically, however, the task is concerned with the identification of what are or should be the objectives for the account of a client, and, for non-discretionary accounts in particular, with the task of making sure that the client follows and approves portfolio manager recommendations. Although the objectives of an account typically have quite a long range perspective, the client is obviously concerned with short run fluctuations in performance. Furthermore, some clients are inherently difficult to satisfy. A major thrust of the client relations sub-task is to manage these problems.

The investment sub-task is the task directly involved with managing the physical assets in an account so that they perform in accordance with the objectives of the client. It involves decisions on specific trades and on how a portfolio should be composed at a more macro level. The Portfolio Composition System was designed to support the investment sub-task.

It is interesting to note that the portfolio managers perceive that client relations is the key and most visible issue upon which they are evaluated by senior management. In response to a question asking what they thought was the most important criteria used by management to evaluate portfolio managers (a question posed in a questionnaire administered in an exploratory study in the Trust department) eighteen of the forty-two responses given mentioned customer relations. In contrast there were only three responses that mentioned account performance which is the primary objective of the investment sub-task.
The administrative sub-task is involved in the more clerical, legal, and operational matters that relate to both the client relations and the investment sub-tasks. Efficiency and accuracy are prime concerns in this task. In other words, ensuring that in fact Mrs. Jones received her fall cheque in time for her trip to Florida.

The net result of the large number of dimensions of the portfolio manager task is that the overall task is characterized by what Mintzberg (1973) appropriately labels variety, brevity, and fragmentation of activities. A typical scenario might be:

...The portfolio manager is reading a recent economic report. Before he is halfway through, he is interrupted by a twenty minute call from a client who is concerned with the market implications of a McGovern victory in November....The portfolio manager has to finally cut short the discussion, which he skillfully does, in order to attend a one hour account review meeting.... On his way, he quickly steps up to Quotron to find out how much Matell, a stock that his accounts are heavily invested in, has tumbled since he last looked at it two hours ago....He is concerned about whether he should sell now or hope for a recovery....Upon his return from the account review meeting the manager again checks Matell on the Quotron and then calls the analyst who is responsible for the stock to get her opinion...Two days later he might return to the economic report that he never finished in the first place....

The manager is constantly switching between the different sub-tasks. This is partially because of different problems being brought to his attention, and partially because he cannot resolve an issue immediately, but must wait for more information in terms of a response from a client, the result of a series of trades, new information from an analyst, or just for an event to develop so he can read it more clearly.

As a result, the task of the portfolio manager is quite unstructured, part of the complexity resulting from the intermeshed nature of the three-sub-tasks identified above. Other dimensions of this complexity alluded to previously are the large number of information elements and sources that
are relevant to the task of the managers, the uncertainty attached to estimates of key variables, the lack of clear feedback on the outcome of decisions, and multiple and not necessarily consistent objectives. Restriction of the universe of relevant securities through the Common Stock List and guidelines from senior management are organizational attempts to bring some structure to the portfolio manager task. However, there is no evidence that the task is structured to the extent implied by Clarkson's seminal simulation of the Trust Officer investment process (1962). Clarkson was dealing with one of the most structured decisions facing a portfolio manager -- composing a portfolio for a new account from an all cash position where the universe of relevant securities had been severely constrained by the Prudent Man Rule.

Summary.

The organizational context of the task to be studied, portfolio management supported by an advanced Conversational Computer System, has been reviewed in this chapter. The discussion suggested that the task of the portfolio manager is quite unstructured and very much an information processing task. The task can be seen as consisting of three main sub-tasks: the client relations sub-task, the investment sub-task, and the administrative sub-task. The Conversational Computer System available to the portfolio managers in the Trust department, the Portfolio Composition System, was designed primarily to support the investment sub-task. To the extent that it is really possible to separate out this sub-task, the investment sub-task is the focal task into which the constructs of Complexity Theory will be mapped.
Chapter 4: Research Hypothesis: Differences in Process as a Function of Conceptual System Structure.

Complexity Theory, the main theoretical framework for this study, suggests that the Integrative Complexity of an individual's conceptual system is a determinant of important aspects of decision making behavior, labelled Level-of-Information-Processing. Furthermore, the theory insists that one must consider situational variables, labelled Environmental Complexity, in addition to the personality variable Integrative Complexity as a determinant of Level-of-Information-Processing. As suggested in Chapter 2, this general framework might be useful to understand a number of dimensions of possible variability in behavior: cross-sectional differences in managerial decision making processes across managers working in tasks of similar complexity; cross-sectional differences in managerial decision making processes across tasks performed by managers similar in Integrative Complexity; and longitudinal shifts in managerial decision making processes as a result of new information processing technology changing the complexity of the task.

The empirical effort of this study attempts to explore hypotheses that cover some limited, but important issues identified within the more general framework. Simply stated, the hypotheses to be tested attempt to explore whether Complexity Theory identifies dimensions along which managers in a field setting -- in the "real" world -- differ in their use of information and decision making processes, and that the theory can explain these differences. Specifically, it is the issue of exploring whether differences in the Integrative Complexity of the managers in the organizational setting
reviewed in the previous chapter explains significant differences in Level-of-Information-Processing. An answer to this question seems as an appropriate first step in both investigating the importance of individual manager characteristics for differences in decision making processes, and for the formulation of further empirical research efforts designed to explore issues surrounding managerial decision making processes within the framework of Complexity Theory.

The chapter first presents the general research hypothesis. This general hypothesis is then mapped into the specific research setting by a choice of the focal portfolio management decision making process and using a simple model of the relevant task.

General Hypothesis.

The Level-of-Information-Processing manifest in the decision making processes of managers in a task is positively related to the Integrative Complexity of the manager's relevant conceptual system.

Integrative Complexity is defined as a structural characteristic of a conceptual system which is a function of the number of dimensions, but primarily a function of the number and nature of integrating rules. The central concept in Complexity Theory underlying the hypothesis is the view that increasing Integrative Complexity enables and leads an individual to interpret a given set of stimuli from his environment in a number of alternate fashions. With higher Integrative Complexity, the individual therefore is hypothesized to see greater uncertainty and ambiguity in his environment, a situation which in turn leads to behavior that is characterized by a higher Level-of-Information-Processing.
Level-of-Information-Processing is a label given to a number of different, although interrelated aspects of the manager's information processing behavior. In this study, the following characteristics will be considered: the number of different information sources sampled (in other words, breadth in source use), the balance in use of the different information sources sampled, the total volume of information source use, the number of alternatives considered in the problem solving process, and the degree to which information search is guided by perceived opportunities as opposed to being guided by perceived problems. Level-of-Information-Processing is hypothesized to form a unitary concept; in other words, all the different components of the construct are hypothesized to be positively correlated.

Let us turn to the critical issue of which conceptual system is relevant to which behavior. It is the issue of mapping the more abstract hypothesis into concrete measures for the specific task studied.

Mapping the General Hypothesis into the Concrete Setting.

The choice of behavior or problem solving process is dictated by a focus on the use of the Portfolio Composition System, the Conversational Computer System available to the portfolio managers in the Trust department. Given that the Portfolio Composition System was designed to support primarily the investment decision making processes of the managers, the focus will be on the decision making processes that relate to the portfolio composition decision and problem. Excluded are the decision making processes only relevant to the customer relations and the administrative sub-tasks, the two other components of the overall portfolio manager task.
For measures of information source sampling, an issue remains on how to aggregate information sources. The approach taken is that the overall information use can be considered separately for three distinct classes of information sources: impersonal sources, people or personal sources, and finally the Portfolio Composition System. For the analysis of system use, each function or command is considered as an independent source of information. The breakdown of the information environment of the portfolio manager into three major groups of information sources reflects a concern for the issue that for radically different classes of information sources the Level-of-Information-Processing construct of balance in use across sources is no longer valid.

Note that the choice of focus in terms of portfolio manager sub-task for information source use is not too critical. The reason is that the identification of which use is relevant to the investment sub-task is both difficult and not obvious. For example, a source might be sampled for a client relations issue and simultaneously be relevant to the investment sub-task.

The choice of which conceptual system or cognitive domain is, however, critical. A simple model of the investment task is suggested to determine what are the relevant central objects of the investment decision making process. The model sees the investment process divided into two main sub-tasks:

1. **Information Sources Sub-task** which is concerned with finding, evaluating, and choosing information sources that are relevant to the investment decision.
2. **Portfolio Composition Sub-task** which is concerned with sampling and processing data from the information sources chosen in order to arrive at a portfolio composition decision.

Based on this simple model both the Integrative Complexity of the conceptual system dealing with portfolios and the Integrative Complexity of the conceptual system dealing with information sources is hypothesized to be relevant to the Level-of-Information-Processing in the investment decision making process. In a choice between the two, Complexity Theory is not very useful as this is a **content** issue that the theory does not deal with. Obviously, both hypotheses can only be supported in an identical fashion, over all the components of Level-of-Information-Processing, in the case where there is a strong correlation between the two conceptual systems. A more probable finding is that differences in the Integrative Complexity of one of the conceptual systems is the more important determinant of differences in Level-of-Information-Processing.

Note that the sub-tasks defined in the model of the investment task imply that the Level-of-Information-Processing of different behavior might be relevant to the Integrative Complexity of the different conceptual systems. The focus is primarily on the second sub-task in terms of process characteristics and the sampling of behavior will refer explicitly to this sub-task. However, it is difficult to separate out information processing behavior that is relevant to the identification, evaluation, and choice of information sources from information processing that is concerned with the sampling and processing of data from these sources. The model of the investment task is clearly a conceptual tool and in reality the two processes are parallel and intermeshed.
It is obvious, particularly in retrospect, that a number of other task models might have been proposed. In particular, the entities in the second sub-task could have been individual securities rather than portfolios. Some of the reasons for the model actually chosen are:

1. The explicit recognition of the Information Sources sub-task reflects the belief that the portfolio management task is very much an information processing task where the manager is presented with a large array of quite different sources of information. Furthermore, based on exposure to the portfolio management environment, and based on data collected in an exploratory study, it was hypothesized that in response to the unstructured nature of the task some portfolio managers might have emphasized the development of an ability "... to evaluate the quality of their information sources and have emphasized the development of a good network of such sources...." (Stabell, 1973). In contrast, other managers might have emphasized the development of a complex conceptual framework relevant to the portfolio composition sub-task to process information sampled in an elaborate fashion.

2. The choice of portfolios as the entities of interest in the portfolio composition sub-task was based on the belief that portfolio perception might be particularly relevant to the use of the Portfolio Composition System. The system has been designed to support a portfolio-oriented decision making process.

To conclude, the specific research hypotheses for the portfolio management task can now be formulated as follows:
The Level-of-Information-Processing manifest in the investment decision making task over the set of impersonal sources, personal sources, and Portfolio Composition System functions

H1: is positively related to the Integrative Complexity of the portfolio manager's conceptual system relevant to the perception of information sources;

H2: is positively related to the Integrative Complexity of the portfolio manager's conceptual system relevant to the perception of portfolios.

A final comment -- in Complexity Theory, the hypotheses to be tested are only valid if one can assume that the portfolio managers all have tasks of similar complexity. In a first order analysis task complexity will be assumed identical for all managers. The possible effects of task complexity will be explored in a secondary analysis. However, this analysis can only be at best quite qualitative, given the small sample sizes involved.
Chapter 5. Measurement: Conceptual System Structure

The purpose of this chapter is to present the instruments, procedures, and algorithms used to measure the main independent variables in this study, the structural properties of the conceptual systems relevant to portfolios and information sources. The chapter is organized into two main parts. The first part, covering measurement per se, does not consider the data obtained. In this part the instrument used to sample raw data from the individual portfolio managers is discussed separately from the various transformations applied to the raw data to generate measures of structure. Convergent validity among the measures and the evidence supporting it in the data is the topic of the second major part of the chapter.

Validation of measures was not initially considered a serious problem or a critical task in this study. In the course of the research effort, mainly as a result of a more detailed interaction with other research, it became however increasingly clear that the measurement of conceptual system structure is still at a rather crude level. The issue of measure validity is therefore critical. The basic conclusion of this chapter is that the data collected gives little evidence of convergent validity among the measures of integrative complexity, the main independent variable of the study.

The content and format of this chapter reflects both the complexity of the properties to be measured and the problems encountered. Experience with other research reports in this area suggests that painstaking detail and explicit definitions are to be preferred to conceptually simple and
abstract presentations. The latter often hide critical transformations, or mistaken and incomplete logic. For example, in both the studies that this research relies heavily on (Riesing, 1972, Smith & Leach, 1972) there is extensive interpretation of some relationships which imply the opposite of the interpretations given by the authors.* As a result, portions that might perhaps have been relegated to an appendix are here in the main discussion. It is hoped that the chapter thereby represents a contribution to research in the measurement of conceptual system structure, in addition to its contribution to the overall flow of this study.

Instrument versus Transformation

Measurement of structural properties of a conceptual system is analogous to trying to determine the programs and data structures of a complex computer system solely on the basis of limited knowledge of inputs and outputs. One cannot "open up" the individual and measure directly the relevant structural properties of his conceptual system. Rather, we must rely on creating a situation (a set of inputs, pursuing the computer analogy) to which the individual will respond and generate a behavior (outputs) from

* Smith & Leach, in their discussion of the relationship between their measure of complexity and Bieri's measure of complexity, conclude that because three different tests show a negative correlation between the measures, one significant, that subjects who have differentiated construct systems according to Bieri are simple in terms of their measure. (1972, p. 567). However, the conclusion should be the opposite, as low scores on the Bieri measure indicates a differentiated system.

Riesing presents data that shows a very significant positive correlation between his measure of complexity and his measure of differentiation (1972, p.119). This is a surprising result that he ignores. In fact, as defined there should theoretically be a significant negative correlation between his measure of integrative complexity and his measure of differentiation.
which we can infer the structural properties of his conceptual system. It follows that the measurement procedure can be described as consisting of (1) the application of an instrument to generate the appropriate behavior, (2) the application of more or less complex transformations to the raw behavioral data generated in order to obtain measures of conceptual system structure.

This breakdown helps us distinguish the two extreme prototypical measurement procedures available. (Crockett, 1965, p. 52; Riesing, 1972, p. 53). On the one hand, the phenomenological (or direct) procedures are characterized by instruments that generate a limited number of complex responses from individuals and employ simple and somewhat subjective transformations. Examples of such procedures are projective tests such as the Sentence Completion Test and the "This I Believe" test. (Schroder et al, 1967, p. 189; Harvey, 1966). On the other hand, the analytical (or indirect) procedures are characterized by instruments that generate a large number of relatively simple responses from the individual but employ relatively complex analytical transformations. A good example of an analytical measurement procedure is the factor analysis of data obtained when the Role Construct Repertory Test (Kelly, 1955) is the instrument.

Although the choice of instrument constrains the choice of transformations and vice versa, conceptually and for clarity of presentation the measurement problem can be broken into two subproblems: choice of instrument and choice of transformation(s). Theoretical considerations should guide one through both issues. However, as noted in the discussion of Complexity Theory, we are dealing with relatively imprecise definitions of the central variable, integrative complexity. Although the interjection of a model of
the task has helped some, this study is still very much troubled by Suedfeld's characterization of the connection between theory and studies in personality research within the information processing paradigm, which he characterizes as "tenuous at best" (1971, p. 8). The problem is mainly the lack of an explicit, formal model of the underlying conceptual system that is sufficiently complex to capture the notion of programs or procedures, from which more complex inferences and judgements can be made. As shall become evident, the problem troubles most the selection of the appropriate transformations to apply.

The Instrument: The Role Construct Repertory Interview

A modified version of Kelly's Role Construct Repertory Interview (RCRI) was chosen as the instrument for generating individual behavioral data. This choice was determined to a large extent by the requirement to sample data from specific and well defined conceptual systems. Other considerations which led to the specific choice of the Role Construct Repertory Interview (RCRI) were face validity, ease of use, ability to generate content data as well as measures of structure, and prior use in research.

The Role Construct Repertory Interview is an instrument that has been widely used in quite different research efforts, all having the common need for data on the perceptual and conceptual systems of individuals (for a recent review, see Bannister & Fransella, 1971). The RCRI was originally developed by George Kelly as a natural methodological extension of his Personal Construct Theory (1955). This theory has clear roots in a psychology of interpersonal relations based on an information processing
paradigm. The basic postulate of Personal Construct Theory is that each individual evolves a hierarchically organized system of bipolar constructs to interpret and predict events in the interpersonal domain.

For our purposes, the RCRI can be viewed as an interview that consists of three distinct phases (ref. Figure 5.1). In the first phase, the individual being interviewed generates a number of familiar objects from the conceptual domain to be sampled. He is aided in this phase by a list of "roles." Each role is designed to help the individual generate a specific object that he is familiar with from the domain in question. In the case of the domain of portfolios, one such role used in this study is "The portfolio you dealt with most recently." The manager writes down on a card the identifier of a portfolio that fits the role. An example of a role used for the domain of information sources is "The Equity Research document you find the most useful." At the end of the first phase of the RCRI, the manager has generated a number of objects, here portfolios or information sources, each written on a separate card.

In the second phase of the interview, the individual generates a number of bipolar attributes or constructs through comparisons of triads of the objects generated in the first phase. This is done by asking him to tell how two of the objects on a triad of cards are alike, but different from the third. For a comparison of portfolios, a manager might respond that two portfolios are alike because they are both "discretionary." The opposite pole of the bipolar construct is elicited by asking what is the opposite of the way the first two objects were alike. In the case of the response given above, the manager might respond "directed" -- the construct elicited in this sort is therefore "discretionary versus directed."
Figure 5.1 The Different Phases of the Role Construct Repertory Interview.
Finally, in the third phase, the individual rates the different objects identified in the first phase along the bipolar attributes generated in the second phase. Hence, the basic output of the interview is a list of M objects, a list of N bipolar constructs, and a M x N matrix of the rating of the M objects on the N constructs. It follows from this short description, that the RCRI belongs to the class of analytical measurement procedures of conceptual system structure: the basic output of the interview is a large number of simple responses. As a result, the instrument is easy to use, an important property in field research. Furthermore, the individual is involved with objects that he is familiar with and is asked to rate them using his own constructs. This gives the instrument high face validity.

By an appropriate choice of roles used to suggest objects in the first phase of the interview, the RCRI enables one to sample specific conceptual systems; for example, by choosing roles or situations that suggest portfolios familiar to the portfolio manager, the whole interview can be focused on the managers conceptual system relevant to portfolios. Failure to satisfy the requirement to sample data from specific and well defined conceptual systems was sufficient cause to exclude the existing phenomological instruments used in Complexity Theory research such as the Sentence Completion Test.

One major alternative analytical instrument that also can be focused on a specific conceptual domain, what Schroder et al label Multidimensional scaling (1967, pp. 169 - 174), asks the individual to directly judge the relevant objects as to similarity. In comparison to this instrument, the RCRI has the advantage of generating data relevant not only to measurement
of structure, but also to the content of a conceptual system. Content
data is provided through the labels of the constructs generated in the
second phase of the RCRI. This content information has proven to be valu-
able for the interpretations of the findings of the study.

A final, and in retrospect not adequately considered reason for the
choice of the RCRI, was the large number of studies that had previously
used the RCRI to measure structural properties of conceptual systems. In
fact, beyond the obvious differences in domain, very few studies have used
precisely the same version of the RCRI. As noted by other authors (Harrison
and Sarre, 1971, pp. 367 - 371), the RCRI is but a generic framework within
which to capture data on an individual's conceptual system. The inherent
flexibility in the RCRI format makes the instrument attractive from a meth-
odoligical perspective, but raises a number of issues concerning its validity.

The important point to note here is that the use of the RCRI in a con-
crete setting involves choosing the values for a number of parameters:

phases: should all the three phases of the RCRI be executed in one
continuous session? If not, how should they be grouped and
what is the appropriate time sequencing?

roles: beyond the obvious choice of roles that elicit objects from
the domain of interest, what wording should be used and how
many roles are required?

sorts: how should the different objects generated in the first phase
of the interview be grouped in the second phase? How many
sorts are required to sample the conceptual system in ques-
tion?
objects: One variant of the RCRI is to do away with the first phase of the interview and present all individuals with a standard set of objects for the subsequent phases. It is a distinction between using standard versus the individual's own personal objects.

constructs: Again here, instead of using constructs generated by the individual, i.e., his personal constructs, he can be provided all or a part of the constructs to be used in the rating phase of the interview. How many constructs should be used?

rating: If using a fixed number of points on the scale to be used in the rating phase, how many intervals should be used? Or should the individual determine how many scale intervals are applicable for each different construct? Should the rating exercise recognize that some constructs might not be applicable to certain objects?

The remainder of this section presents the specific version of the RCRI used in this research. The discussion is organized around the choice of the parameter options identified above. In addition, the size and composition of the actual sample of portfolio managers is reviewed. The discussion is necessarily detailed. For the weary reader, it might be useful to scan table 5.4 on page 83 - which gives a summary of the major choices made.

In order to improve the flow of the discussion, the term "Portfolio RCRI" stands for "the RCRI used to sample the portfolio conceptual system," and the term "Information Sources RCRI" stands for "the RCRI used to sample the information sources conceptual system." Unless explicitly stated to the contrary, the discussion of the choice for a particular parameter pertains
to both the Portfolio RCRI and Information Sources RCRI.

RCRI Sample

As mentioned in the description of the Trust department in chapter 3, the department employs approximately thirty portfolio managers. Twenty-eight Information Sources RCRI’s and twenty-three Portfolio RCRI's were conducted (all twenty-three Portfolio managers in the latter group are included in the form.) One of the five portfolio managers sampled only for the Information Sources was, in fact, interviewed for the Portfolio RCRI. but did not return the completed final rating exercise. In a follow-up the manager insisted that he had completed the interview and the point was therefore dropped. The remaining four portfolio managers included one senior Personal Trust portfolio manager and three Retirement & Endowment portfolio managers. Interviews with these last four managers were not completed as an evaluation of the extra cost in terms of their time and in prolonging of the data collection effort, was deemed to be substantially more than the value of the data likely to be obtained. The consideration underlying this evaluation, which only crystallized after a number of managers had been interviewed, was that the Portfolio RCRI violates an important implicit assumption for the use of the RCRI as an instrument to obtain measures of conceptual structure. It is basically a problem of heterogeneous objects. When the RCRI is used to generate measures of conceptual structure an implicit assumption is made that the set of objects generated and rated are similar across individuals. Otherwise, differences in scores
might be due to differences both in the individual's conceptual systems and in the objects rated. However, as is evident from the discussion of the research setting in Chapter 3, the portfolio managers manage a set of portfolios that vary both in size, content and orientation. These differences in the portfolio managers' portfolio of portfolios is precisely what defines the three product groups in the Trust department.

The problem is serious and difficult to deal with. Any attempt to control for differences in actual accounts managed would require making untenable assumptions about individual differences in portfolio perception, the property that is to be measured. In short, the uncertainties were such that the decision was made not to push the collection of Portfolio RCRI's to the point of covering all managers sampled with the Information Sources RCRI.

The data collection effort covered a period extending June 1973 to March 1974 with the bulk of the data collected in the months of July, September and October 1973. The major reasons for the length of the data collection period were travel distance, scheduling problems, interviewer fatigue and a desire at all cost to limit impositions on the portfolio manager.

RCRI Steps

The RCRI was administered in two distinct steps. The first step comprised the object generation phase and the construct generation phase of the RCRI. The second step of the interview, executed in the form of a self-administered questionnaire, covered the final rating phase of the
interview. On the average, two weeks elapsed between the two steps of the interview.

This two-step procedure, similar to that used by both Wilcox (1970) and Riesing (1972), was chosen so as to minimize the maximum continuous length of time requested from the portfolio managers. The first, face-to-face part of the Portfolio RCRI and Information Sources RCRI took an average thirty-five and forty-five minutes respectively. A further reason for choosing this two-step procedure was that it made it possible to fully control the selection of the constructs used in the rating exercise. The procedure had the disadvantage of not being able to clear up ambiguities and duplicate constructs with the manager interviewed.

RCRI Roles.

Table 5.1 and Table 5.2 present the complete set of roles used in the Information Sources RCRI and the Portfolio RCRI respectively. The choice of number of roles, which determines the number of objects generated in the RCRI is also here a trade-off between discrimination power and reliability on the one hand, and portfolio manager load on the other hand. The greater number of roles in the Information Sources RCRI reflects that three of the roles (roles 1, 13, and 15) in fact identify specific sources of information. The use of standard or provided objects in this case seemed both justified and useful. The three sources in question are used daily by the portfolio managers and they are therefore quite familiar with them. By providing some standard objects, the length of the RCRI is that much shortened in time.

For the Information Sources RCRI, the choice of roles was designed to sample sources from the whole information environment of the portfolio mana-
TABLE 5.1: Information Sources Role List

1. The Stock Purchase List.
2. An Equity Research document that you use frequently.
3. An Equity Research document that you find not too useful.
4. An Equity Research document that you imagine very few portfolio managers read.
5. A portfolio manager colleague that you might consult when faced with a complex decision.
6. A portfolio manager colleague that you probably would not consult when faced with a complex decision.
7. A portfolio manager colleague that you consult frequently.
8. The research analyst that you find hard to communicate with.
9. A research analyst that you communicate with most frequently.
10. A research analyst that you find easy to communicate with.
11. A research analyst that tends to contact you often.
12. An outside broker or money manager that you think might have much useful information to give you.
14. A financial periodical that you find of little value.
15. The Quotron.
16. The PCS function or command you find the most useful.
17. The PCS function or command you find the least useful.
18. The PCS function or command you find the most difficult to use.
TABLE 5.2: Portfolio Role List

1. The portfolio you dealt with most recently.
2. The portfolio you most enjoy managing.
3. The portfolio you least enjoy managing.
4. The portfolio you feel has been best managed up until presently.
5. The portfolio you feel has been least well managed up until presently.
6. The portfolio for which you expect the best performance over the next 18 months.
7. The portfolio for which you expect the worst performance over the next 18 months.
8. A portfolio that you have not dealt with for some time.
9. A portfolio you review frequently.
10. A portfolio you review infrequently.
11. A portfolio that needs a lot of attention in the near future.
12. A portfolio that needs little attention in the near future.
13. A portfolio that requires relatively little effort on your part to manage.
14. A portfolio that you find tough to manage.
15. A portfolio where you had to make a decision that you did not like.
16. A portfolio where you had to make a decision recently that you are very happy with.
17. A portfolio where you had a major problem recently.
gers (see Chapter 3). In both the Portfolio RCRI and the Information Sources
RCRI, the wording of the roles was chosen so that it would not elicit ob-
jects using constructs that were relevant to the construct generation phase.
This was easier to do in the case of the Portfolio RCRI than in the Informa-
tion Sources RCRI.

RCRI Sorts.

The composition of the sorts was determined in order to obtain interest-
ing and important comparisons between objects (see Appendix 2 for an overview
of the actual sorts used). The number of sorts was different for the two
RCRI's -- seven for the Portfolio RCRI and thirteen for the Information
Sources RCRI. The difference reflects the decision to rely mainly on pro-
vided or standard constructs in the rating phase of the Portfolio RCRI (see
section on RCRI Constructs), with the construct elicitation phase of the
Portfolio RCRI therefore serving primarily as a training session for the
portfolio managers. It also made possible the same general interview for-
mat for both RCRI's, thereby hopefully minimizing the portfolio managers con-
fusion.

For both RCRI's, the construct elicitation phase was tape recorded,
although notes were also taken. The portfolio managers did not write down
the constructs. The recording of the construct elicitation phase for the
Information Sources RCRI was transcribed verbatim, and the transcript served
as a basis for determining the personal constructs to be used in the rating
exercise of the Information Sources RCRI. No transcript was made of the
elicitation phase of the Portfolio RCRI as standard or provided constructs
were used in the rating phase.
The choice of number of sorts for the Information Sources RCRI again represents a trade-off between coverage and imposition on the portfolio managers. The lower number of sorts than that used by either Wilcox or Riesing reflects the emphasis on measuring Integrative Complexity, which is primarily a function of number and nature of integrating rules in the conceptual system. It is therefore less sensitive than dimensionality to the actual number of constructs used in the rating exercise. The fact that the mean number of constructs obtained in the Information Sources RCRI is 13.8, however, suggests that perhaps 15 sorts might have been more appropriate as a point to settle in the trade-off. This suggestion reflects the uncertainty concerning the exact relationship between number of constructs that an individual has available, number of constructs elicited, the actual Integrative Complexity of the conceptual system, and the measure of Integrative Complexity obtained on the basis of the elicited constructs.

RCRI Constructs.

The RCRI was chosen primarily due to the ability it gives, by the choice of appropriate roles, to sample data from specific conceptual systems. Although this is true in a relative sense when the RCRI is compared to other instruments, it is not true in an absolute sense. One problem is that an object label can denote two rather different objects in the physical world. This issue is rather clear in the case of the portfolio RCRI: the portfolio manager can think of the objects, portfolios, both in terms of the client as a person and in terms of the actual assets in the account and the formal account objectives. The proposed model of the investment task suggests that
it is mainly the construct system relevant to the latter view of portfolio (assets and objectives) that is relevant to the behavior of interest. Constructs generated in the course of nine Portfolio RCRI's conducted as part of an exploratory study in the Trust helped identify the issue. Furthermore, the data on constructs thereby available suggested that there are a limited number of constructs available to the portfolio managers that are used to characterize portfolios in the sense of interest here (see Appendix 1 for a list of the constructs obtained in the nine Portfolio RCRI's). Both in order to deal with the problem of multiple label-object relations, and in order to reduce the imposition on the portfolio managers, a decision was made to use a set of ten provided or standard constructs for the rating phase of the Portfolio RCRI.* The ten constructs used, shown in Table 5.3, represent a summary of the relevant constructs available from the nine Portfolio RCRI's mentioned above (see Appendix 1).

In order to make the whole Portfolio RCRI interview seem natural and logical to the portfolio managers, two of the constructs generated in the seven sorts of the construct elicitation phase of the interview were added to the ten standard constructs used in the rating phase. In general, constructs generated seemed to be highly similar to those in the set of standard constructs. Furthermore, even though we asked the PM's not to think of the portfolios "in terms of the personal characteristics of the client

* Tripodi and Bieri have shown that "... provided constructs are comparable to own constructs in measuring cognitive complexity..." (1963, p. 26). Riesing's finding that this is not necessarily so can perhaps be attributed to that he not only used provided constructs, but also provided objects (1972, p. 87).
TABLE 5.3: List of Standard Constructs used in the
Portfolio Role Construct Repertory Interview.

1. Active account versus Inactive account
2. High in equity versus Low in equity
3. Small portfolio versus Large portfolio
4. Conservative versus Aggressive
5. Overconcentration versus Diversified
6. Low Liquidity need versus High liquidity need
7. Income oriented versus Total return oriented
8. Portfolio is very flexible, not tied to particular assets
    versus
    Portfolio is inflexible, tied to particular asset
9. Sole discretion versus Directed
10. High risk orientation versus Low risk orientation
or in terms of your personal relationship with the client..." most PM's ended up by deriving similarities and differences along client personal characteristics. In a number of cases these client related constructs served as the personal constructs used in the rating exercise of the portfolio RCRI.

For the Information Sources RCRI, having no priors on what might be the relevant and irrelevant ways of thinking about information sources, the PM's were only constrained by asking them to think of the objects as "sources of information in terms of your job as an investment officer..." Experience with the Information Sources RCRI identified some issues not considered in the initial design:

- the managers had trouble verbalizing the common trait and its opposite. They would instead tend to enumerate all the explicit characteristics of the different objects in the sort. In certain cases the manager had problems identifying the opposite, for instance, the constructs were bipolar with a "hidden" pole.

- Some constructs were bipolar with a labeled midpoint; in other words, historical versus projection with a midpoint label of current. This kind of construct could result in 1, 2, or 3 different bipolar constructs.

- At times, the managers were dominated by concrete characteristics of the objects compared. For example, when comparing two people with a machine, the manager would generate the construct people versus machines. Together with the high rate of scale-does-not-apply responses, the experience gained indicates that for some managers the interview was actually sampling one or more loosely connected
but different conceptual subsystems.

Furthermore, some portfolio managers generated several constructs in a sort. It did not seem meaningful to pursue the idea of making them select the most important construct for each sort. One obvious reason was that such a procedure might lead to an interview with less than 13 constructs for a person who obviously had more.

As a consequence, more than 13 constructs were obtained for quite a few portfolio managers (the average number of constructs generated is 13.6). In a number of cases the determination of the constructs to be in the final step of the RCRI was not perfectly objective in that it required some interpretation to determine the individual's constructs.

The procedure used was to scan the verbatim transcript of the construct elicitation step (step 2) and underline all possible constructs in each sort. A list was made up where most of the constructs had explicit opposites. "Obvious" duplicates were then eliminated. In the remaining, the constructs without opposites were given opposites by simple negation; for example, "updated" would get an opposite "not updated." The constructs were sorted before being written up on a standard form (see Appendix 3). The sort was made so that relatively similar constructs would not follow immediately in the rating exercise. Similarly, favorable-unfavorable poles were intermixed so that all poles identical on this dimension were not on one side of the rating form.
RCRI Rating

The rating phase used a self-administered questionnaire, where the portfolio managers were asked to rate the objects on the constructs using a five-point scale. The choice of a five-point scale reflects the desire to obtain data that could be treated by techniques such as factor analysis. The choice of a scale with a fixed number of intervals rather than letting the portfolio manager decide how many intervals were appropriate for each construct (a technique used by both Wilcox (1970) and Riesing (1972)), was based primarily on a desire to reduce the load on the portfolio managers. Furthermore, a review of some of the data presented by both Wilcox and Riesing suggests that there is not much variation in the number of intervals used, the typical number of intervals used being two and three; in other words, the use of a fixed scale does not seem to reduce, and may in fact be increasing discrimination.

What seems to have been a much more important scale related decision was explicitly recognizing that portfolio managers would see some constructs as not applicable to one or more of the objects rated. Theoretically, this relates to the notion of centrality discussed in Chapter 2; to the extent that a subset of constructs are the only ones applicable to the whole range of objects in a conceptual domain, this subset is more central than are the other constructs in the system.

In fact, the data obtained reveals that this is an issue only in the Information Sources RCRI, where on the average, over all constructs and over all managers, ten percent of the objects were not rated (see measure of average centrality in Table 5.6).
RCRI Summary.

Table 5.4 summarizes the specific options chosen for the Portfolio RCRI and the Information Sources RCRI.

For the discussion of measure validity it is important to keep the two following points in mind. First, the discussion of the RCRI suggested that the Portfolio RCRI violates an implicit assumption of object homogeneity across interviews. This problem makes questionable the use of Portfolio RCRI data for the analysis of individual differences across portfolio manager groups.

Secondly, the extent to which the scale-does-not-apply response was employed in the Information Sources RCRI makes it imperative that the assumptions about the underlying mathematical space made by the alternative transformations be examined. To be more specific, does the technique recognize and deal with measures of association of similarity that are based on different sample sizes and different subsets of the sample considered? A major part of the effort in the area of measure development and measure choice was, in fact, concerned with this issue.

A final point: In the discussion of the difference between the phenomenological and the analytical measurement procedures, it was suggested that the latter were more objective than the former. Although it is difficult to assess either the importance or extent of the problem, experience in this study suggests that the RCRI also involves a number of subjective translations. In particular, the determination of the individual's constructs involved some interpretation.
Table 5.4 Summary of options chosen for Portfolio Role Construct Repertory Interview and for Information Sources Role Construct Repertory Interview.

<table>
<thead>
<tr>
<th>Conceptual System</th>
<th>Sample Size</th>
<th>Number of Objects</th>
<th>Number of Constructs</th>
<th>Rating Scale Interval</th>
<th>Number of Sorts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolios</td>
<td>23</td>
<td>-</td>
<td>17</td>
<td>10</td>
<td>2 Fixed 5 point</td>
</tr>
<tr>
<td>Information Sources</td>
<td>28</td>
<td>3</td>
<td>15</td>
<td>Variable</td>
<td>Fixed 5 point</td>
</tr>
</tbody>
</table>
Transformations.

In terms of the two-step model of the measurement process, this section deals with the choice of appropriate transformations, given that the Role Construct Repertory Interview has been applied as an instrument. The output of the transformations are measures of four interrelated properties of conceptual systems: differentiation, articulation, centrality, and integration or integrative complexity. Articulation refers to the fineness of organization among stimuli that are ordered on a dimension. Differentiation is the number of elementary dimensions in a conceptual system. Centrality of a dimension is the extent to which the dimension is seen as applicable to a larger or smaller set of the stimuli in a domain. The centrality of a conceptual system is the extent to which only one or a limited number of dimensions are seen as applicable to the whole range of stimuli in a domain. Integrative complexity is a function of the number and nature of the rules in a conceptual system. The property is primarily defined in terms of the resultant behavioral properties of the conceptual system. For example, a highly integratively complex structure is seen as leading to behavior with a more even weighting of the constructs in the conceptual system (see Schroder et al., 1967, p. 73).

Although the theoretical framework used is imprecise on the inter-relationship of the four characteristics of conceptual systems measured and their relationships to the dependent variable of this study, Level-of-Information-Processing, the hypothesis is the Integrative Complexity is the most important determinant of the dependent variable. The development and choice of transformations is therefore focussed primarily on Integrative Complexity. The primary purpose of the measures of the other properties of conceptual
system structure is to use them in an attempt to establish the validity of the primary measure Integrative Complexity.

Measurement of Articulation.

Following Scott (1969) and Riesing (1972), articulation of the conceptual system is defined as the average articulation of the constructs in the system; articulation of a construct is defined as the number of scale intervals used by the portfolio manager in rating objects on the construct:

$$\text{ARTCL} = \frac{1}{K} \times \frac{1}{M} \times \sum_{j=1}^{M} \sum_{k=1}^{K} f_k(a_{ij})$$

where

$$a_{ij} = \text{rating of } i^{th} \text{ object on } j^{th} \text{ construct}$$

$$f_k(a_{ij}) = \begin{cases} 0 & \text{if } a_{ij} \neq k \text{ for all } i=1,...,N \\ 1 & \text{otherwise} \end{cases}$$

ARTCL = Average articulation

K = Number of scale intervals (here = 5)

M = Number of constructs

N = Number of objects

If follows that average articulation (ARTCL) is a score varying theoretically between 1/K (here .2) and one. High values of ARTCL represent high articulation and should generally be positively related to complexity of the conceptual system. However, both Scott and Riesing found that articulation is an independent characteristic of a conceptual system. In this context it is important to note the differences between the measure of articulation
used here and those used by Scott and Riesing respectively. Scott defines articulation in terms of reliable distinctions and his measure is based on data gathered by having the subjects rate the same objects along the same constructs at two distinct points in time. Riesing, on the other hand, used a single rating exercise, but had the subjects specify the number of distinctions they felt they could identify on each construct (i.e., variable interval RCRI). The actual number of different scale distinctions defined, and not those used, served as a basis for his measure of average articulation. As a result, it is not obvious that the findings of Riesing or Scott are directly applicable in this study (differences in relation between articulation and other measures might be due to difference in either one or both of the measures employed).

Measure of Centrality.

Centrality of a conceptual system is defined as the average centrality of the constructs in the system; centrality of a construct is the number of objects rated on the construct:

$$\text{CENTR} = \frac{1}{N} \frac{1}{M} \sum_{i=1}^{M} \sum_{j=1}^{N} g(a_{ij})$$

where \( \text{CENTR} = \) Average centrality

\( a_{ij} = \) rating of the \( i^{th} \) object on \( j^{th} \) construct

\( N = \) Total number of objects that could be rated
\[
g(a_{ij}) \begin{cases} 
1 & \text{if } a_{ij} = \text{scale value response} \\
0 & \text{if } a_{ij} = \text{scale-does-not-apply response}
\end{cases}
\]

in other words,

\[
\sum_{j=1}^{N} g(a_{ij}) = \text{actual number of objects rated on construct } i.
\]

The measure of centrality is quite similar to that used by Riesing (1972). The measure differs from Riesing's by it being standardized in terms of number of objects rated in the RCRI. The standardization makes possible a comparison of centrality scores across RCRI's differing in number of objects. It follows that CENTR is a score that theoretically varies between \((N+M-1)/MN\) (when only one object is rated on each construct except one constructs where all the N objects are rated) and 1, where low values of CENTR imply high centrality.

Theoretically, high centrality scores, that is, low centrality should be the property of complex conceptual systems. Low centrality scores indicate that one or a limited number of constructs are the only ones that the subject feels is applicable to the whole conceptual domain. They therefore dominate functioning in the conceptual domain. Note that the centrality measure used here does not correct for the maximum number of objects rated on any construct. The measure therefore assumes that the maximum number of objects rated is the same in all the RCRI's analyzed. In fact, for all the RCRI's taken in this study, there was always one or more constructs that was applicable to the whole range of objects rated. The transformation therefore captures the desired property of conceptual systems.
Measurement of Differentiation.

Differentiation is defined as the number of elementary dimensions evident in a conceptual system. Two different transformations are used to generate measures of differentiation, Bieri's measure of complexity (Tripodi & Bieri, 1964) that Warr suggests is primarily a measure of differentiation (1970, p. 143) and a measure derived by Alpha Factor analysis (Riesing, 1972).

In the initial research design, only the Alpha Factor Analysis based measure of differentiation was considered. However, due to the implementation of the Bieri measure in the program package converted for use in the measurement of Integrative Complexity and the extent of the scale-does-not-apply response, Bieri's measure was added. This last measure is not troubled by questionable assumptions concerning the underlying mathematical space of the RCRI scores. The measure is a simple non-parametric transformation, which counts the number of similar ratings of all objects over all possible pairs of constructs:

\[
\text{BIERI} = \frac{1}{N} \times \frac{2}{M (M-1)} \sum_{j=1}^{N} \sum_{i=1}^{M-1} \sum_{k=1+1}^{M} f(a_{ij}, a_{jk})
\]

where \( \text{BIERI} \) = Bieri measure of complexity

\( a_{ij} \) = rating of \( i^{th} \) object on \( j^{th} \) construct

\( M \) = Number of Constructs

\( N \) = Number of objects

\[
f(a_{ij}, a_{jk}) = \begin{cases} 
1 & \text{if } a_{ij} = a_{jk} \\
0 & \text{if } a_{ij} \neq a_{jk}
\end{cases}
\]
The Bieri measure has been standardized both for number of constructs and for number of objects. With the unstandardized version, the highest possible score is \( N \times \frac{M(M-1)}{2} \). It follows, clearly, that if not standardized, the larger the number of constructs the subject generates in the RCRI, the higher his Bieri score will be, irrespective of whether he is more or less complex. In fact, lower Bieri scores indicate a larger number of different object ratings and thus a more differentiated conceptual system. With the standardized measure, the Bieri score will vary between 0 and 1, with low scores theoretically indicating a more complex conceptual system.

The second measure is obtained using an Alpha Factor analysis (Kaiser, 1965) of the RCRI grid. Factor analysis was used to determine how many distinct constructs are implied by the RCRI scores obtained. Alpha Factor analysis was chosen as the problem is similar to that for which this method of factor analysis was developed. From the M constructs sampled inferences are to be made about the universe of constructs, rather than making inferences from the N objects sampled about the universe of objects (see Kaiser & Caffrey, 1965, p. 1 and Riesing, 1972, p. 88).

The differentiation measure, DIFF, is the number of generalizable factors. In Alpha Factor analysis the choice of generalizable factors is unambiguous: only those alpha factors which have associate eigenvalues greater than one (Kaiser & Caffrey, 1965, p. 11). Theoretically DIFF can vary between one and M, where M is the number of constructs elicited in the RCRI. The larger the value of DIFF the more differentiated the conceptual system.
A program was developed for the Alpha Factor Analysis.* The computation of correlation coefficients was done by pairwise deletion of missing values; in other words, mean ratings for each construct were based on all scale responses and cross product terms were computed for all pairs where both scale responses existed. The pairwise deletion produces a set of correlation coefficients which are based on a different number of objects and possibly on a quite different subpopulation of objects. The Alpha Factor analysis, however, ignores these differences in sample size and sample composition of the set of similarity measures. The use of the Alpha Factor analysis or, for that matter, any other transformation which relies on an undifferentiated use of the product moment correlation coefficients, is therefore questionable in the case of the Information Sources RCRI, where on the average 10 percent of the responses are missing, in other words, 10 percent scale-does-not-apply responses.

Measurement Of Integrative Complexity

Integrative Complexity is the most important and the least well defined construct or variable in Complexity Theory. The measurement is similarly messy, or rather, is therefore messy. Three different measures are considered in this study, one based on the Alpha Factor analysis used to generate the DIFF measure of differentiation, the two others using Johnson's hierarchical clustering procedure (Johnson, 1967) as a central

* The program was verified against the Alpha Factor analysis procedure available under SPSS.
technique for transforming similarity measures into measures of structure.

As suggested by Driver (1962, as reported in Schroder et al., 1967, p. 26.), "... the more evenly each dimension (of a conceptual system) was weighted in any given set of judgements or perceptions, the greater the probability that the response was generated by an integratively complex structure...," a notion similar to centrality. Translated into factor analysis terms, this is equivalent to an even weighting of the different factors in terms of the amount of variance they account for. The measure adopted is the evenness of factor weighting measured by the mean absolute difference of eigenvalues of the generalizable factors obtained in the Alpha Factor analysis of the RCRI grid scores * (as proposed by Schroder et., 1967, p. 73):

\[
ALPHIC = \frac{1}{(M-F)(F-1)} \sum_{i=1}^{F-1} \sum_{j=i+1}^{F} |e_i - e_j|
\]

where

\[ALPHIC = \text{measure of integrative complexity}\]
\[e_i = \text{the eigenvalue of the } i\text{th generalizable unrotated factor} **\]
\[F = \text{number of generalizable factors}\]
\[M = \text{number of constructs}\]

* The ratio of the largest eigenvalue to the sum of the generalizable factor eigenvalues, in other words, the number of constructs in the RCRI, was not used (used by Riesing[1972]). Both Bieri (1966, p. 27) and Ware (1958, as reported in Vannoy [1965]) suggest that it is a measure of differentiation.

** Riesing used rotated factors (1972, p. 88). However, the unrotated solution seems much more appropriate. It is the solution that captures the largest variance in the first factor, the largest part of the remaining variance in the second factor, and so on -- the most uneven solution possible.
ALPHIC has been standardized partly to control for the number of terms in the sum which is determined by the number of generalizable factors $F$. It has also been standardized to control for the number of constructs in the RCRI grid. The most uneven possible weighting exists when all but one factor have eigenvalues equal to one. In such a situation, assuming $F$ generalizable factors, the last and largest eigenvalue, $E_{\text{max}}$, is given by

$$E_{\text{max}} = M - (F - 1) = M + 1 - F$$

In this case, all differences between eigenvalues are zero, except the $(F - 1)$ differences between the largest eigenvalue and the remaining eigenvalues, $E_i$

$$E_{\text{max}} - E_i = (M + 1 - F) - 1 = M - F$$

Thus

$$\text{ALPHIC}_{\text{max}} = \frac{1}{(M-F) \times (F-1) \times [M - (F-1) - 1]} = 1$$

It follows that ALPHIC varies between zero and one, where low values of ALPHIC should indicate an integratively complex structure.

The standardization of ALPHIC is an attempt to deal with on the one hand, in the case of the Information Sources RCRI, grids that have a variable number of constructs. On the other hand, it is hypothesized that Integrative Complexity is a property that is not necessarily a function of the
number of constructs or of the differentiation in a conceptual system. It is therefore desirable to have a transformation that is mathematically as orthogonal as possible to the measure of differentiation.

The second method used for the measurement of integrative complexity is the measure developed by Smith and Leach which makes extensive use of Johnson's hierarchical clustering scheme (Johnson, 1967). Their measure is one of the few transformations, using RCRI grid data, that has been partially validated as a measure of integrative complexity. Unfortunately it is even more exposed to the problem of scale-does-not-apply responses. However, before reviewing this issue and the Smith and Leach measure in more detail, it seems useful to briefly summarize the hierarchical clustering technique used. This presentation will serve as an introduction to the third measure of integrative complexity, which also relies on the same clustering technique.

In general terms, cluster analysis covers a wide range of techniques designed to determine important and meaningful groupings or clusters of objects. The input is measures of similarity between objects to be clustered. An important property of cluster analysis in general and hierarchical cluster analysis in particular is that it does not require parametric measures of similarity or association. Rather, it can work with any measure of similarity that one finds appropriate or has available for the objects considered.

Johnson's hierarchical clustering scheme (1967) is a scheme that generates "... a sequence of clusterings having the property that any cluster is a merging of two or more clusters in the immediately preceding clustering..." (Miller, 1969, p. 177). The use of this clustering scheme seems particu-
larly appropriate in situations where we might assume that the underlying relation between the entities studied is hierarchical. The technique has seen numerous previous uses, including the study of relationships between verbal concepts (Miller, 1966) and the study of deep structure of English language sentences (Levett, 1970). Its use in the analysis of conceptual systems is theoretically appealing as both Complexity Theory and Kelly's Personal Construct Theory model conceptual systems as being hierarchically organized.

Johnson's hierarchical clustering scheme is deceptively simple. It starts off with all objects considered as independent clusters. It then finds the two most similar clusters based on a scan of all similarity ratings. The pair of most similar objects are merged. In the next step the scheme now has one less cluster to consider. It again chooses the pair of most similar clusters and merges them. This process terminates when all objects are clustered into one single cluster. The output of the algorithm is a hierarchical diagram which is simply a graphical record of the sequence of mergings. At each step the similarity of the two clusters merged is recorded.

Although the hierarchical cluster analysis scheme is simple and easy to follow, it generates an unambiguous sequence of clusterings (in terms of objects and clusters entered and in terms of similarity of clusters merged) only under a very specific condition: when the similarity measures satisfy Johnson's ultrametric inequality (Johnson, 1965, p. 245). The problem arises in determining the distance or similarity between two clusters when the distance or similarity between pairs of objects, taken from each cluster, is not identical. Johnson proposes two different ways to resolve
the ambiguity: a diameter method (or maximum method) which uses the maximum distance over all possible pairs as the distance between the two clusters; a connectedness method (or minimum method) which instead uses the minimum distance over all possible pairs as the distance between the two clusters. As noted by Miller, if the hierarchies obtained by applying respectively the diameter method and the connectedness method are quite different, "... We should be warned either that we are not dealing with a hierarchical conceptual system, or that the data are too noisy for precise analysis..." (Miller, 1969, p. 181). This observation is the source of the idea underlying the third measure of integrative complexity. This point will be returned to after the presentation of the Smith and Leach measure.

Smith and Leach rely on the version of Johnson's hierarchical clusterings scheme which uses the diameter method to determine similarity measures between clusters. They apply the technique successively to cluster both objects and constructs, using the product moment correlation coefficient as similarity measure. The idea is then to simulate a change in the individual's conceptual system and measure how the rating of objects is affected. The individual's construct system is "impoverished" by collapsing constructs into a single construct in terms of the significant clusters determined in the hierarchical clustering of the constructs. A significant cluster is defined as one where the similarity score, that is, the product moment correlation coefficient, at which the cluster was generated, is significantly (p < 0.05) different from zero. The similarity scores for objects are recomputed using object ratings on the new constructs in the impoverished conceptual system. The objects are then clustered a second time using Johnson's hierarchical clustering scheme.
The difference between the original object cluster diagram and the object cluster diagram obtained using the impoverished constructs is measured by a simple node counting technique. A large difference measure indicates a complex conceptual system as they hypothesize "...that the fine details of the construct system will be more important for a complex subject that for a simple subject, so that impoverishing the structure will have a more dramatic effect on the relationships between the objects (people) for the more complex subject ..." (Smith & Leach, 1972, p. 564). In the 1972 article, Smith and Leach report on a number of experiments designed to assess the reliability and validity of their measure. In a test-retest experiment the measure was found to be reliable (rho = .76, p < .01). Validity was assessed using Harvey's "This I Believe" (TIB) test, a phenomenological measure of Integrative Complexity, Bieri's measure of complexity, and a measure of general intelligence (Baddeley's reasoning test [Baddeley, 1968]). Using Mann-Whitney tests, it was found that "...subjects who are cognitively complex on the hierarchical measure tend to be classified as abstract on the basis of their TIB test, while simple subjects are concrete on the TIB test (U = 50, p = .05)..." (1972, p. 565-566). In two of the three experiments, no such relationship was found with Bieri's measure and no significant correlation was found with the reasoning scores (rho = .29, N = 42).

To summarize, the Smith and Leach measure of Integrative Complexity is both theoretically appealing and has been partially validated. It represents a rather complex transformation of RCRI data which is, in part, the reason for its theoretical appeal. However, it is therefore also rather vulnerable to the scale-does-not-apply response problem. The Smith and
Figure 5.2 Overview of Flow of Algorithm to Compute Smith & Leach Measure of Integrative Complexity.
Leach measure faces the scale-does-not-apply, that is, the missing observations, problem, in two places: in the computation of similarity measures both for constructs and objects, and in the computation of simulated ratings of objects on the new constructs in the impoverished construct system (see Figure 5.2). Given that the hierarchical clustering scheme can accept any ordinal or nominal scale measure of similarity, the first problem is not serious. However, a criterion of significance for the similarity measure used must exist in order to be able to determine the impoverished construct system.

The problem of computing object ratings on simulated constructs is more serious. Essentially it is a question of computing a rating of an object on an artificial construct, where the object is not rated on one or more of the constituent constructs. The problem is similar to computing factor scores for objects which do not have scores on one or more of the underlying variables.

The approach taken in this study is to ignore the scale-does-not-apply responses by pairwise deletion of missing values in the computation of correlation coefficients, and by computing a rating on the artificial constructs of the impoverished construct system which considers only those constructs in the cluster that the object has been rated on.

In the collapse of the construct system, the average number of objects rated (equal to the total number of objects possible to rate times the average centrality of the conceptual system) was used to determine the value of a significant correlation coefficient. For example, if the total number of objects rated is eighteen and average centrality is .50, then the value of a significant ($p < .05$) correlation coefficient used is that
for a sample of eighteen times .05 equal to nine.

The solution used is not very satisfactory in the sense that it is difficult to know how it affects the validity of the measure obtained. A third measure was therefore developed that is derived from the notion that large differences between the clusters obtained using both the diameter version and the connectedness version of Johnson's hierarchical clustering scheme should be an indication that the underlying conceptual system is not perfectly hierarchical (see page 93). Such a measure enables us to take advantage of the clustering scheme's ability to deal with non-parametric measures of association used as a measure of object and construct similarity.

Theoretically, high Integrative Complexity should be the property of a conceptual system that is not perfectly hierarchical and compartmentalized (see Schroder et al., 1967, p. 15). It is therefore hypothesized that the difference between the two clusters obtained using the two clustering rules (the diameter and the connectedness rule) could be a measure of integrative complexity. The larger the difference for instance, the less perfectly hierarchical the similarity measures, the more complex the conceptual system.

In short, the final measure of integrative complexity transforms the raw RCRI grid data by simply computing similarity scores for all construct pairs; the constructs are then hierarchically clustered twice on the basis of these similarity measures, once using each of Johnson's rules. Finally the two clusters are compared and the difference between the two clusters is hypothesized to be a measure of integrative complexity.
This general transformation has been performed using both the product moment correlation coefficient and the Goodman and Kruskal lambda measure of association for symmetric, nominal scales (1954), as the measure of construct similarity. In the latter case, the RCRI rating of objects is considered to apply to a six-point nominal scale consisting of the five scale points plus the scale-does-not-apply response.

The difference between the two clusters obtained is measured using a metric proposed by Boorman and Olivier (1973, p. 30-32) to compare valued trees. The metric is based on computing the sum of the absolute difference in value of the lowest node in common for a pair of constructs, over all possible different construct pairs. This metric was chosen because it was simple and intuitively appealing in that it gives less weight to a difference in clustering when the constructs cluster at very close similarity values than when they cluster at similarity values far apart. The measure has been standardized for the number of terms in the sum, which is a function of the number of constructs in the RCRI.

Transformations - Summary.

The discussion of transformations has introduced eight different measures covering four different structural properties of conceptual systems. Table 5.5 attempts to pull together some of the important properties of the transformations introduced, in terms of the characteristics they are hypothesized to measure, the basic measure of association used, the general characteristic of the transformation, and the abbreviated label to be used in the discussion of validity in the final section of this chapter. The
Table 5.5 Overview of Measures of Conceptual System Structure Considered.

<table>
<thead>
<tr>
<th>Characteristic of Conceptual System Structure Measured</th>
<th>Label</th>
<th>General Description of Transformation used</th>
<th>Measure of Construct Similarity Used</th>
<th>Direction of Hypothesized Relation to Int. Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articulation</td>
<td>ARTCL</td>
<td>Average over all constructs</td>
<td>- none -</td>
<td>positive (+)</td>
</tr>
<tr>
<td>Centrality</td>
<td>CENTR</td>
<td>Average over all constructs</td>
<td>- none -</td>
<td>positive (+)</td>
</tr>
<tr>
<td>Differentiation</td>
<td>BIERI</td>
<td>Average over all pairs of constructs</td>
<td>Non-parametric count</td>
<td>negative (-)</td>
</tr>
<tr>
<td>Differentiation</td>
<td>DIFF</td>
<td>Number of generalizable factors from Alpha Factor analysis</td>
<td>Pearson product moment correlation</td>
<td>positive (+)</td>
</tr>
<tr>
<td>Integrative Complexity</td>
<td>ALPEIC</td>
<td>Mean absolute difference between eigenvalues of generalizable factors from Alpha Factor Analysis</td>
<td>Pearson product moment correlation</td>
<td>negative (-)</td>
</tr>
<tr>
<td>Integrative Complexity</td>
<td>SMLIC</td>
<td>Hierarchical Cluster analysis and simulation of collapse of construct system</td>
<td>Pearson product moment correlation</td>
<td>positive (+)</td>
</tr>
<tr>
<td>Integrative Complexity</td>
<td>CMPIC</td>
<td>Hierarchical Cluster analysis and comparison of clusters obtained using Diameter and Connectedness Method respectively</td>
<td>Pearson product moment correlation</td>
<td>positive (+)(^a)</td>
</tr>
<tr>
<td>Integrative Complexity</td>
<td>CPNOM</td>
<td></td>
<td>Goodman and Kruskal lambda</td>
<td>positive (+)(^a)</td>
</tr>
</tbody>
</table>

Note: a - Based on subsequent validation tests, it is hypothesized that the relationship between CMPIC and CPNOM, and Integrative Complexity is rather negative (-).
same label will be used for both RCRI's with the subscript PORTFOLIO and the subscript INFO. SOURCES denoting respectively the measure based on the Portfolio RCRI and the Information Sources RCRI.

Table 5.5 identifies an important distinction, in terms of logical unit of transformation, between the ARTCL, CENTR measures and the BIERI, DIFF, ALPHIC, SMLIC, CPNOM, CMPIC measures. The logical unit of the transformations for the two first measurements is a characteristic of single constructs, which is averaged over all constructs. On the other hand, the logical unit of the transformation underlying BIERI, DIFF, ALPHIC, SMLIC, CPNOM, CMPIC is the measure of the similarity of pairs of constructs which are subjected to more or less complex transformations. The simplest of these is BIERI which is an average of construct similarity given all different pairs of constructs. The difference between logical unit of transformation is a distinction between surfact properties of conceptual systems and deeper structural properties of conceptual system. A priori, from a notion of transformational complexity (see Miller & Chomsky, 1963, p. 485) it would seem that only the transformations working on measures of properties of the relation between constructs have the necessary complexity to be able to fully capture a characteristic such as Integrative Complexity. Obviously, this is not the same as saying that they have sufficient or the appropriate complexity.
Validation and Selection of Measures

In this final section data based on the sample obtained is presented and discussed in order to evaluate and choose among the different measures considered. Formally the section is an attempt to perform a "weak" test of the convergent validity of the measures. The test is weak in the sense that compared with the full blown multitrait-multimethod test suggested by Campbell and Fiske (1959), it is to a large extent a multitrait-singlemethod test. It is an important step given that a number of different measures of conceptual structure have been defined, some theoretically measuring the same thing, all theoretically interrelated.

The test of convergent validity attempts to determine if the null hypothesis of no relationship between measures is rejected by the data. If in fact the null hypothesis is clearly and consistently rejected, then the hypotheses of the study can be tested using the measures obtained. On the other hand, if the data do not suggest convergent validity and a number of theoretically related measures which in the sample obtained, either are not related or are related but in a fashion opposite to what is hypothesized, then some serious problems arise. Before proceeding with a test of hypothesis, a decision must be made on which, if any, of the numerous measures capture the properties of interest. Otherwise data on relationships cannot be used for hypothesis testing but only for describing actual relationships evident in the sample collected. Stated bluntly, it is the difference between a formal test of hypothesis and a fishing expedition.
A priori, two major problems make the validity of the measure suspect: (1) The problem of the homogeneity of the underlying object space in the case of the portfolio RCRI; (2) The problem of the scale-does-not-apply responses in the case of the Information Sources RCRI.

As the rest of the chapter will show, there is little evidence of convergent validity in the measures considered. The problem of selection is therefore complex and hope is expressed that the reader will bear with a rather tortuous line of reasoning from which emerges a limited number of measures that have captured interesting characteristics of the conceptual systems sampled.

Specifically, based on theoretical, methodological and empirical considerations, two measures of the structure of information source perception are retained for subsequent hypothesis testing: ALPHIC, the Alpha Factor analysis based measure of Integrative Complexity, and CPNOM, the measure based on comparing the two clusters obtained using either of Johnson's clustering rules on a matrix of similarity measures computed using the lambda nominal scale measure of association (see Table 5.5).

Convergent Validity of Measures of Integrative Complexity

Table 5.6 gives an overview of the mean, standard deviation and skew for all the measures considered, both for the Portfolio RCRI and Information Sources RCRI.

Convergent validity is tested on the basis of the first order relationship between the different measures. The measure of association used is the Pearson product moment correlation coefficient. A test of the dis-
Table 5.6 Some Descriptive Statistics for the different measures of Conceptual System Structure considered.

<table>
<thead>
<tr>
<th>Portfolio RCRI</th>
<th>Information Sources RCRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>DIF</td>
<td>3.00</td>
</tr>
<tr>
<td>ALPHIC</td>
<td>.54</td>
</tr>
<tr>
<td>BIERI</td>
<td>.19</td>
</tr>
<tr>
<td>ARTCL</td>
<td>.90</td>
</tr>
<tr>
<td>SMLIC</td>
<td>284</td>
</tr>
<tr>
<td>CMPIC</td>
<td>.30</td>
</tr>
<tr>
<td>CPNOM</td>
<td>.20</td>
</tr>
<tr>
<td>CENTR</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: N = 23 for Portfolio RCRI based measures; N = 28 for Information Sources RCRI based measures.

* significantly skewed - p < .05 one tailed test of significance
tribution of scores on most of our measures indicates that most are not significantly skewed (see Table 5.6). For those where there is a significantly skew, examination of first order relationships using Kendalls' rank order correlation coefficient does not seem to affect the conclusions. In an effort to keep an already messy discussion as simple as possible, the product moment correlation coefficients will only be considered.

Table 5.7 presents the multi-measure correlation matrix with two entries in each cell for measures respectively based on Portfolio RCRI and on Information Sources RCRI data.

Convergent validation is a conceptually simple test. In reality, with a large number of measures interpretation of a correlation matrix becomes very much a complex pattern recognition task in all but the clear cut situations involving either complete support or complete lack of support. Amongst other problems, it is difficult to keep straight the hypothesized direction of the relationship between pairs of measures in a situation where complexity is hypothesized to indicated by high scores on some measures and low scores on others. In an effort to simplify matters the sign of the hypothesized relationship is indicated in the appropriate cell for each pair of measures.

Given that we are primarily concerned with the direct measurement of Integrative Complexity, the discussion will focus initially on the relationship among the four different measures hypothesized to capture this property. There is little evidence of convergent validity. Only two relationships have the hypothesized relationship: CPNOM_{Info. Sources} and CMPIC_{Info. Sources} (p < .10, one-tailed test of significance) and CPNOM
Table 5.7  Correlation between four measures of Integrative Complexity in the two domains sampled.

<table>
<thead>
<tr>
<th></th>
<th>SMLIC</th>
<th>CMPIC</th>
<th>CPNOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPHIC</td>
<td>(-) .19</td>
<td>(-) -.22</td>
<td>(-) .10</td>
</tr>
<tr>
<td></td>
<td>.13</td>
<td>.32</td>
<td>.21</td>
</tr>
<tr>
<td>SMLIC</td>
<td>(+) -.03</td>
<td>(+) .33*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMPIC</td>
<td>(+) .06*</td>
<td></td>
<td>.28</td>
</tr>
</tbody>
</table>

Note: Portfolio RCRI based measures in top of cell (N = 23); Information Sources RCRI based measures in bottom of cell (N = 28). Sign of hypothesized relationship between measures in parenthesis in front of relevant coefficients.

* p < .10 one tailed test of significance
Portfolio and SMLIC Portfolio (p < .10, one-tailed test of significance). The remainder of the correlation coefficients are not significantly different from zero in the hypothesized direction. In fact, seven of the twelve relationships have the wrong sign and one is significantly different from zero in the wrong direction: CMPIC Info. Sources and ALPHIC Info. Sources (p < .10, two-tailed test of significance). In short, there is no or little evidence of convergent validity among the direct measures of integrative complexity.

Relation to a Cognitive Style Measure.

As noted in the introduction to this section, this test of convergent validity is in fact a multitrait–singlemethod version, since all measures rely on the RCRI as instrument. However, data was collected using a different instrument that is relevant to the issue, although it cannot be used other than as secondary evidence. As part of an exploratory study in the Trust department, portfolio managers were administered the Learning Style Inventory (Kolb, 1971), a cognitive style measure that was developed to capture a distinction between reflective observation and active experimentation, on the one hand, and concrete experience versus abstract conceptualization on the other. The latter style distinction can be considered similar to the concrete–abstract distinction in Complexity Theory (Stabell, 1973). The Learning Style Inventory was not administered a second time during the main study, as it is difficult to focus the instrument on a specific cognitive domain. However, some arguments exist that suggest that the data obtained in the exploratory use of the LSI did in fact
sample style components relevant to portfolio management (Stabell, 1973). It therefore seems worthwhile to explore the relationship between LSI scores and the measures of integrative complexity considered in the study.

LSI data exists for sixteen of the portfolio managers sampled with the portfolio RCRI and for twenty of the portfolio managers sampled with the Information Sources RCRI. The sample is biased as it represents the more experienced portfolio managers and, in the case of those that overlap with the portfolio RCRI, it includes mainly portfolio managers in the Personal Trust and Investment Advisory groups. Given this bias, the correlation coefficients in Table 5.8 between the measures of integrative complexity and the LSI scores must only be interpreted as suggestive.

In terms of the hypothesized direction of the relationship, three significant, non-zero correlations are indicated: AC and ALPHIC \textsubscript{Info. Sources} (p < .05, one-tailed test of significance), AC and SMLIC \textsubscript{Portfolio} (p < .10, one-tailed test of significance and CE and CPNOM \textsubscript{Info. Sources} (p < .05, one-tailed test of significance). Furthermore, the pattern of relationships differ across conceptual domains, with two significant non-zero correlation coefficients with a sign opposite to that hypothesized in the portfolio domain; CMPI \textsubscript{Portfolio} and CE \textsubscript{Portfolio} (p < .10, two-tailed test of significance) and CMPI \textsubscript{Portfolio} and AC \textsubscript{Portfolio} (p < .05, two-tailed test of significance). In fact, five of eight (two significant) predicted signs in the case of the measures from the Information Sources RCRI, while only one of eight correct signs in the case of the measures derived from the portfolio RCRI data. The differing pattern can be interpreted as evidence that the LSI has sampled the concrete abstract direction in one cognitive domain, and not necessarily that the measures have low validity.
Table 5.8  Correlation between measures of Conceptual System Structure and the components of the Learning Style Inventory.

<table>
<thead>
<tr>
<th></th>
<th>Concrete Experience</th>
<th>Reflective Observation</th>
<th>Abstract Conceptualization</th>
<th>Active Experimentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPHIC</td>
<td>(+) - .39</td>
<td>.15</td>
<td>(-) .40**</td>
<td>-.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(-) -.41</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMLIC</td>
<td>(-) -.06</td>
<td>-.38</td>
<td>(+) .34*</td>
<td>.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMPIC</td>
<td>(-) .48°</td>
<td>.62</td>
<td>(+) -.52</td>
<td>-.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CNPOM</td>
<td>(-) -.48**</td>
<td>.06</td>
<td>(+) .36</td>
<td>.18</td>
</tr>
</tbody>
</table>

Note: Portfolio RCRI based measures in top of cell (N = 16); Information Sources RCRI based measures in bottom of cell (N = 20). Sign of hypothesized relationship between measures in parenthesis in front of relevant coefficients.

** p < .05 one tailed test of significance
*  p < .10 one tailed test of significance
°  p < .05 two tailed test of significance
°  p < .10 two tailed test of significance
From the analysis of the relationship between the measures of integrative complexity and the relevant dimensions from the LSI there is some evidence that particularly ALPHIC and CPNOM are capturing some relevant, although different, characteristics of a conceptual system that relates to the abstract-concrete distinction. Again care must be taken not to give too much weight to this conclusion in the overall analysis given the limitations and biases inherent in the sample considered. Rather it should be considered as but one small piece in the puzzle that this analysis is attempting to put together.

Relation to other Measures of Structure

The final step in the formal test of convergent validity involves examining the measures of other structural properties of conceptual systems, all of which are theoretically related to Integrative Complexity. The relationship between these measures and the direct measures of integrative complexity could furnish limited support for the validity for one or more of the latter measures.

The relationship between the two measures of differentiation, BIERI, and DIFF, does not indicate convergent validity in the measures of this property (see Table 5.9). In the case of the Information Sources constructs the relationship has actually a sign opposite to that predicted.

In terms of the interrelationship between the measures of differentiation, articulation and centrality, there are two correlations coefficients that indicate some convergent validity: BIERI<sub>Info. Sources</sub> and CENTR<sub>Info. Sources</sub> (p < .05, one-tailed test of significance) and
Table 5.9 Correlation between measures of Integrative Complexity and other measures of conceptual System Structure in the two domains sampled.

<table>
<thead>
<tr>
<th></th>
<th>BIHER</th>
<th>ARTCL</th>
<th>CENTR</th>
<th>ALPHIC</th>
<th>SMLIC</th>
<th>CMPIC</th>
<th>CPNOM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DIFF</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>(-)</strong> -.29</td>
<td>(+) -.20</td>
<td>(+) na</td>
<td>(-) -.10</td>
<td>(+) -.39°</td>
<td>(+) -.17</td>
<td>(+) -.03</td>
</tr>
<tr>
<td></td>
<td>.26</td>
<td>.25</td>
<td>.11</td>
<td>.42°</td>
<td>.13</td>
<td>.28</td>
<td>.21</td>
</tr>
<tr>
<td><strong>BIHER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-) -.28*** (-) na</td>
<td>(+) .03</td>
<td>(-) -.03</td>
<td>(-) -.30</td>
<td>(-) .13</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-.51 ** (-) -.39 **</td>
<td>.03</td>
<td>.03</td>
<td>-.08</td>
<td>.33°</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ARTCL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(+) na</td>
<td>(-) -.47**</td>
<td>(-) .06</td>
<td>(+) .12</td>
<td>(+) -.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.25</td>
<td>-.10</td>
<td>.11</td>
<td>-.02</td>
<td>-.34°</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CENTR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-) na</td>
<td>(+) na</td>
<td>(+) na</td>
<td>(-) -.39°</td>
<td>(+) na</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-.16</td>
<td>-.11</td>
<td>-.39°</td>
<td>.01</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Portfolio RCRI based measures in top of cell (N = 23); Information Sources RCRI based measures in bottom of cell (N = 28). Sign of hypothesized relationship between measures in parenthesis in front of relevant coefficient. na - not applicable

*** p < .01 one tailed test of significance
** p < .05 one tailed test of significance
* p < .10 one tailed test of significance
° p < .10 two tailed test of significance
BIERI_{\text{Info. Sources}} and ARTCL_{\text{Info. Sources}} (p < .01, one-tailed test of significance). Of a total of nine correlation coefficients five have the predicted sign. However, except for the relationship between ARTCL and DIFF (which is the opposite of that predicted) the relationship between the different measures is quite different as we move from the domain of portfolios to the domain of information sources. Tentatively this can be interpreted as indicating that the different characteristics are not interrelated as predicted, and are in fact different independent characteristics of conceptual systems that can have different inter-relationships across conceptual systems. The analysis also indicates that an examination of the relationship between ARTCL, BIERI, CENTR and DIFF, on the one hand, and the direct measures of Integrative Complexity on the other hand, will not help very much in selecting a "valid" measure of Integrative Complexity. It is still worthwhile, however, as an attempt to document the actual empirical relationships.

Of the 28 relationships between the four measures of integrative complexity and the four other measures of conceptual system structure, only one is significant in the predicted direction: ARTCL_{\text{Portfolio}} and ALPHIC_{\text{Portfolio}} (p < .05, one-tailed test of significance). Thirteen of the relationships are consistent with the direction predicted. Among those fifteen that are not consistent, five are significantly different from zero: SMLIC_{\text{Portfolio}} and DIFF_{\text{Portfolio}}' ALPHIC_{\text{Info. Sources}} and DIFF_{\text{Info. Sources}}; CPNOM_{\text{Info. Sources}} and BIERI; CPNOM_{\text{Info. Sources}} and ARTCL; CMPIC_{\text{Info. Sources}} and CENTR_{\text{Info. Sources}} (p < .10, two-tailed test of significance).
Three aspects of this overall pattern seem important:

1. The analysis gives no support for convergent validity of a single of the measures of Integrative Complexity.

2. The pattern of relationship differs for the two construct systems sampled. Or stated in other words, there is no dominating pattern of relationships across construct system.

3. Two of the significant relationships with a sign opposite to that predicted involve CPNOM^ Info. Sources. Although a couple of significant correlations in a sample of twenty-eight should not be given any weight, they still might be interpreted as a hint that the direction of the relationship, if any, between CPNOM and integrative complexity is opposite to that predicted. Hierarchic construct systems (in the sense of Johnson's ultrametric) are perhaps the more integratively complex and not the more integratively simple as hypothesized.

Conclusions of Validation and Selection Discussion

The overall conclusions from the test of the measures for convergent validitu is simple: there is no or little evidence of convergent validity. This conclusion is based both on an analysis of the relationship between the four direct measures of Integrative Complexity and on an analysis of the relationship of these latter measures with the other measures of conceptual system structure considered.

The lack of convergent validity in the measurement of the major independent variable implies that it will be difficult to test the hypothesis of this thesis. Support or rejection of the null hypothesis using the
measures cannot necessarily be taken as evidence either way concerning the theory. However, the lack of a consistent pattern in the relationship between the measures across construct systems does indicate that it is in fact the theory that needs to be reconsidered. Although it is difficult to establish the effect of non-homogeneous objects in the case of the portfolio RCRI, the data does suggest that there are perhaps a number of independent properties of conceptual systems.

As noted in the discussion of Complexity Theory in Chapter 2, the underlying model of a conceptual system is imprecise and non-operational. Any effort aimed at refining the theoretical basis of this thesis will require a major effort directed towards developing a more formal model which predicts the relationship between the different properties considered. It is only when armed with such a theory that one can expect to develop a theory relating these structural characteristics of conceptual systems to aspects of the managers decision making and information processing behavior. The development and testing of such a theory is obviously neither appropriate to nor within the scope of this thesis. However, the implication for this effort is clear; given that different aspects of conceptual system structure seemingly have been measured, which measures capture the aspects most related to Integrative Complexity? It is in the context of this question that the data from the relationship of the measures and the Learning Style Inventory can be used. The analysis suggested that ALPHICPortfolio, ALPHICInfo. Sources, CMPICPortfolio and CPNOMInfo. Sources might be relevant to the integratively simple (concrete) - integratively complex (abstract) dimension. They can therefore be used for a weak test of the hypothesis of the study.
Measurement and methodological considerations form a secondary basis for the rejection of certain measures of integrative complexity. Both SMLIC\textsuperscript{Info. Sources} and CMPIC\textsuperscript{Info. Sources} are rejected on the basis of the scale-does-not-apply response issue. CMPIC\textsuperscript{Info. Sources} is rejected solely on the basis of a comparison with CPNOM\textsuperscript{Info. Sources} where the latter is seen as methodologically more valid (ref. scale-does-not-apply problem). The same logic is used to drop CPNOM\textsuperscript{Portfolio} relative to CMPIC\textsuperscript{Portfolio} as in the case of the portfolio RCRI data, the product moment correlation coefficient is an appropriate measure of similarity.

In the case of the portfolio RCRI data, SMLIC can be retained on the basis of the validation performed by Smith and Leach.

To summarize the discussion to this point, the following measures of integrative complexity have been retained for a test of the hypothesis of the thesis: (ALPHIC, SMLIC, CMPIC)\textsuperscript{Portfolio} and (ALPHIC, CPNOM)\textsuperscript{Info. Sources}.

There is a problem with CMPIC and CPNOM in that there is some weak evidence that the direction of the measure is opposite to that initially hypothesized. In retrospect, it is obvious that I fell into the very trap identified in the discussion of measures used by other researchers. The CPNOM (CMPIC) was suggested on the basis of a very broad and non-specific hypothesis concerning the properties of integratively complex conceptual system. In fact, the measure was developed on the basis of a hypothesized property of the categorization of stimuli or objects, compartmentalization, which was assumed equivalent to the compartmentalization of construct systems. The issue of directionally cannot be resolved
with the data available. Instead, the hypothesis testing will refer to CMPIC (CPNOM) as a measure of the degree of hierarchical organization in a conceptual system, a property for which there is weak evidence of a relationship to the notion of integrative complexity. A finding that this measure is highly correlated with the dependent variable suggests that it will be of great value to validate and understand in more detail the measure developed.

The problem of the non-homoneneous objects sampled in the case of the portfolio RCRI, implies that the measures of integrative complexity derived from this measure cannot be assumed to be solely a function of the individual portfolio manager, but also a function of characteristics of the task he is performing. This in turn implies that for the test of the major hypothesis, only measures derived from the information sources RCRI can be used. We cannot test directly the hypothesis that it is the integrative complexity of the portfolio construct system which is the determinant of the managers' Level-of-Information-Processing in the investment task.

Finally, considering the four other measures of conceptual system structure measured, the data suggests that they are independent characteristics of conceptual structure. From a theoretical point of view, Integrative Complexity is the important determinant of Level-of-Information Processing. Explicit hypotheses concerning the relationship between articulation, centrality and differentiation, on the one hand and Level-of-Information-Processing on the other hand does not exist. The implicit hypothesis is rather that these three characteristics are all related to
the Integrative Complexity of a conceptual system, and only thereby to Level-of-Information-Processing. Given the general lack of convergent validity, the hypothesized link is tenuous. These measures of conceptual structure will therefore not be used in a hypothesis testing mode, but rather primarily in a descriptive mode.

To conclude, ALPHIC_{Info. Sources} and CPNOM_{Info. Sources} are the two measures of Integrative Complexity that will be used to test the main hypothesis of the study.

Implications.

Before leaving this chapter on the measurement of conceptual system structure, it seems appropriate to summarize some of the implications and directions for further research in the area.

Before much more progress can be made in the area of measurement of conceptual system structure, a more explicit model of conceptual systems must be developed. This model must include both attributes and rules or procedures for making more complex judgements. This study seems to indicate that there are a number of independent structural properties of a conceptual system and a formal model could help to clarify some of the possible interrelationships. In particular, one plausible hypothesis to explore is that the relationship between the different properties varies with the degree of overall development of the conceptual system.

A promising avenue of research would be to develop a model of a conceptual system that was implemented as a computer program where one could
simulate the implications of different degrees of Integrative Complexity for responses to a task similar to the Role Construct Repertory Interview. Integrative Complexity could be modeled and explored in terms similar to those proposed by Miller and Chomsky in the discussion of "Towards a Theory of Complicated Behavior", (1963, pp. 483-488): information and redundancy, degree of self embedding, depth of postponement, structural complexity, and transformational complexity.

At a more concrete level, when using the Role Construct Repertory Interview, care must be taken to consider the problem of non-homogeneous objects. In cases where it is important to sample conceptual systems where the individuals interviewed are only familiar with objects that necessarily are heterogeneous across individuals, it seems advisable to consider other techniques. One such technique might be Zajonc's procedure which operates directly on the constructs elicited to determine the structural characteristics of the conceptual system in question (see Zajonc [1960]).
Chapter 6: Measurement: Level-of-Information-Processing

This chapter is concerned with the measurement of process characteristics. The process characteristics considered, labelled Level-of-Information-Processing, are the focal and dependent variables of the study. They cover such aspects of managerial decision making as number of information sources used, volume of information sources used, volume of information source use, balance in use, and number of alternatives considered. Although the measurement issues are different from those faced in the measurement of conceptual system structure, they are, however, equally complex and problematic. The chapter presents the different measures considered, the instruments used, and some methodological and theoretical issues uncovered.

Direct attempts at assessing the validity of the measures used have not been made. As the discussion will indicate, the issue of validity is not attached so much to the instruments used or the scores devised, but rather to the behavior sampled and how it should be aggregated. However, all the measures considered are theoretically indices of the same more general process characteristic, Level-of-Information-Processing; that is, they are hypothesized to be interrelated, being all indices of a unitary concept. The relationship between the measures of different process characteristics considered are reviewed in order to determine if they exhibit the hypothesized relationship in the data sampled. Although this analysis suggests a certain local support of the theoretical hypothesis, it clearly is not supported in a global sense, that is, over all information processing behavior sampled. Together with the problems encountered in the measurement of conceptual system structure, the conclusion of this chapter implies that the
analysis of the relation between structure and process will have to be approached in a fashion quite different from that anticipated.

Internal versus External Process Characteristics

From the point of the individual decision maker, his decision making and problem solving processes are a single flow of interrelated events and interactions. From the perspective of the measurement of characteristics of this process, however, the flow has two quite distinct components: on the one hand, those events and interactions that involve an observable interaction between decision maker and the physical environment; on the other hand, those events and interactions that are internal to the individual, involving his conceptual systems and the perceived or internal representation of the environment. The distinction has been labelled a distinction between external and internal process characteristics.

This study is concerned with both aspects of the decision makers total decision making and information processing behavior. However, given that the study covers a large number of decision makers (relative to studies such as Clarkson's (1962) which focused on the internal processes of a single decision maker), the emphasis is on measures of external process characteristics. The discussion, which has been broken up into two parts dealing with the measurement of characteristics of the two different components of the decision making process, is therefore most extensive when it deals with the measurement of external process properties.
Measurement: External Process Characteristics

The discussion of the theoretical framework proposed suggested that the primary measures of external information processing characteristics deal with the managers sampling of information. The three aspects of this information sampling behavior involve the number of different sources sampled or breadth in information source sampling, the total volume of information source sampling, and the balance or evenness of information source sampling. These three measures have been applied to two distinct classes of information sources, personal and impersonal, and within the latter, to a more detailed analysis of the use of the interactive computer based system designed to support the portfolio managers investment decision making in the Portfolio Composition System.

The analytical form of the measures used is identical across the three different sets of information sources considered. The common form of the measures will therefore be discussed first.

Breadth of Source Use.

Some of the measures used are quite simple and straightforward. The breadth of information source use is the number of different sources which have been referenced once or more:

\[ M = \sum_{i=1}^{K} f(N_i) \]
where \( M \) = breadth of information source use
\( K \) = total number of different sources available
\( N_i \) = number of references to information source \( i \)

\[
f(N_i) \begin{cases} 
1 & \text{if } N_i > 0 \\
0 & \text{if } N_i = 0 
\end{cases}
\]

Theoretically, a reference to an information source is the event involving access, information transfer, and release of the information source. In practice, a reference to a source is defined as what the managers considered a distinct reference to a source of information in the case of the use of impersonal and personal sources. For the use of the Portfolio Composition System, a reference is defined as a request for a report.

The measure of breadth differs from that used by Karlins (1967), in that it does not adjust for differences in the total number of references to information sources. Karlins used analysis of covariance to test his hypothesis concerning the relationship between breadth and integrative complexity. The analysis was done controlling for number of requests for information using cell means adjusted for total number of requests (Karlins, 1967, p. 275). Such an adjustment would imply that the theory hypothesizes that for an equal amount of total information source use, the integratively complex individual will sample a greater number of information sources. This hypothesis goes beyond what the theory used explicitly states. The adjustment has therefore not been made.
Volume of Source Use.

The volume of information source use is the total number of references to the information sources considered:

\[ N = \sum_{i=1}^{K} N_i \]

where  
\( N = \) volume of use  
\( K = \) total of different information sources available  
\( N_i = \) number of references to information source \( i \).

Balance in Source Use.

A modified version of the uncertainty measure \( H \) used by Karlins (1967) to measure breadth and evenness of information search is the basis for the measure of evenness or balance in information source use. The uncertainty measure \( H \) is defined as

\[ H = (\log_2 N - \frac{1}{N} \sum_{j=1}^{M} N_j^{*} \log_2 N_j^{*}) \text{ for } M > 1 \]

and  
\[ H = 0 \text{ for } M \leq 1 \]

where  
\( N_j^{*} = \) number of references to the \( j^{th} \) source used; that is, \( j^{th} \) source where \( N_i > 1 \)  
\( N_i = \) number of references to source \( i \)  
\( N = \) volume of information source use = \( \sum_{j=1}^{M} N_j^{*} = \sum_{i=1}^{K} N_i \).
\[ K = \text{total number of information sources available} \]
\[ M = \text{breadth in information source use} \]

The uncertainty measure \( H \) is particularly suitable in a situation where one is interested in the evenness of a distribution of a sampling frequency over a discrete number of states, in this case, information sources. Intuitively, it captures our knowledge about the process studied. High values of \( H \) indicate that the sampling distribution is flat and that there is quite a lot of uncertainty about which source will be the next one sampled. On the other hand, a very uneven sampling distribution, indicated by low \( H \) values, suggests that there is quite a lot of certainty about what source will be sampled next. The probability that another sampling will increase this knowledge of the process is therefore low. Therefore the use of the term "uncertainty measure."

The measure \( H \) defined above is a function of the breadth \( M \) in information source use. Specifically, in the case that all the \( N_j \)'s are identical, in other words, for a completely even use of the sources referenced, the value of \( H \) is \( \log_2 M \). In order to obtain mathematically orthogonal measures of balance and evenness, the \( H \) measure has been standardized for breadth in use:

\[
B = \frac{1}{\log_2 M} \left( \log_2 N - \frac{1}{N} \sum_{j=1}^{M} N_j \log_2 N_j \right) \text{ for } M > 1
\]

and \( B = 0 \) for \( M \leq 1 \)
The balance measure B has a value that varies between zero and one. The greater the value of B, the more balanced the sampling of the different sources used.

Instruments used to Sample Information Source Use.

From the discussion of the three measures of information source use we see that they all operate on a common data structure. For the measurement of these properties of an individual's use of a set of information sources, the only datum required is a vector of the individual's usage frequency of the individual sources in the set. The instruments used to capture estimates of this vector for the three different sets of information sources considered is the topic of the next section.

The basic data collection instrument used to sample individual information source use is a self-administered questionnaire similar to the questionnaires used by Allen to study information flows in organizations. (Allen, 1969). In addition, the Portfolio Composition System records all interactions between portfolio managers and system. The log of these interactions is the source of detailed data on system use.

Information Sources and Communication Pattern Survey.

The Information Sources and Communication Pattern Survey questionnaire used to sample information source use is shown in Appendix 4. The first question in the questionnaire provides estimates of impersonal source use, while the second question was used to sample use of personal sources. There
is some overlap in information sources covered in the two questions given that question one requests data on aggregate use of personal sources (such as colleagues, traders, and analysts). Having the managers give aggregate and disaggregate data on the same events was an attempt to get an estimate of the reliability of the data provided. Furthermore, question two contains individuals (such as administrative officers) with whom communication is not assumed relevant to the investment task that the study focuses on. They were included, however, in order to facilitate the task of the portfolio managers in terms of filling out the questionnaire by not leaving them with the burden of deciding in detail what communication was relevant and what is not relevant to the investment task.

Let us briefly review some general properties of the instrument used before focusing on some of the specific issues faced in the design and use of the Information Sources and Communication Pattern Survey questionnaire.

The fundamental idea of this type of self-administered questionnaire is to have the individual being surveyed report recent events. In order to facilitate his task, as many as possible of the actual events of interest are listed and thereby should help trigger his recall. In the case of the questionnaire used here, the portfolio manager is asked to fill out the questionnaire at the end of the work day and report events that occurred during the same day. The events of interest are use of information sources and the questionnaire therefore lists the set of relevant information sources.

This brief presentation suggests an important issue in the design of a specific and concrete questionnaire: what is the set of relevant information sources? Stated in other words, the question is one of how to define an information source. In the case of personal information sources, the
natural definition is the individual as it represents a distinct physical entity (this is not the same as saying that all communication with an individual is relevant). However, the issue is not as simple when we consider for example the Wall Street Journal (a frequently used source of information in the Trust Department): should each edition of the newspaper be considered as a distinct source or should one rather consider the set of all editions of the Wall Street Journal as one source of information? These issues are raised here merely to put in perspective the reasoning that lay behind the actual list of information sources used. The issue will, however, re-emerge when the data obtained are discussed.

The information sources listed in the first question of the Information Sources and Communication Pattern Survey Questionnaire were determined primarily on the basis of experience with, and exposure to the Trust department. The list of sources reflects the labels used by portfolio managers in a number of interviews over a two-year period. Furthermore, it covers those sources mentioned in a portfolio manager manual available in the Trust Department. Finally the questionnaire was pretested both in the form of using a similar list of information sources in a pre-PCS usage survey, and, in its final form, with a limited number of portfolio managers. The main concern of the pretesting was that the individual labels used made sense to the portfolio managers, and, that the set of labels covered the range of sources available and used.

In short, the set of information sources used in question one does not reflect a theoretical position of what defines a distinct impersonal source of information in the Trust Department, but rather reflects the "culture" of the department; in other words, what is considered by the members of
the department as distinct and recognizable sources of information.

The list of individuals that were considered relevant personal sources of information were determined in a fashion similar to the list of impersonal sources. The major categories of individuals were suggested from interviews and discussion with personnel in the Trust Department. An exhaustive list of individuals was made primarily on the basis of the bank's internal telephone catalogue. The list obtained was then pretested with a limited number of portfolio managers.

The Information Source and Communication Pattern Survey Questionnaire was administered three times, twice in November 1973, and once in December 1973. The choice of a sample of three days reflects the same basic trade-off between reliability and representativeness, on the one hand, and the amount of time that the managers were perceived willing to contribute. The questionnaire was handed to the managers at the beginning of their work day, all on the same three days. Most managers filled out the questionnaire at the end of the day it was handed out, as requested. A limited number filled it out at a later date. The response rate was 86%. However, some managers were not administered a questionnaire, either because they were ill, on vacation, or away on a customer call. Consequently the average number of responses per manager considered is 2.3 as opposed to the 2.6 responses per manager that the 86% response rate might imply (.86 x 3 responses per manager = 2.6 responses per manager). The questionnaire was administered to all managers contacted in the Role Construct Repertory interviews.
At this point, we are ready to discuss measures generated from the Information Sources and Communication Pattern Survey questionnaire, and their interrelationship. However, for purposes of completeness and ease of flow, the base for estimates of detailed Portfolio Composition System use will first be reviewed. Thereafter, the discussion will focus on the whole set of Level-of-Information-Processing measures and their interrelationship.

The Portfolio Composition System Log.

The Portfolio Composition System has a unique property that differentiates it from the other sources of information considered in this study: it keeps track of all interactions between system and users at the level of a record for each major event occurring in this dialog or conversation. Examples of events recorded are

"Logon of user X at 12:00 on January 10, 1974"

"Histogram report requested by user X on account Y at 12:05 on January 10, 1974"

"Scatter report on account Y sent to user X at 12:10 on January 10, 1974"

The event records of the system log contain information on the identification of the user badge logged on, a day and time stamp, the function in question, what type of event (report requested, report sent, log on, log off), the set of accounts to which the user is attached, and the identification of the specific account or specific security involved.
Although it does not tell either why the user requested a specific report, or what the user saw in the report presented on the terminal, this log of interactions gives a detailed recording of system activity at the level of the different functions available. Over a month, the PCS log contains, on the average, over 100,000 records. As part of this study, data on the period from September 1972 to January 1974 has been processed, in other words, over a million log records. Obviously, this wealth of data was overwhelming and unmanageable. Figure 6.1 gives an overview of the general procedure used to aggregate the data. First a record was generated that summarizes the events of interest on a session basis (a Portfolio Composition System session was defined as the set of events occurring between a logon to the system and the subsequent logoff the system.) Thereafter a record that summarizes sessions over a month was generated. Thus the output of this processing was a record for each manager for each month considered, where the record contains, amongst others, the three process characteristics considered. Each of the ten functions on the system were considered for the purpose of this study as a distinct source of information. Furthermore, function use is assessed in terms of a request for a report using the function. The summary statistics accumulated on a monthly basis were therefore the breadth in function or command use, the total number of reports requested, and balance in use of functions. For this study, system use was based on average monthly statistics for November and December 1973.

Theoretically, the measure obtained on system use should be error free. However, in fact, this is not so. Simply stated, the problem reflects the inability of the system to know who physically is viewing
PORTFOLIO COMPOSITION SYSTEM

System Use Log:
Records at the level of Basic PCS events.

Program:
Summary of Event Records

System Use:
Records at the level of a PCS session, one for each session.

Program:
Summary of Session Records

System Use:
Records at the level of PCS use for a month, one per month and per portfolio manager.

Figure 6.1 Overview of Data Collection and Data Aggregation Routines for Portfolio Composition System Use.
screen and requesting reports. All the system knows is the identification of the badge employed and the set of accounts that the user is connected to.

The portfolio managers are under sufficient pressure in the management of their own accounts that it seems fair to assume that they do not spend much time reviewing other managers' accounts. The session records have therefore been ascribed to the manager responsible for the accounts being viewed. This results in plausible, but not error-free measures of system use for most managers.* The scheme however, breaks down in the two cases where a pair of portfolio managers co-manage the same set of accounts. This problem has been dealt with by assigning the use of the co-managed accounts to the manager in the pair that is most likely to be responsible for the interactions of the system, in other words, dropping one manager from the pair. The interrelationships of measures over the sample of managers have been analyzed both with and without the system usage measures for the remaining two managers, one from each pair and there is no significant effect.

Before concluding this discussion of the different instruments used to sample source usage, it seems appropriate to discuss the use of different time periods, or, what can be termed "time windows" for the measures of use: a day for the impersonal and personal source use measures and a month for the PCS use measures. The term time window captures the notion that our only means of describing process characteristics is by integrating behavior and events over a constant time period. This can be considered as analogous to observing a process through a window and

* Based on a comparison of system use figures available from question one of the Information Sources and Communication Pattern Survey questionnaire and system use figures derived from this analysis of the system use log, it seems that the magnitude of the error is small (see page 139).
and taking snapshots at fixed intervals.

The choice of time window for the measures of impersonal and personal source use reflects the type of instrument used, where the manager is asked to recollect events from the most recent work day. Furthermore, the fact that the number of days sampled varies across managers, makes it impossible to work with other than a one-day time window if the number of managers considered is to be kept reasonable large.

The time window for the analysis of Portfolio Composition System use was chosen in order to obtain use of a reasonable number of different functions. With a one-day time window, on the average 1.9 functions were used, which leads to measures of balance that are not necessarily very meaningful. Furthermore, the number of days that the system is used at all varies between managers (maximum is 42 days for the two-month period considered, minimum is 21 days). Although the volume measure is not affected by this problem (it can be adjusted), it is not clear how to average balance scores where there exists balance scores of zero that are obtained in the case where the manager has not used the system at all. In an attempt to assess the impact of using different time windows, missing days were ignored. Given the high correlation (.70 for breadth and balance, and 1.0 for volume) between the measures using a time window of one month and measures of system use with the time window of one day, it seems fair to conclude that for Portfolio Composition System use the issue is not of practical importance in this study. The time window of a month for system use was therefore chosen.

This was the logic and issues surrounding the choice of time windows for the analysis of information source use. Both this issue and the issue
of defining an information source mentioned previously will be reconsidered in a final section of this chapter where an attempt is made to summarize what has been learned about the measurement of Level-of-Information-Processing components. They represent some of the issues that were only partly recognized at the outset of the study and were therefore not fully taken care of in the design, and administration of Level-of-Information-Processing sampling instruments.

Having covered the instruments, the discussion now turns to review some limited evidence of the validity of the data obtained and thereafter explores the relationship between the measures of information source use both within the three different sets of information sources and across sets.

Completeness of Information Source List

For both impersonal and personal sources, the completeness of the list of sources can partially be checked by looking at the extent that the managers made use of the opportunity to specify sources used, but not explicitly listed. For the 72 questionnaires returned, about 100 of a total 2900 references were to sources not explicitly listed (in other words, less than 4% of the information source use sampled). One interpretation of this limited use of the option is that the explicit listings has in fact covered the major set of information sources used.
Communication with Colleagues, Traders, and Analysts.

The overlap in information sources covered in Question 1 and Question 2 of the Information Sources and Communication Pattern Survey makes possible a weak test of the reliability of the data concerning use of personal information sources. Table 6.1 gives an overview of the total number of communications with the major categories covered in Question 1 and the same data summarized from the responses given in Question 2. The data presented suggests that, on an overall basis, the data on references and communications with research analysts is relatively reliable when compared to the references to colleagues and the references to Traders, where there is a factor 2 difference in overall volume. Let us explore some of the possible explanations for the latter observed discrepancy.

Given the limited volume of trader reference and communication, this discrepancy has been directly explored by going back to the questionnaires. The analysis suggests that four or five managers are responsible for most of the error. They either overreport communication in Question 1 or under-report communication in Question 2.

An alternate hypothesis is that a part of the trader communication reported in Question 1 is with traders outside the Trust Department. This communication has, however, not been reported at the appropriate place in Question 2.

Finally, for one manager, a response indicating a continuous communication with traders (> 15) was reported as 15 references when broken down on the individual traders in Question 2. The greater than 15 response (> 15)
Table 6.1 Total Number of Communications with the three major groups of Personal Sources based on Question one and Question two of the Information Sources and Communication Pattern Survey Questionnaire.

<table>
<thead>
<tr>
<th>Trust Department Group</th>
<th>Total Number of Communications Based on Aggregate Source of Information (Question 1)</th>
<th>Total Number of Communications Based on Individuals as Source of Information (Question 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portfolio Manager</td>
<td>413</td>
<td>852</td>
</tr>
<tr>
<td>Colleagues</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity Research Analysts</td>
<td>100</td>
<td>124</td>
</tr>
<tr>
<td>Traders</td>
<td>201</td>
<td>113</td>
</tr>
</tbody>
</table>
has been coded as 30 references in the analysis of impersonal and personal source use * and this one manager therefore accounts for 17% of the difference between the two measures of overall communication volume between portfolio managers and traders.

The difference in overall communication volume with colleagues would seem to reflect a fundamentally different problem than that encountered in estimates of trader communication. The issues follow from the fact that while portfolio manager communication with analysts and traders is typically initiated by the portfolio managers, communication with colleagues is by definition a bidirectional affair: if portfolio manager A initiates a communication with portfolio manager B, then one of the communications experienced by B with a colleague will not have been initiated by B. A possible explanation for the difference in volume reported in Question 1 and the volume reported in Question 2 is that the managers in general only report communications initiated by themselves in question 1, while reporting all communications with colleagues in Question 2. This hypothesis is supported by experience gained in the pre-testing of the Questionnaire, where the wording of the question only mentioned "references" to information sources. The managers sampled in the pre-test reported that they understood this to mean source usage intitated by them. The wording was therefore changed to "references and communications." This seemingly was not sufficient to deal with the problem, which obviously is accentuated by

* The data presented here and subsequently was subjected to a test where the >,15 response was set equal to 16 and 30 respectively. The relationships observed do not change perceptively, reflecting the fact that there was a small number of > 15 responses in the data. Conceptually, coding > 15 as 30 is more satisfactory as it captures the difference between a response of > 15 and, for example, 14 references or communications.
the fact that colleagues are the only sources mentioned in Question 1, where the source cannot or usually does not initiate interactions.

It seems important to note that theoretically, the variable of interest is in fact references to colleagues initiated by the portfolio manager. However, based on previous experience with this type of questionnaire, manager reporting of initiator of communication is unreliable.* No attempt was therefore made to have the managers indicate what percent of the interaction reported was initiated by themselves. This represents another decision trading off manager load and value of information gained.

Portfolio Composition System Use.

Finally, the data on use of the Portfolio Composition System can be cross-checked with the use of statistics obtained from the system use log. Considering the data reported in Question 1 as representing number of reports requested, the average volume per day per manager reported is somewhat less than that derived from the system log (6.7 references to the System versus 8.5 reports requested). This difference can be interpreted partially as an indication of unreliable data in the questionnaire responses, partially as caused by some managers considering system sessions as the unit of system use, and partially that the system log contains use that

* Subsequently, Michael Tushman (personal communication) has suggested that the low reliability might be due to the fact that the subjects sampled were only given the opportunity to indicate whether they or the other individual initiated the communication. Tushman suggests that by introducing a third category, "mutual", the reliability of the measure will improve.
has been ascribed to the manager, but in fact is use by individuals other than portfolio managers.

In summary, the analysis of reliability and completeness suggests that the list of sources presented in the Information Sources and Communication Pattern Survey questionnaire were relatively complete. The analysis suggests that the data provided in the question sampling disaggregate use of personal information sources includes a high proportion of communications that were not initiated by the portfolio managers.

RELATION BETWEEN MEASURES OF INFORMATION SOURCE USAGE.

Based on the data collected, Table 6.2 presents some summary statistics for the different measures of information source use considered. Two issues seem important to note. First, the average balance measures suggest that manager use of the Portfolio Composition System is quite different from respectively their overall use of impersonal sources and their use of personal sources. The low average balance in function use can be interpreted as indicating that a limited number of the average six different functions used account for a large part of total system use. In fact, an analysis of the distribution of function use (over all managers) shows that two functions account for 80% of system use. At this point, this last observation does not necessarily have any important implications for the relations to be studied. However, it will turn out to be one of a number of key corroborating pieces of evidence used to support the interpretation of the findings relevant to the central hypothesis of the study.
Table 6.2 Some Descriptive Statistics for External Process components of Level-of-Information-Processing.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Range</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>Impersonal Sources (per day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breadth</td>
<td>10.1</td>
<td>2.2</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>Volume</td>
<td>42.0</td>
<td>21.9</td>
<td>11</td>
<td>101</td>
</tr>
<tr>
<td>Balance</td>
<td>.84</td>
<td>.08</td>
<td>.62</td>
<td>.97</td>
</tr>
<tr>
<td>Personal Sources (per day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breadth</td>
<td>8.3</td>
<td>4.5</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Volume</td>
<td>15.6</td>
<td>11.6</td>
<td>2</td>
<td>43</td>
</tr>
<tr>
<td>Balance</td>
<td>.91</td>
<td>.09</td>
<td>.63</td>
<td>.99</td>
</tr>
<tr>
<td>Portfolio Composition System (per month)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breadth</td>
<td>6.0</td>
<td>2.2</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Volume</td>
<td>163.7</td>
<td>93.3</td>
<td>35</td>
<td>376</td>
</tr>
<tr>
<td>Balance</td>
<td>.47</td>
<td>.22</td>
<td>.14</td>
<td>.89</td>
</tr>
</tbody>
</table>

Note: N = 27
The second point to notice in Table 6.2 is the range of volume of information source use. There is an order of magnitude difference between extreme scores. The question is now whether these differences in scores move together across the three sets of information sources considered, in other words, whether the value of these scores is a global property of manager information processing behavior. This issue, and the issue of the relation between the three different components of Level-of-Information-Processing within a set of information sources, is the topic we now turn to.

The relationships between all measures are examined using Pearson correlation coefficients. Table 6.3 presents the relevant matrix of correlation coefficients. Starting with the analysis of the relationship between the different measures within a set of information sources, we note that for all sets there is, as predicted, a significant (p < .01, two-tailed test of significance) positive correlation between number of sources used or breadth, and volume of information source use. This is not an unexpected finding in the case of impersonal sources and personal sources, given that the average number of references per source is respectively 4 and 2 (see Table 6.2).

The relationship between balance and the two other measures of use, however, is only as predicted in the case of balance and number of different PCS functions (p < .01, two-tailed test of significance). Of the five other relations, four are not significantly different from zero, two with the hypothesized positive sign and two with a negative sign. The final relation, between balance and volume of impersonal source use, is significantly different from zero (p < .01) and negative.
Table 6.3 Correlation between External Process components of Level-of-Information-Processing.

<table>
<thead>
<tr>
<th>Impersonal Sources</th>
<th>Personal Sources</th>
<th>Portfolio Composition System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>Balance</td>
<td>Breadth</td>
</tr>
<tr>
<td>Impersonal Sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breadth</td>
<td>.64***</td>
<td>-.18</td>
</tr>
<tr>
<td>Volume</td>
<td>-.38*</td>
<td>.35*</td>
</tr>
<tr>
<td>Balance</td>
<td>-.37*</td>
<td>-.19</td>
</tr>
</tbody>
</table>

Personal Sources

| Breadth | .83*** | .06 | .36* | .25 | .39* |
| Volume | -.18 | .34* | .34* | .48** |
| Balance | -.06 | -.02 | .04 |

Portfolio Composition System

| Breadth | | .52*** |
| Volume | | .56*** |

| Volume | .28 |

Note: N = 29; *** p < .01 two tailed test of significance
     ** p < .05 two tailed test of significance
     * p < .10 two tailed test of significance
Although Karlins (1967) does not report comparable data, and these results are not necessarily inconsistent with his findings, an attempt was made to explore the effect of controlling a number of different sources used for total volume of source use (the measure of breadth used by Karlins). A simple control is to use as measure of breadth the number of different sources used divided by the total volume of source use. Using this measure of breadth, the data does show a positive relation between balance and breadth in information source use for both impersonal sources \( r = .50: p < .01, \) two-tailed test), and personal sources \( r = .42: p < .05, \) two-tailed test of significance). It seems therefore, natural to conclude that the data shown in Table 6.3 are not inconsistent with those reported by Karlins.

These results suggest that there is little or no support for the hypothesized positive relationship between all three components of information source use considered. The significant negative relationship between balance and volume of impersonal source use indicates in fact that higher volume is achieved by higher use of a single or limited number of the ten different impersonal sources sampled on the average. One interpretation of this finding is that we are not comparing commensurable measures of source use across quite different sources of information. For example, is a reference to the Quotron (a tool that basically gives real-time data on the most recent quoted price of a given security, this for any security, traded on Wall Street) comparable to a reference to a 20-page industry review? Or are we comparing apples and oranges?

The positive relationship between balance and breadth of Portfolio Composition System use would seem to support this interpretation. Use of the different system functions are the most comparable references of all
the three sets of sources considered. Furthermore, balance is the measure that is the most "sensitive" to the issue of incommensurable use figures. Ceteris paribus, higher use rates of a single source will not affect the number of sources referenced, in other words, the breadth in source use, but will reduce the balance score.

Together with the issues of what defines an information source and of what is an appropriate time window, the issue of incommensurable use measures suggest that the theoretical framework of this investigation is not sufficiently elaborate to deal with the variety of information sources available in a real world organizational setting. It is interesting to note that, in fact, the basic hypotheses of Complexity Theory have not been tested in other than laboratory settings. A common property of these settings has been a single, or a set of homogeneous, source(s) of information available to the decision makers.

As a final part of the exploration of the relationship between measures of information source use, let us consider what is the relationship of the measures across sets of sources. Stated somewhat differently, is information usage a homogeneous and global property of the managers as we move from impersonal sources to personal sources to the portfolio composition system?

The matrix of relevant correlation coefficients in Table 6.3 suggests that, if balance of source use is excluded, there is a significant positive relation between similar measures for personal and impersonal source use, and, for personal and portfolio composition system use. These two significant positive relationships, however, together with the non-significant negative relationship between impersonal source and portfolio
composition system usage, suggests that this latter relationship is more negative if it is looked at controlling for use of personal sources. In fact, there is a more significant negative correlation (although not statistically significant: \( p = .12 \)) between volume of overall impersonal source use and volume of portfolio composition system use for managers that have high volume of personal source use. Remembering that PCS is one of the sources included in the computation of impersonal source use measures, the data suggests that managers who make extensive use of the system make, in relative terms, much lower use of the other impersonal sources of information considered. One interpretation of this finding could be that use of the system is a phenomenon quite different from the managers use of other sources. Together with the low average balance in system use that was noted previously, this last point will be taken up in the interpretations of the overall findings of the study.

Summary -- Measurement: External Process Characteristics

The issues covered can be classified into two categories: issues relevant to the actual behavior sampled and issues that map back into the theoretical framework of this study. The first set of issues have immediate implications for the rest of the study. The second set of issues can be considered more as one of the outputs of the study.

The data obtained shows an order of magnitude difference between extremes in measures, which suggests an important variation in the use of information across the different portfolio managers of the Trust Department. For example, a difference between communicating with two persons
and communicating with seventeen different persons in the course of a work day seems intuitively significant. However, how much of this variation that can be explained, the topic of the next chapter, is a different and open issue.

To the question of whether portfolio manager use of information follows the same pattern, across the different sets of information sources considered, the data suggests a qualified "yes." There is however, no positive relation between use of the Portfolio Composition System and use of impersonal sources in general.

This result implies that it is quite unlikely that a single independent variable can explain the variation of Level-of-Information-Processing variables across the three sets of information sources considered.

Similarly, the weak and at times negative relation between breadth and volume of information source use, on the one hand, and balance of source use, on the other hand, implies that the overall hypothesis of the study has little support in the data obtained. In the discussion of these findings it was suggested that in fact the theoretical framework used was not sufficiently elaborate to deal with the variety of information sources available in a real world organizational setting. The final part of this summary will review in a more integrated fashion some of the more theoretical issues identified.

Defining a source and source sampling

The basic problem identified is that of trying to compare apples and oranges: is reading a 20-page report on the office equipment industry
equivalent to the use of a system to get the current price that IBM is being traded for? With the measures used in this study, these two events are in fact treated as equivalent. Intuitively, one would like to have a measure that captured not only the event but also the information transferred.

The rate of change of the information contained in a source is another related issue. A one-month sample of the information sent to the portfolio managers from the research department shows that over the set of sources considered in Question 1 of the Information Sources and Communication Pattern Survey Questionnaire, there are some important differences in the rate of flow of documents. Again, it seems that a reference to a source of information that is constantly changing in data content should be considered as different from a reference to a source that, as one portfolio manager suggested, "has a library function..."

If the issue of quantity of information transferred in a reference and the rate of change in the underlying data base of the source need to be considered in measures of information use, it follows that differences in these characteristics should also be considered when defining the set of distinct sources that are to be considered. This in addition to the more obvious distinction along the dimension of information content.

Finally, it seems important to recognize that a portfolio manager is situated in a task where he at times is not the end consumer of the information he seeks out, but serves rather as an information link. For example, on the average that portfolio managers requested hard copies of approximately 44% of the reports they requested to see on the screen of their video display terminal. A part of these hard copies are sent to their clients
as documentation in the regular portfolio review reports. In other words, a part of the original reports requested on the terminal were not in response to information demands in the managers decision making process, but rather in response to the clients control and decision making process. An accurate measure of information source use should exclude such references for certain purposes.

The Time Window

Choosing the appropriate time window is not an issue specifically attached to the measurement of information source use, but is rather an issue relevant whenever we want to sample complex properties of a process. Single measures of process characteristics can only be obtained by integrating the events of interest over a time period. Use of different time periods or time windows can give radically different scores on a complex process measure although the underlying event series is the same. A simple example will suffice to make the point.

Assume that manager A has the following usage pattern of the Portfolio Composition System:

Day 1: 10 requests using command X
Day 2: 10 requests using command Y

while manager B has the following usage pattern:

Day 1: 5 requests using command X
  5 requests using command Y
Day 2: 5 requests using command X
  5 requests using command Y
If one now uses a time window of one day, then we will have the following breadth and balance scores for the two managers:

- Manager A: Breadth = 1, Balance = 0
- Manager B: Breadth = 2, Balance = 1

If the time window however is two days, using the same data we have:

- Manager A: Breadth = 2, Balance = 1
- Manager B: Breadth = 2, Balance = 1

This simple example shows that by a change in the time window used to study the process, the measures of use have changed dramatically. The most dramatic change is in the more complex measure, balance in information source use. Volume of information source use per time period has not changed. From the data collected in this study similar shifts are evident. For the use of the Portfolio Composition System, a change of time window from one day to one month resulted in a change of breadth in function use from 1.9 functions to 6.0 functions and in a change in balance in function use from .36 to .47.

What is the appropriate time window? It seems obvious that there is no universally correct time window; rather it is a parameter whose determination is contingent upon a number of factors. A theoretically appealing approach would be to link the determination of the time window to the notion, in Open Systems theory, of systems as cycles of events. The time window should be the cycle of "... the interrelated set of events which return upon themselves to complete and renew a cycle of activities..." (Katz and Kahn, 1966, p. 21) and thereby define the repetitive cycles of the task investigated.
There are probably a number of parallel sequences of interrelated events, with different cycles, in unstructured tasks such as portfolio management. For example, there is perhaps one cycle surrounding the identification of a security as an investment opportunity, the design of when to trade, and the execution of the trade, another cycle is linked to review cycles imposed by the client or legal requirements, and a third cycle linked to the management of cash inflows and outflows. The operational determination of the appropriate time window is therefore difficult. What is important in the context of the present investigation is that there is good reason to believe that a time window of one day is not appropriate. Interviews indicated that the cycle through the intelligence, design, and choice phases has more the dimension weeks and months than days.

**Measurement: Internal Process Characteristics.**

For the measurement of internal process characteristics, the problems faced are very much those faced in the measurement of conceptual systems structure; determining process characteristics internal to what essentially is a black box. Here again one must rely on instruments that generate externalized and observable behavior from which can be inferred internal process characteristics.

The component variables of Level-of-Information-Processing that theoretically deal with internal process characteristics are numerous (see Chapter 2). However, in this study attempts were made to measure only two components; number of alternatives considered in the decision making process, and the extent to which the process is primarily opportunity-guided
as opposed to being guided by perceived problems. This choice of variables reflects very much an evaluation of what was thought possible to measure across a sample of twenty-eight managers at a number of points in time, in addition that the variables obviously should be theoretically relevant.

Instrument

The instrument used to sample the two components of interest was Question Three and Question Four in the Information Sources and Communication Pattern Survey questionnaire (see Appendix 4). Sample size and sample composition is therefore identical to that of the measures of personal and impersonal source use.

Question Three was an attempt to get a measure of the number of alternative securities considered by the portfolio managers in their decision making process. Question Four attempted to measure the degree of opportunity-guided decision making as opposed to problem-guided decision making by sampling what were the triggers in the portfolio managers' information search and decision making process. In both questions, buy and sell decisions were distinguished to get multiple indices of the constructs to be measured.

Theoretically, the Integrative Complexity of the managers' perception of portfolios should be related primarily to the number of alternative portfolio strategies considered, and less to the number of alternative securities considered. The pre-test version of the Information Sources and Communication Pattern Survey questionnaire contained a question to
sample alternative portfolio strategies. However, based on the results of the pre-test, it was concluded that either the managers were not familiar with the notion of alternative portfolio strategies or that it was difficult to formulate a question that captured in a meaningful fashion the concept. An appropriate question would have to be rather complex and time consuming to respond to. This was considered too much of a burden on the managers and the question was therefore dropped from the final version of the questionnaire.

Triggers.

Question Four was an attempt to list all possible triggers that might occur in the investment decision making process. Of the triggers listed, triggers A, D, and E were hypothesized to be problem-oriented, while triggers G and H were hypothesized to be opportunity-oriented.

An analysis of the responses of the portfolio managers suggests that the attempt to measure differences in triggers was not successful. A major difference existed between managers in terms of how many triggers they indicated were relevant. Some indicated almost all the events listed as having occurred, while others marked only one or two of the events listed as having occurred. The interpretation of these differences in responses in terms of the characteristic to be measured is not obvious. Two approaches were explored. In the first approach, two indices were computed, one measuring the number of events checked that were hypothesized to be opportunity triggers, the other index being based on the number of events defined as problematic triggers. The second measure, an index of
opportunity-guided decision making, was computed as the ratio of the first
of the two previous indices to their sum. The pair of indices obtained,
based on buy and sell decision or situations respectively, did not cor-
relate for the three indices explored. Furthermore, there was no signi-
ficant correlation between the three indices and the other components of
Level-of-Information-Processing. The indices were therefore dropped from
all further analysis.

Number of Alternatives Considered

The responses to the three sub-questions of Question Three in the
Information Sources and Communication Pattern Survey questionnaire were
coded by counting the number of different securities mentioned.
The coding generated three different measures of number of alternative
securities considered dealing with the number of securities considered
for a buy, the number of securities considered for a sell, and the num-
ber of securities just being followed. The three measures were averaged
over the number of questionnaires completed and returned by the managers;
in other words, the time window is one day and the measures are the average
number of alternative securities considered per day.

The three measures of number of alternative securities considered
are significantly intercorrelated (Pearson correlation coefficients of
.57, .66, and .67 \( [p < .001] \)). They were therefore combined into a single
index by simply adding up the scores on the three component measures.
The measure thereby obtained is referred to as number of alternative se-
curities considered.
Finally, let us consider the relationship between the measure of number of alternatives considered and the other components of Level-of-Information-Processing measured. Table 6.4 gives an overview of the relationships using the Pearson correlation coefficient. Two comments seem particularly appropriate:

1. There is some evidence that supports the hypothesized positive relationship between number of alternatives considered and the other components of Level-of-Information-Processing if use of the Portfolio Composition System and balance in source use in general are excluded.

2. The lack of relationship between number of alternatives considered and the different measures of Portfolio Composition System use is another indication that the use of the system is a phenomena quite different from the managers use of the other sources considered in this study. The negative relation between balance of personal and impersonal source use and number of alternatives considered strengthens the belief that the balance measure used does not capture the complexity of the information environment of a real world setting.

Summary

Due to some anticipated and some unexpected problems, the measurement of characteristics of the internal decision making and problem solving processes has been limited to a measure of the number of alternatives considered. As a result, the emphasis of the remainder of the study is necessarily on information use and less on internal process characteristics.
Table 6.4 Correlation between Number of Alternative Issues Considered and External Process components of Level-of-Information-Processing.

<table>
<thead>
<tr>
<th></th>
<th>Impersonal Sources</th>
<th>Personal Sources</th>
<th>Portfolio Composition System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breadth</td>
<td>Volume</td>
<td>Balance</td>
</tr>
<tr>
<td>Number of Alternative Issues</td>
<td>0.47***</td>
<td>0.34**</td>
<td>-0.20</td>
</tr>
</tbody>
</table>

Note: Sample size shown in parenthesis under each coefficient.

*** p < .01 one tailed test of significance
** p < .05 one tailed test of significance
* p < .10 one tailed test of significance
° p < .10 two tailed test of significance
With only one aspect of the internal processes sampled it obviously can lead to but a very limited analysis of the complex process involved.
Chapter 7: Exploring the Hypothesis: Relation between Process and Structure.

The subject of this chapter is appropriately labelled *exploring* the relation between structure and process: the lack of convergent validity in the measurement of conceptual structure and the problems, both methodological and theoretical, in the measurement of process, suggests that it is meaningless to approach the issue as a formal test of hypothesis. Given the measurement problems, whatever the outcome of the test of the hypothesis, this result *alone* will be highly inconclusive.

In a sense, this chapter covers an analysis at an extremely abstract level, a number of transformations removed from the concrete data collected. Not being sure what has actually been measured, it does not seem worthwhile to perform extensive investigations at this level of abstraction. The chapter is therefore brief. The main purpose is to give some direction to a second level analysis that will operate in a more messy, but more concrete world. In the process of attempting to set the stage for a formal test of hypothesis, quite a lot of insights and knowledge were generated that could not be directly integrated into the formal test of hypothesis. In the second level analysis, this knowledge, dealing more with content and function than structure and process, will be introduced.

The analysis of the measures of respectively structure and process (chapters 5 and 6) indicate that the data will not either completely refute nor completely support the hypothesis of a positive relationship between Integrative Complexity and Level-of-Information-Processing. In fact, the
analysis of the relationship indicates some support for the hypothesis except in the case of measures concerned with the use of the Portfolio Composition System. In the next chapter, an attempt is made to understand this negative finding through a secondary analysis of the data available. To the degree that this secondary analysis is successful, it in turn lends greater credence to the positive findings identified in this chapter.

Hypothesis.

The hypothesis to be tested is:

The Level-of-Information-Processing manifest in the decision making behavior of a portfolio manager in the investment task is positively related to the Integrative Complexity of the manager's conceptual systems relevant to the perception of Information Sources and to the perception of Portfolios.

Level-of-Information-Processing is primarily measured in terms of breadth, volume, and balance of personal sources, impersonal sources, and Portfolio Composition System use. In addition, one measure of an internal process characteristic, number of alternative securities considered, has been measured.

Due to problems in the measurement of structure of portfolio perception (the heterogeneous nature of the portfolios used in the portfolio RCRI -- see page 70), the actual test of hypothesis will only consider measures of Integrative Complexity of Information Source perception. The analysis of measures of structure resulted in the selection of two measures of Integrative Complexity for this last domain: one based on an Alpha Factor analysis of the Role Construct Repertory Interview data, ALPHIC, and one using hierarchical cluster analysis of a nominal scale based measures of
association, CPNOM (see Table 5.5 and pages 114-18). Both measures are hypothesized to be measures where low scores indicate high Integrative Complexity. However, the evidence of convergent validity is weak. The relationship between measures of structure and of process will therefore be explored using tests that are not based on assumptions concerning the sign of the relationships (a difference between using one-tailed and two-tailed tests of significance).

Exploring the Hypothesis.

The hypothesis is explored using Pearson product moment correlation coefficients as measures of the relationship between the two measures of structure and the different components of Level-of-Information-Processing. Table 7.1 presents the matrix of correlation coefficients.

Remembering that support for the hypothesis, and rejection of the null hypothesis of no relationship, is indicated by a significant negative relationship between the measures of structure and process, three points seem important to note concerning the data presented in Table 7.1:

1. On an overall basis, there are five significant negative correlations (p < .10) out of the 20 examined. In addition 11 of the remaining 15 coefficients are negative, but non-significant.

2. Looking only at the relationship between CPNOM and the measures of Level-of-Information-Processing, there are four significant negative correlations (p < .10) out of the total of ten. Only one coefficient, which is almost zero, has a positive sign.
Table 7.1 Correlation between measures of Level-of-Information-Processing and measures of Integrative Complexity of Information Source Perception.

<table>
<thead>
<tr>
<th>Integrative Complexity</th>
<th>Impersonal Sources</th>
<th>Personal Sources</th>
<th>Portfolio Composition System</th>
<th>Number of Alternative Issues Considered</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPHIC</td>
<td>-.12</td>
<td>-.47**</td>
<td>.12</td>
<td>-.05</td>
</tr>
<tr>
<td>CPNOM</td>
<td>-.44**</td>
<td>-.38**</td>
<td>-.14</td>
<td>-.27</td>
</tr>
</tbody>
</table>

Note: Sample size shown in parenthesis underneath each correlation coefficient.

** p < .05 two tailed test of significance
* p < .10 two tailed test of significance
3. In terms of the different components of Level-of-Information-Processing, the hypothesis has the least or no support in the case of Portfolio Composition System usage.

Let us ignore for a moment the problems of measurement validity. The findings above could then be interpreted as indicating that the hypothesized positive relationship between integrative Complexity and Level-of-Information-Processing is supported in terms of use of impersonal sources, partially supported in terms of use of personal sources, and, partially supported in terms of number of alternatives considered. It is rejected in terms of usage of the Portfolio Composition System. This partial breakdown of the hypothesis is most clear when looking at the relationship between CPNOM, the measure of Integrative Complexity based on hierarchical cluster analysis and a nominal scale measure of association, and the measures of Level-of-Information-Processing.

A look at the correlation between the other measures of structure, both for the domain of information sources and the domain of portfolios, and the measures of Level-of-Information-Processing suggest a similar pattern. Table 7.2 presents the relevant correlation coefficients. The data indicates that there basically is no relation between the measures of structure from the domain of Information Sources and the use of the Portfolio Composition System. Of the eighteen coefficients examined, only three are significantly different from zero ($p < .10$). In the case of portfolio perception, the same picture emerges. Only one measure of structure, DIFF, has a couple of significant correlations with the measures of Portfolio Composition System use. In all, nineteen of the twenty-one coefficients computed are not significantly different from zero. Some that are almost significant at the
Table 7.2 Correlation between measures of Level-of-Information-Processing and measures of conceptual system structure not covered in Table 7.1.

| For Portfolios: | Impersonal Sources |          |          |          |          |          |          |          |          |          |          |
| ALPHIC         | .11     | -.09   | -.02    | .22     | .10    | .06     | .20     | .35    | .27     | .26     |          |          |
| SMLIC          | .20     | .51**  | -.34    | .16     | .19    | -.03    | -.07    | -.21   | .01     | .44**   |          |          |
| CMPIC          | .12     | -.09   | -.01    | .21     | .10    | .04     | .20     | .35    | .25     | .27     |          |          |
| CPNOM          | -.26    | -.15   | -.28    | .27     | .28    | -.13    | .33     | .24    | .06     | .01     |          |          |
| BIERI          | .07     | .07    | -.18    | .13     | .18    | -.10    | .16     | -.15   | .10     | .29     |          |          |
| DIFF           | -.18    | -.23   | -.01    | .05     | .04    | -.25    | .47**   | .55*** | .14     | -.17    |          |          |
| ARTCL          | .13     | -.08   | -.02    | .23     | .11    | .04     | .20     | .34    | .25     | .27     |          |          |
|                | (23)    | (23)   | (23)    | (23)    | (23)   | (23)    | (22)    | (22)   | (22)    | (23)    |          |          |

| For Information Sources: |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
| SMLIC          | .05     | .01     | -.02    | .25     | .24    | -.16    | .38*    | .07    | .40**   | -.08    |          |          |          |          |
| CMPIC          | -.23    | -.06    | -.45**  | .09     | .02    | .29     | .03     | .04    | .18     | -.30    |          |          |          |          |
| BIERI          | -.06    | .09     | .05     | -.34*   | -.32*  | -.45**  | -.10    | -.13   | -.15    | .21     |          |          |          |          |
| DIFF           | -.06    | -.30    | .05     | .13     | .18    | -.14    | .15     | .01    | .17     | .10     |          |          |          |          |
| ARTCL          | .36     | .37*    | -.17    | .32*    | .28    | .34*    | -.11    | .03    | .35*    | .20     |          |          |          |          |
| CENTR          | .21     | .23     | .07     | .08     | .14    | -.20    | -.27    | -.16   | .00     | .46**   |          |          |          |          |

Note: Sample size shown in parenthesis for each corresponding column of correlation coefficients

*** p < .01 two tailed test; ** p < .05 two tailed test; * p < .10 two tailed test
ten percent level, have a sign opposite to that predicted \( \text{ALPHIC}_\text{Portfolio} \) and volume of system use, \( \text{CMPIC}_\text{Portfolio} \) and volume of system use, and \( \text{CPNOM}_\text{Portfolio} \) and breadth of system use).

Finally, a test was made to see the effect of eliminating the pair of portfolio managers whose usage statistics for the Portfolio Composition System were possibly unreliable (see page 113). The change in sample has no effect on the pattern of coefficients describing the relation between measures of structure and measures of Portfolio Composition System use, the only coefficients affected.

Conclusion.

It seems appropriate to terminate the exploration of the main hypothesis of the study at this point. Although it might be possible to take a closer look of some of the relationships between specific measures, this does not seem worthwhile given the measurement problem encountered; the key problem in this context is the limited evidence for convergent validity on the measures of the independent variable, Integrative Complexity. The significant findings must be sought at the level of pattern of relationships across a number of specific measures, and not looking at simple relationships.* At this level, the data suggests two major, interrelated findings;

* The planned exploration of the possible effect of task differences has not been performed based on the same line of reasoning. In this case, measurement problems are amplified by the small sample size available to explore the main hypothesis within tasks of similar complexity. A rough test of the possible direct effect of task difference, furthermore, indicates that such differences do not account for much of the variation in Level-Of-Information-Processing. Based on a F-test of significant differences in mean scores for the three product groups in the Trust department (Personal Trust, Investment Advisory, and Retirement and Endowment),
they are interrelated in the sense that, to a certain extent, the interpretation underlying the one assumes the other is correct, and vice versa.

On the one hand, there is limited support for the hypothesized positive relationship between Integrative Complexity and Level-of-Information-Processing measures covering use of impersonal and personal sources.

On the other hand, there is clearly no support for the hypothesis in terms of the use of the Portfolio Composition System. The data suggest no relation between measures of conceptual system structure and system use.

Measurement problems can account for some of the negative findings for specific relationships between components of Level-of-Information-Processing covering impersonal and personal source usage and measures of Integrative Complexity:

- the comparison of incommensurable usage statistics can account for the support of the null hypothesis for the relationship between balance of source usage and structure (see page 144).

- the inclusion of data on communication initiated by other portfolio managers can account for the weak support of the hypothesis in the case of personal source usage (see page 138).

It therefore does not seem worthwhile to pursue these negative findings. They seem far less meaningful and clear cut than the negative finding concerning the relation between Portfolio Composition System usage and mea-

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only two of the components of Level-of-Information-Processing have statistically significant differences in means. Volume of personal source use is significantly lower (p = .04) in the Personal Trust group than in either of the other two groups; balance in Portfolio Composition System use is also significantly lower (p < .001) in the same group.
asures of structure. Together with the fact that understanding which factors affect managerial use of conversational computer systems is a central theme of this investigation, the major part of the remaining effort to understand and interpret the findings will therefore focus on the use of the Portfolio System.

One final comment concerning the findings reviewed in this chapter. The consistent and relatively significant relationship between the different components of Level-of-Information-Processing and the particular measure of Integrative Complexity developed in this study, CPNOM (comparison of clusters obtained using a nominal scale measure of association), implies that this measure should be explored more systematically in further research. The measure is methodologically relatively sound. However, evidence for its theoretical relevance is limited to the data presented in this study.
Chapter 8. Understanding some of the Findings: A Look at Content and Function.

Language and content shift markedly with this chapter. The focus is no longer primarily on abstract concepts such as Level-of-Information-Processing and Integrative Complexity, but rather on issues such as the content of the conceptual systems of the portfolio managers and the concrete characteristics of the sources of information they use. Even more important, there is a shift from a concern with individual differences between managers to looking for similarities across managers.

The purpose of the analysis and discussion in the chapter is to develop and explore an explanation for the apparent lack of a relationship between the use of the Portfolio Composition System and the Integrative Complexity of managers' conceptual systems.

Complexity Theory provides some general hypotheses for an explanation of the negative finding concerning the relation between Integrative Complexity and use of the Portfolio Composition System: the managers are quite homogeneous in terms of Integrative Complexity; the investment task is either very structured or very unstructured. In all three cases, the theory would predict that the variation in use of the system would not be systematically related to variations in Integrative Complexity.

Such an explanation, however, does not accord with the fact that the hypothesized relation is supported in the case of the use of personal and impersonal sources of information. This would also be true of any explanation based on the position that the lack of relations is due to measurement error, or that Complexity Theory is all wrong, as all of these explanations
are equally applicable to the use of personal and impersonal sources in general. Although the limited support of the hypothesis in the case of use of personal and impersonal sources might be spurious, a line of reasoning is taken in this chapter to explore the case where it is assumed that this is not so.

An explanation of the negative finding concerning the use of the Portfolio Composition System that is consistent with Complexity Theory and the positive finding concerning the use of personal and impersonal sources of information must be based on establishing that the system in some sense is a unique source of information in the portfolio manager environment. This chapter explores the issue of cognitive domain as a possible explanation. In the terms of this study, cognitive domain is the content issue of a model of the specific task investigated. The model serves to map the more abstract constructs of Complexity Theory into concrete variables relevant to the specific setting considered. In mapping Complexity Theory into the specific setting of portfolio management, a simple model of the investment task was proposed (see Chapter 4). The model has two components, an Information Source subtask and a Portfolio Composition subtask. The hypothesis explored in this chapter suggests that the negative finding concerning the relation between Portfolio Composition System use and conceptual system structure can be understood by a more detailed descriptive model of the investment task. Specifically, the investment process of the managers is seen as primarily individual security-oriented and not portfolio-oriented as implied by the simple model initially assumed. In a security-oriented process, it is suggested that the Portfolio Composition System is only relevant to a component of the overall investment task
where task characteristics are the primary determinants of system use.

The chapter begins with an expanded review of the difference between a portfolio-oriented and a security-oriented decision making process. Evidence is then reviewed that suggests that the decision making of the portfolio managers is in fact security-oriented. The reasons that such a security-oriented process implies the finding that there is no relation between Integrative Complexity and Portfolio Composition System use is discussed. An analysis of why the process is security-oriented and not portfolio-oriented is the topic of the final section of the chapter.

It seems important to note that the discussion in this chapter is more a development of hypotheses than a test of hypotheses. This study was not designed to test hypotheses concerning why the use of the Portfolio Composition System is not related to the Integrative Complexity of manager perceptions. The evidence presented to support the hypotheses is therefore only suggestive. However, the issues reviewed are directly pertinent to the overall concerns of this study and the implications of the suggestive findings are sufficiently important to warrant proceeding beyond what stringent statistical tests might permit.

Portfolio-Oriented versus Security-Oriented Decision Making.

In order to give some substance to the discussion of differences between a portfolio-oriented and a security-oriented decision process, it can be useful to think of both processes as broken down into the three phases suggested by Simon: Intelligence, Design, and Choice.
As implied by the name, the primary entities considered in a portfolio-oriented decision making process as it moves through the intelligence, design, and choice phases, are portfolios. The problems or opportunities defined in the intelligence phase are in terms of problems or opportunities in portfolios. For example, a portfolio might be overconcentrated in cyclical stocks when the stock market is just coming out of a bullish period, the risk of a portfolio is far above that desired by the client. The design phase is concerned with changing a portfolio so that it deals with the problem or makes use of the opportunity defined in the intelligence phase. Having looked at alternate portfolio structures that might be appropriate, it is only at this stage that the process starts looking for individual securities or other assets to buy or sell. The portfolio solution chosen is thereby implemented.

In contrast, a security-oriented decision making process deals with securities as its primary entity. In the intelligence phase, industries or companies define and determine problems or opportunities. Information that a company is just about to announce a new product or a bad year-end report, are common triggers to the decision making process. The design phase in a stock-oriented decision making process is primarily concerned with the timing of trading activity in terms of factors affecting possible changes in important parameters over time. Having more or less made a decision to buy or sell a security, the process finally focuses on which portfolios should be or are affected by such a decision in order to implement or execute the decision arrived at.

We see that although the processes are radically different in focus and considerations, the output is the same in both cases: a set of trades
for one or more accounts. In other words, both processes contain a security-oriented and a portfolio-oriented component given that decisions have to be made on both securities and portfolios. The difference between the processes resides in which component dominates and when the subordinate component is triggered. Furthermore, the higher level process in a sense represents the intelligence phase of the lower level process: as the lower level process is entered, the problem to be solved has been defined. Very simply, both processes can be represented as a two-level hierarchy of interconnected subprocesses (see Figure 8.1) very similar to the TOTE representation used by Miller et al. (1960).

In an analysis of the decision making process of the portfolio managers of the Trust department prior to the design and implementation of the Portfolio Composition System, it was hypothesized that the decision making was in fact individual security-oriented. This conclusion was based primarily on data collected through interviews, such as the Role Construct Repertory Interview and decision protocols, and different questionnaires administered to managers in the Retirement and Endowment group. An important part of the review of the data collected deals with the results of Role Construct Repertory Interviews (with six portfolio managers) that attempted to sample the managers' perception of stocks and portfolios. The data suggested that while the managers had quite a number of stock-related constructs, a number of which were expected performance- and status-oriented, they had less portfolio constructs, where very few related to portfolio status and expected performance (1971, pp. 219-221). Based on this data and other data obtained, Gerrity concludes:
Note: In a security-oriented decision making process, the focus of Level (1) is securities and the focus of Level (2) is portfolios.

In a portfolio-oriented decision making process, the focus of Level (1) is portfolio and the focus of Level (2) is securities.

Figure 8.1 A Two-Level Model of the Investment Decision Making Process.
In summary, the PM (portfolio manager) defines his problems more in terms of individual stock characteristics than in terms of portfolio goals and status and his focus of attention is more on single assets than total portfolios. The PM sees himself choosing among single asset trades, not as selecting from alternative possible portfolios. (Gerrity, 1971, p. 222).

The conclusion summarizes the fundamental idea underlying the Portfolio Composition System. The purpose of the system was precisely to enable the managers to have what normatively was considered a more appropriate decision focus: portfolios.

How was the system to bring about such a change? The design rested on the following diagnosis of why the portfolio managers had a stock-oriented decision making process:

.... A reasonable hypothesis is that this primary focus on individual assets is due in large part to the PM's current information system... (Gerrity, 1971, p. 226).

.... The decision process as described is not "good" or "bad" per se but represents a reasonable adaption by intelligent men to limitations and constraints in the information and processing systems available to them.... (Gerrity, 1971, p. 229).

Although not stated explicitly, the diagnosis implies that the portfolio managers do not have the cognitive capacity to manipulate and process the volume of data required in a portfolio-oriented decision making process -- particularly in terms of evaluating present status or changed status and how it relates to expected performance of the portfolio. The design objective of the Portfolio Composition System was to develop a system that would give the managers such a capability.

As noted in Chapter 3, the Portfolio Composition System provides the user with functions that enable him to view and manipulate portfolios in a number of fashions. For example, the HISTO function enables the manager
to view a histogram distribution of the assets in an account along any of a number of dimensions.

A basic design philosophy underlying the Portfolio Composition System was to provide the manager with a number of information processing primitives that he could then put together into larger programs. The design therefore reflects very much a Simon-esque view of managerial decision making in unstructured and semi-structured tasks as being governed by programs that organize myriads of simple information processes into orderly, complex sequences (Simon, 1965, p. 81). The design implies that the system is very much a decision support system; it does not make portfolio composition decisions. In order that the system really be an extension to the managers own internal primitives, it must be similarly accessible. Therefore the interactive system.

An important point that follows from this review of the Portfolio Composition System is that only by using the system in a fully interactive fashion, can the managers entertain a portfolio-oriented decision making process. The first piece of evidence to support the conclusion that the decision making process of the portfolio managers is still very much security-oriented comes from an analysis of how the system is being used.

Portfolio Composition System Use.

Let us first look at overall usage patterns, before focusing on the particular functions used. The Portfolio Composition System was designed to support a dialog between man and machine. If such a dialog were to occur, the terminal sessions would be sufficiently long or frequent to
support a process moving between different levels of aggregation of the information available on the system and between different perspectives on the data base. The managers would use the system to follow up immediately hunches and to explore immediately problems or opportunities identified. The prototype use reported in Gerrity's study can be used as a reference point, where the average session length was 60 minutes, the average number of reports requested per session was thirteen, and where no function accounted for more than twenty-one percent of total function use (1971, p. 305 and p. 312).

Table 8.1 gives an overview of average portfolio manager system use based on use of the system for a two-month period. The data indicates that the sessions are relatively short. The typical session consists of a log on, requests for three reports on the screen, requests for a hard copy of half the reports seen on the screen, and log off. This all takes five minutes, on the average.

The limited number of reports requested per session and the limited number of sessions per day (approximately two sessions per day) preclude any substantive man-machine dialog in the sense described above. The low balance in function use confirms this picture. It indicates that the managers make extensive use of a limited number of functions. Table 8.2 gives an overview of the actual distribution in function use. Two functions, STATUS and RUN, account for approximately 80 percent of total system use.

STATUS, a portfolio-oriented function, displays detailed information on the holdings of an account in a tabular format. RUN, an individual security-oriented function, enables the manager to get a picture of ac-
Table 8.1 Some Characteristics of Average Manager Use of the Portfolio Composition System (N = 27).

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breadth in Function Use</td>
<td>6.0</td>
<td>Different Functions per month</td>
</tr>
<tr>
<td>Volume in Function Use</td>
<td>169</td>
<td>Reports Requested per month</td>
</tr>
<tr>
<td>Balance in Function Use</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>Number of Sessions</td>
<td>55</td>
<td>Sessions per month</td>
</tr>
<tr>
<td>Volume of Hardcopy Use</td>
<td>63</td>
<td>Hardcopy Reports per month</td>
</tr>
<tr>
<td>Percent of Reports Requested in Hardcopy</td>
<td>44%</td>
<td></td>
</tr>
<tr>
<td>Volume in Function Use per Session</td>
<td>3</td>
<td>Reports Requested per session</td>
</tr>
</tbody>
</table>
Table 8.2  Distribution of Function Use on the Portfolio Composition System

<table>
<thead>
<tr>
<th></th>
<th>DIRECTORY</th>
<th>STATUS</th>
<th>SUMMARY</th>
<th>ISSUE</th>
<th>RUN</th>
<th>PIE</th>
<th>SCATTER</th>
<th>HISTOGRAM</th>
<th>TABLE</th>
<th>TRADE</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Report Requests</td>
<td>340</td>
<td>6500</td>
<td>230</td>
<td>200</td>
<td>1040</td>
<td>140</td>
<td>70</td>
<td>530</td>
<td>210</td>
<td>180</td>
<td>9440</td>
</tr>
<tr>
<td>%</td>
<td>3.6</td>
<td>68.9</td>
<td>2.4</td>
<td>2.1</td>
<td>11.0</td>
<td>1.5</td>
<td>.7</td>
<td>5.6</td>
<td>2.2</td>
<td>1.9</td>
<td>99.9</td>
</tr>
</tbody>
</table>
count holdings in a particular stock, across accounts. It also displays detailed information in a fixed tabular format.

As seen in Table 8.2, the use of the STATUS function is much higher than the use of the RUN function. One could ask whether this is not evidence that the system is used to support a portfolio-oriented decision making process? Not necessarily so. The ratio of one RUN report for every seven STATUS reports is consistent with a security-oriented process, given that a RUN report typically will uncover a number of accounts that either hold or do not hold a specific security. Based on a single RUN report, the manager might therefore take a closer look at a number of accounts using the STATUS report.

In fact, analysis of the usage log indicates that the RUN and STATUS reports are used quite independently, at least from a time perspective. Data on the sequence of different command use was generated at the same time as the measures of system use relevant to the Level-of-Information-Processing were generated from the system log (see Chapter 6, page 131). A simple transition matrix between the different function, log on, and log off was produced. Table 8.3 presents the matrix of transition frequencies based on system use in November and December 1973. A cell in the matrix represents the number of times managers requested a report using the function of the corresponding column after having requested a report using the function of the corresponding row. For example, the matrix shows that having requested a RUN report (entering the matrix via the RUN row) managers requested a STATUS report (the STA column) 70 times.

An analysis of the transition matrix indicates that the RUN function is entered only eight percent of the time from other functions. It is
Table 8.3 Overview of Portfolio Composition System Use in terms of Transition Frequencies between different Functions (N = 27 Portfolio Managers).

<table>
<thead>
<tr>
<th>REPORTS</th>
<th>HARDCOPY</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>STA</td>
</tr>
<tr>
<td>ON</td>
<td>29</td>
</tr>
<tr>
<td>DIR</td>
<td>8</td>
</tr>
<tr>
<td>STA</td>
<td>141</td>
</tr>
<tr>
<td>SUM</td>
<td>2</td>
</tr>
<tr>
<td>ISS</td>
<td>4</td>
</tr>
<tr>
<td>RUN</td>
<td>21</td>
</tr>
<tr>
<td>PIE</td>
<td>4</td>
</tr>
<tr>
<td>SCA</td>
<td>1</td>
</tr>
<tr>
<td>HIS</td>
<td>2</td>
</tr>
<tr>
<td>TAB</td>
<td>4</td>
</tr>
<tr>
<td>TRA</td>
<td>11</td>
</tr>
<tr>
<td>DIR</td>
<td>6</td>
</tr>
<tr>
<td>STA</td>
<td>98</td>
</tr>
<tr>
<td>SUM</td>
<td>1</td>
</tr>
<tr>
<td>ISS</td>
<td></td>
</tr>
<tr>
<td>RUN</td>
<td>10</td>
</tr>
<tr>
<td>PIE</td>
<td></td>
</tr>
<tr>
<td>SCA</td>
<td></td>
</tr>
<tr>
<td>HIS</td>
<td>4</td>
</tr>
<tr>
<td>TAB</td>
<td>3</td>
</tr>
<tr>
<td>TRA</td>
<td></td>
</tr>
</tbody>
</table>

\[ \sum: 319 \quad 34 \quad 650 \quad 23 \quad 20 \quad 104 \quad 14 \quad 7 \quad 53 \quad 21 \quad 18 \quad 11 \quad 269 \quad 3 \quad 2 \quad 22 \quad 2 \quad 3 \quad 42 \quad 13 \quad 2 \]

Note: All frequencies in tens (10's).

Abreviations:
- ON : Log on
- OFF : Log off
- ISS : ISSUE function
- DIR : DIRECTORY function
- PIE : PIE function
- RUN : RUN function
- STA : STATUS function
- SCA : SCATTER function
- TAB : TABLE function
- SUM : SUMMARY function
- HIS : HISTOGRAM function
- TRA : PENDING TRADE function
entered directly after the managers log on thirty percent of the time. Figure 8.2 presents a summary of the transitions particularly relevant to the use of the RUN function. The numbers on the solid arcs can be considered as estimates of transition probabilities.

The interesting point about the transition probabilities presented in Figure 8.2 is that there is a very low probability of moving to another function on the system, once the manager is in the RUN function (.07 when having requested a RUN report; .10 when having requested a hard copy of a RUN report). These figures can be interpreted as another indication that the Portfolio Composition System is not being used to support a man-machine dialog in the sense of shifting quickly from one perspective to another and back -- here, of shifting between a focus on securities to a focus on portfolios and back, or vice versa.

Finally, the low use of the three graphical functions on the system (PIE, HISTOGRAM, and SCATTER) which account for only eight percent of the total number of reports requested (see Table 8.2) again seems to suggest that the managers are not making use of the ability the Portfolio Composition System gives them to get a number of perspectives on their accounts.

As indicated by the interpretation of the relation between volume of RUN function use and use of the STATUS function, low use of the graphical functions per se does not necessarily mean that the functions are not used to support a portfolio-oriented decision making process. A single graphical report might trigger a process involving a number of report requests providing more detailed information on an account. A look at manager perceptions, however, seems to rule out this hypothesis.
Figure 8.2  A State-Transition Model for the Use of the RUN function on the Portfolio Composition System.
Manager Perceptions.

The primary source of information on how managers perceive the Portfolio Composition System is the Information Sources Role Construct Repertory Interview. The content data provided are rather qualitative and the selection presented here is a limited sample. However, it does capture what is believed to be some of the dominant characteristics of the beliefs and attitudes of the managers interviewed.

The most apparent, and not so surprising, message given through the Role Construct Repertory Interview is the overwhelming agreement among portfolio managers on what are the most and least useful functions on the Portfolio Composition System. Twenty-five of the twenty-eight managers interviewed proposed the STATUS function in response to the question (in other words, RCRI role), "The Portfolio Composition System function or command you find most useful." Similarly, twenty of the managers proposed PIE function (a graphical function that gives a pie chart like picture of the distribution of the holdings of an account) in response to the question, "The Portfolio Composition System function or command you find the least useful." This last statistic would seem to refute a hypothesis that although PIE is not used much, it might be an important trigger in a portfolio-oriented decision making process.

Manager constructs and substantive comments are, however, more revealing. A common theme is to characterize the Portfolio Composition System as "a snapshot of previous decisions, output" as opposed to "basic data, input to decision making"; as "a reporting tool" as opposed to "a tool in the investment process"; as "a tool to look at present and past" as opposed to
"a source for future decisions"; as "a report of current" as opposed to "a guide in making decision, in the future"; as "an administrative tool, helps implement decisions" as opposed to "gives information for (making) a buy/sell decision".

A similar picture emerges from the comments of one portfolio manager as he talks about the relation between the Stock Recommendation List (a list of currently attractive securities) and the STATUS function on the Portfolio Composition System:

The Stock Recommendation List and the STATUS function are pretty nice to have; at least, STATUS makes .... the Stock Recommendation List a lot easier ... because, sure everything might look good on the list, might look attractive, fairly well researched, and they all have pretty good appreciation potential, but it is only common sense that you can put so much into a particular area and this is where this (STATUS) fits in ... it kind of tempers the purchase list to a certain extent, because in many cases, even if everything looks attractive, you can't do it, you can only hit cookies so often, ... above a certain amount, it is not good for it, for a portfolio. So these two, I think, work pretty nicely interactively.....

The important point to note in this comment is that the manager clearly suggests that in his decision making process the flow is from a focus on the stocks in the Common Stock List to finding portfolios where a "cooky" might fit in. It is not a flow from a portfolio that needs or could use a certain kind of stock to a scan of the Common Stock List in an effort to find a suitable candidate.

The same manager, this time talking about the Common Stock List (a report on key statistics for all the stocks actively followed by the Trust department) and the STATUS function:

... the Common Stock List and STATUS ... use (them) much more frequently... again, the inverted triangle, starting with the
Common Stock List, filtering it down to what I fine tune
(using STATUS)... the old funnel approach type thing...

Perhaps even more important than the evidence that the Portfolio
Composition System is seemingly used to support a security-oriented deci-
sion making process, is that there is no evidence that suggests the system
is being used to support a portfolio-oriented process. There are no con-
structs or comments that suggest that the system is being used to support
the intelligence and design phase of a portfolio-oriented process. Only
one manager recognized that a report generated on the system might trig-
ger a new decision:

... The Common Stock List and (an analyst) are basically data
inputs into the resulting STATUS... 'STATUS sort of reflects
decisions. Again, STATUS can trigger further decision making...
I make a decision or a group of decision, and X number of days
later I get STATUS... I look at the account and the previous
decisions were not enough to accomplish those desired ends.
So then I go ahead and do more .... so STATUS is maybe a bridge
between decision making and more decisions....

This statement is revealing in that, although it can be interpreted
as giving some indication that the manager in question uses the Portfolio
Composition System to support a portfolio-oriented decision making process,
it does not indicate that the system is being used to support a man-machine
dialog. In fact, the particular manager, averaged over a two-month period,
requested hard copies of 55% of the reports seen on the screen. This fi-
gure is higher than the average of 44% (see Table 8.1) and indicates that
this manager uses the system to a large extent to generate reports that
he then analyses off the system or uses, for example, for documentation of
reports to his clients.
Other Evidence for a Security-Oriented Process

Finally, let us review some additional, secondary evidence for a security-oriented decision making process.

Analysis of the usage pattern of sources sampled in Question 1 of the Information Sources and Communication Pattern Survey shows that the Quotron is the most frequently used information source. As mentioned previously, the Quotron provides current (in real-time) quotes of single securities traded on Wall Street.

The Common Stock List is still referenced quite frequently although all the information contained in this document is also available on the Portfolio Composition System. However, while the information in the Common Stock List is a report that covers in one place all the securities followed by the Trust department, it is only available on the system through the filter of the holdings of any single account. This latter access is obviously not very convenient in a security-oriented decision making process.

Use of the Portfolio Composition System is significantly correlated with certain aspects of trading activity, the output of the investment process. Specifically, there is a significant positive correlation between volume of system use and the number of purchases (.44, p < .05, two-tailed test of significance) and the number of sales (.38, p < .05, two-tailed test of significance) in December 1973 (system use is based on the two-month period covering November and December 1973). One interpretation of this correlation is that the use of the system is closely linked with
the final stage of a security-oriented decision making process: the implementa-
tion of trade decisions in terms of determining which specific portfolios should be affected.

The Level-of-Information-Processing variable number of alternative securities considered, although not correlated with the measures of Portfolio Composition System use, is correlated with the measures of use of personal and impersonal sources of information (see Table 6.4 in Chapter 6). This can be interpreted as an indication that a component of the use of personal and impersonal sources is connected to the sampling of information to support the primary process in a security-oriented decision making process.

Summary: Security-Oriented versus Portfolio-Oriented Process?

To summarize, the data reviewed supports, and, in fact, led to the finding that the investment process of the portfolio managers sampled is primarily security-oriented. This in the sense that the security-oriented process dominates the portfolio-oriented process. In other words, the security-oriented process defines to a large extent the problems addressed in the portfolio-oriented process, and not vice versa.

Before exploring the consequences of this conclusion, and in particular, how it might explain the negative finding concerning the relation between Integrative Complexity and use of the Portfolio Composition System, it is important to note that the dichotomy "portfolio-oriented versus security-oriented" decision making is quite a simplification of the real state of affairs.
First of all, as mentioned in Chapter 3, the other two major sub-tasks in the portfolio managers' job, client relations and administration, impinge on and interact with the investment subtask. Furthermore, the Trust department and its environment have developed Standard Operating Procedures to reduce some of the possible undesirable consequences of a security-oriented process. In particular, for trust accounts, there is a legal requirement that an account must be reviewed once a year. This review obviously triggers a portfolio-oriented decision making process, although sequentially focused on single accounts. Tax consideration similarly trigger portfolio-oriented decision making processes towards the end of the year, to balance losses with capital gains. In short, the world is much more messy than the discussion might have led one to believe. However, the fact that the investment process is primarily stock-oriented is proposed as only one, although an important one, reason for the negative finding concerning the relation between conceptual systems structure and use of the Portfolio Composition System. Other possible reasons were suggested in the introduction of the chapter: measurement error and relatively homogeneous managers.

Consequences.

Why does the position that the investment process is primarily security-oriented explain that there is no relation between Integrative Complexity and usage of the Portfolio Composition System? Should it not be equally applicable to the use of personal sources and impersonal sources of information in general? There are two parts to the answer to this question.
First, of the ten functions presently available on the Portfolio Composition System, not one supports the intelligence, design, or choice phase of the dominating process (see Figure 8.1) in a security-oriented decision making process. In contrast to the other sources of information considered in this investigation, only one function of the Portfolio Composition System presents information relevant to the selection of individual securities, the decision entity of the dominant process of a security-oriented process. The one function focused on the individual security, ISSUE, presents a limited amount of information, mostly on the current status of the issue (such as current price, total units held by Trust department, percent of total outstanding stock held by the Trust department, action price, and investment strategy). In short, the system is of little value in support of the dominating process.

Secondly, at the point where the decision process enters the portfolio centered sub-process, the problem to be solved has been constrained to the extent of making it a highly structured task. In fact, the Portfolio Composition is partly responsible for having made the portfolio sub-process as structured as it now seems to be.

The primary issues to be addressed in the portfolio-oriented sub-process are: which accounts should be affected by the decision (that has already been made) to buy or sell a security, and what volume or dollar amount should be involved in the trade. The decision criteria involved, for a "buy" decision, are the value of liquid assets in the account and the amount of the security in question already contained in the account.

Complexity Theory predicts that in a task that is seemingly so structured, variations in Level-of-Information-Processing are not due to varia-
tions in Integrative Complexity. The situation is so clear-cut that alternative interpretations of the relevant stimuli are unlikely and in fact not very appropriate.

The key point above concerns the degree of structure in the portfolio-centered sub-process. Assessment of the degree of structure is clearly subjective. However, relative to the problem of selecting a security in the first place, the portfolio process is more structured, particularly when it is entered with only one specific buy or sell decision in mind. Furthermore, this lower level process does not have an intelligence or problem finding stage: the manager is solving a well defined problem, he is operating in a "closed" problem space, and the task can therefore be considered as quite structured. This would seem to hold particularly for the choice of which source(s) of information to use in the portfolio-oriented sub-process, that is, the related Information Sources sub-task. With the Portfolio Composition System as an alternative, the choice of information source is rather straightforward. Furthermore, in terms of execution and implementation of trades, the STATUS and RUN functions are in a dominating fashion the most appropriate functions on the system. As noted by most of the portfolio managers, the STATUS function is very useful in this process. Some go as far as saying that it is "... the single most useful source of information...", indicating that in its particular area of application, it is perceived as the source of information.

Assuming that the investment process still is largely individual security-oriented, one key question that remains to address is why the process has not changed? Why has the Portfolio Composition System not had the desired impact? A plausible explanation will further strengthen the case
for believing that the process in fact has not changed.

There is probably not a single answer to the question posed or a single major cause for the lack of change. Rather it is a question of a number of intermeshed and co-existing forces that in total can be considered as a field with no resultant force pulling in the direction of the desired change.

Different participants or actors involved with the Portfolio Composition System have differing opinions about why the system has not had all the anticipated impact. These differences partly reflect different perceptions about what should be or was the desired impact. One explanation, purely technological, is that "the Portfolio Composition System is not here": the present version of the system does not contain all the functions specified in the original design. For example, the version of the system in use at the time of this study did not contain the CREATE function proposed in Gerrity's thesis (1971, p. 234). CREATE was a function designed to enable the managers to create a hypothetical portfolio and thereby look at the consequences of changing the composition of a portfolio. Another technological issue mentioned is that the system still is unreliable and has at times response times that are longer than the specified ten to thirty seconds range.* Finally, some suggest the change in investment management towards a more centralized process, a situation brought about by strong

* Note that this issue was brought up by most managers in interviews in the first months after the initial installation of the system (Fall of 1972). However, in the interviews taken in the Fall of 1973, not one manager mentioned reliability and response time problems when comparing the system functions with the other sources of information available.
competitive pressures in the industry and the poor performance of equities in the money market. The purpose of the system, it is claimed, should and has therefore changed.

In what follows, two other important and revealing possible causes are discussed. The one deals with the nature of the research data base available on the Portfolio Composition System. The other considers the level of manager knowledge and understanding of the different sources of information available to them.

The major difference between these two issues, and those briefly alluded to above, is that this study provides evidence that suggests and documents the first two. However, it is difficult to tell if they are necessary or sufficient causes for the lack of change in the investment process. Obviously, they must be considered as hypotheses more than corroborated facts. However, they do seem very significant. Even more important, they have implications far beyond the scope of the specific setting considered. These implications are discussed in the final chapter.

The Research Data Base.

A key component of the data required to support all the stages of an investment process deals with estimates of future values of key characteristics of individual securities. Simplified, this is a question of estimates of future earnings and future price/earnings ratios. In normative portfolio theory terms, it is a question of estimates of Betas and future overall economic conditions. Historical data on individual securities is useful for reporting and monitoring portfolio performance. However, for
identifying and planning changes in portfolios, data on the future is the key database.

A look at manager perceptions reveals that there is quite a consensus in terms of equity research data that deals with estimates of future security parameters. Twenty-three of the twenty-eight portfolio managers interviewed using the Information Sources Role Construct Repertory Interview suggested the Potentials List in response to the question (that is, RCRI role) "An Equity Research document that you find not too useful" and the question "An Equity Research document that you imagine very few Portfolio Managers read". The Potentials List is precisely the report that gives the research department's estimates of earnings and Price/Earnings ratios for some years ahead.

Based on an analysis of the descriptions given by the portfolio managers, the Potential List is seen as not very useful because it is viewed as inexact, unreliable, not up-to-date, and a mere mathematical transformation of some raw (historical) data.

The important point about the Potential List, a document that actually was discontinued during the fall of 1973, is that it contained basically the same data on individual securities as that available on the Portfolio Composition System. Interestingly, not one Portfolio Manager mentioned that he thought the data on the system was inexact, unreliable, not up-to-date, etc... However, neither did a single portfolio manager view the system as a planning tool. In a sense, the Portfolio Composition System data base concerned with estimates of future P/E ratios and earnings is ignored or overlooked by the portfolio managers.
Portfolio manager perception of the data in the Potentials List, however, reflects a deeper organizational reality. As noted by one manager, the reason that it took months before the Potential List was updated was that

... the analysts take a dim view of this thing, it is a kind of make-work project, to fill out time, ...., at least this is what I found out (when I was) there, and I don't think it has changed, it is a low priority type of thing....

The same manager goes on to suggest that the reason that it was a low priority activity was that the analysts knew that the portfolio managers did not use the Potentials List. This opinion is corroborated by the report of another portfolio manager, that he was met by a surprised, "... I didn't think any of you ever looked at the list...." when he contacted an analyst in order to get an explanation of some discrepancies in the data reported in the list.

What emerges is a situation where the behavior of both the portfolio managers and the analysts make the assumptions underlying their behavior in fact come true. It is a kind of double bind, where the actions of the analyst reinforces the actions of the portfolio managers, and vice versa.

In a pre-Portfolio Composition System world, the low priority on updating the Potentials List on the part of the analysts, and, the minimal attempt to use the data on the part of the portfolio managers can be interpreted as functional. The reason is simple: the portfolio managers could not process and manipulate such a vast quantity of statistical data. The information link between analyst and portfolio manager was rather maintained at a level of information that represented the analyst's summary of
this large database: buy, hold, and sell recommendations for individual securities.

The Trust department seemingly recognized the point, as the research analysts were evaluated and rewarded in terms of the quality of their buy, hold, and sell recommendations. They were not evaluated in terms of the accuracy of their estimates of future earnings and Price/Earnings ratios.

To summarize the point concerning the research data base, in the pre-Portfolio Composition System world, both the portfolio managers had an investment process and the analysts had an information generation process adapted to the information processing capacity of the portfolio managers. With the introduction of the Portfolio Composition System, the situation in terms of the portfolio manager's ability to process data has radically changed. However, neither Investment Research nor the portfolio managers have changed what information they generate and what information they use. The interlocking nature of their respective behavior is an important barrier to change. A significant change in manager use of information probably will only come about by a visible and real change in emphasis of analyst information generation. However, the latter change can only be successful if accompanied by actual portfolio manager use of the information generated.

From another perspective, the design of the Portfolio Composition System recognized explicitly only part of the characteristics of the decision process diagnosed. The link between cognitive capacity and the primary focus on individual securities in the investment decision making process was identified. The diagnosis did not, however, explicitly recognize the link between cognitive capacity and the emphasis of the information support functions in terms of data content. In part, this is probably due
to the fact that the Potentials List was first emerging as a research product at the time of the initial Portfolio Composition System design effort. Gerrity notes,

... The Investment Research group has developed one model for estimating future annual total return of stocks on the approved list, but it is experimental and not fully adopted by the portfolio managers....(1970, p. 226).

As mentioned previously, the model (whose output was the Potential List) was never adopted by the portfolio managers and its use was discontinued in the middle of this investigation (fall of 1973).

A final point on one consequence of how the managers perceive the research data base -- it gives one explanation in particular for why the managers do not value or use the graphical functions on the Portfolio Composition System very much. As noted by one manager, "graphical functions are primarily useful to show extremes...". In a situation where the system is primarily used to view historical data on account holdings, the manager is generally already familiar with and aware of most of the extremes that might be shown. For instance, he is aware that Mrs. Jones' account is overconcentrated in ITT stock, and he also knows why: the late Mr. Jones worked for ITT and therefore Mrs. Jones is emotionally attached to these holdings.

How can this explanation be reconciled with the high use of graphical functions reported in the Portfolio Composition System prototype experiment (Gerrity, 1970, p. 312)? The clue seems to be the fact that most of the system users were viewing accounts that they were unfamiliar with: they were either not portfolio managers or they were viewing in part somebody else's accounts. In such a situation, the graphical functions might be very
useful to give the user an overall view of the accounts.

The point being made is that in a historical perspective the manager
is aware of the general distribution of holdings in an account. For execu-
tion and implementation purposes he is, furthermore, more interested in
knowing that he has 203 RCA shares than that approximately 2% of the ac-
count is in RCA. With uncertain data on the future, however, the situa-
tion might be reversed. Detailed dollar values would be of little interest
as the accuracy of the underlying data does not match this level of detail.
Rather, general, overall distributions as provided by graphical displays
would seem to be a more useful perspective on the data. This last obser-
vation is an appropriate lead into the second possible cause of why the
Portfolio Composition System has not had the anticipated impact. It deals
with why managers seemingly have not recognized that there might be some
value to exploring an inexact data base about an uncertain future.

The Information Sources Sub-Task

Even though the perceived and actual state of the research data
base is not what it could be, it would seem that this alone cannot explain
that there has been no shift towards a portfolio-oriented investment pro-
cess. Inaccurate and stale data would seem to be better than no data. In
fact, the concept of a portfolio embodies precisely the notion of gathering
a set of assets in order to absorb a part of the uncertain future about
individual assets. In other words, uncertainty in the estimates of the
future performance of individual assets is the natural state of affairs
in portfolio management.
Ignoring the potential of the research data base suggests therefore a black-white, undifferentiated view of the world of information sources. It suggests a problem in terms of an ability to integrate information from a variety of sources, each having its strengths and weaknesses.

The constructs elicited in the Information Sources Role Construct Repertory Interview support such an interpretation. What emerges on the basis of an analysis of the content of the perceptual maps obtained is a picture of the managers as not very cognizant of the nature of the information sources available to them. In a sense, the data can be interpreted as indicating that the information sources sub-task is very low in the hierarchy of problem solving processes, subordinate both to the security-oriented sub-process and to the portfolio-oriented sub-process.

From a different perspective, the data suggests that the conceptual system relevant to the perception of information sources is rather undeveloped, and therefore not used extensively in a conscious fashion. As noted by Scott, from a developmental perspective, a conceptual system is initially primarily composed of affective and evaluative constructs (1969, p. 263). An affective construct is one that implies a good-bad distinction. It is only in the more developed conceptual systems that descriptive constructs or constructs that are neutral, emerge and play a more important role in the conceptual functioning.

In a rough coding of the 390 constructs elicited in the twenty-eight interviews, close to fifty percent of the constructs were coded as evaluative in nature. Examples of evaluative constructs in the set of 390 constructs are:
Useful versus Not useful
Valuable versus Not valuable
Unrealistic versus Realistic
Reliable versus Unreliable
Credible versus Not credible
Exact versus Inexact

Of the remaining non-evaluative constructs, a number of them are very concrete, dealing with physical and directly observable characteristics of the information sources considered. Examples are

Numerics versus Graphical
Time consuming to use versus Not time consuming to use
In-bank versus Out-of-bank
Quantitative versus Qualitative

In a Piagetian sense, the logical corollary of development is use. The low development of the information sources conceptual system can therefore be taken as evidence of low use of the conceptual system. In the framework of this study, this implies that the Information Sources sub-task is seldom entered.

The actual labels or language used by the portfolio managers to describe information sources is another subjective and qualitative indication of the position of the Information Sources sub-task. There is seemingly a lack of a homogeneous culture among the portfolio managers on this dimension. As opposed to constructs relevant to the perception of portfolios, the constructs generated by the managers are quite different from manager to manager. Furthermore, the labels used for quite similar constructs
are quite different. The data suggests therefore that there is little discussion among the portfolio managers about the characteristics of the information sources available. The Information Sources sub-task is not a common concern, as it is a low level concern.

The low position of the Information Sources sub-task is the natural and rational adaptation of the individual portfolio manager to the complexity of his task. Already in his task, due to the number of overlapping but different sub-tasks, there is little room for experimentation and learning along the primary dimensions of the task. There is little environmental feedback and the manager seeks out those areas with the most clear feedback, such as client relations, the timing of trade decisions.

In this world, very much similar to the one depicted by Mintzberg (1973) in his study of senior managers, there is little incentive to experiment and learn about such secondary tasks as the choice of information sources. A portfolio manager will not get a pay raise or advancement from giving evidence that he has mastered the complexity of the information game he is playing -- other than in terms of how it affects his main task. And therein lies the problem: how can he know which use will be beneficial to his long-term performance in his main task, managing the assets of the Trust departments clients. A couple of managers express this very clearly in some of their comments about the numerous functions and options available on the Portfolio Composition System:

There are too many options, too many variables to consider and I need some structure to limit the options I should choose...

...choosing and experimenting with the numerous options is compounded by the lack of evidence that it is worth the effort....
Just getting the uninterrupted time to experiment with new functions is difficult due to the brevity, variety, and fragmentation of the activities of the portfolio managers. One manager, commenting on his perception that a function was difficult to use, suggested that this might be due to the fact that he had not yet had time to become really familiar with the function -- this occurred six months after the function became operational!

To summarize the point concerning the position of the Information Sources sub-task, the data suggest the hypothesis that it is a subordinate and loosely connected sub-task in the investment decision making process. It is in a sense difficult for the portfolio managers to see all the possible uses of the system. Important in this context is that in the initial introduction and training with the system, little or nothing was said about the desired impact of the system in terms of changing the decision making process of the managers. An opportunity was missed to give the portfolio managers some feedback from their environment, in the sense of the diagnosis of their decision making process made by the designer of the Portfolio Composition System.

An Additional Implication

The implications of the hypothesized low development of manager conceptual system related to information sources is not limited to the issue of why the investment process has not changed. There are also implications for the main hypothesis of this study. In terms of individual differences, the generally low development of manager perception implies that the managers are quite homogeneous on this dimension. Homogeneous managers might
explain, on the one hand, the limited convergent validity of measures of conceptual system structure, and on the other hand, the limited support for the main hypothesis of the study. Formulated in somewhat different terms, if in fact the managers are quite homogeneous in terms of the Integrative Complexity of information source perception, then the results of the hypothesis testing indicate the Complexity Theory has in fact identified an important leverage point for increasing the Level-of-Information-Processing in the managers' investment process. This line of reasoning must be taken for what it is, namely based on a number of weakly substantiated hypotheses. It does, however, suggest some key issues for further research, issues that will be explored in the next chapter.

Summary.

1. In this chapter, an attempt was made to understand and explain why the breadth, volum, and balance of the Portfolio Composition System usage is seemingly not related to the Integrative Complexity of Information Source perception. The logic of the explanation and analysis moves through several levels.

2. The basic explanation proposed is that the model of the investment task introduced at the outset of the study is incomplete and inaccurate. The decision making process of the portfolio managers is still primarily individual security-oriented and not portfolio-oriented.

3. As a consequence, the Portfolio Composition System, designed to support a portfolio-oriented decision making process, is only useful and used in a very structured component of the investment process. Complexity
Theory would then in fact predict that the Integrative Complexity of Information Source perception is unrelated to the usage of the system; in other words, the finding to explain.

4. In an attempt to understand why the investment process has not changed towards a more portfolio-oriented process, the anticipated impact of the Portfolio Composition System, two reasons are discussed.

First, the Investment Research function has not changed its information generation effort to give emphasis to data that reflects the information processing capability the portfolio managers have acquired. Specifically, their emphasis is still on qualitative information and on trading recommendations, and not on projected future earnings and P/E ratios. The managers, aware of this, do not use the system to manipulate such data.

Secondly, the information sources sub-task of the managers is a subordinate and rarely entered activity. The portfolio managers are not very cognizant of the characteristics of the different sources of information available. Specifically, the managers have problems integrating the Portfolio Composition System with the other sources of information available to them. They therefore limit its use to where the system is obviously very useful, which is the structured portfolio-oriented sub-task of their existing, primarily security-oriented investment process.
Chapter 9: Implications

The overriding aim of this study was to contribute to the development of a theory of managerial decision making processes relevant to understanding the use of advanced Conversational Computer Systems in unstructured tasks. Such a theory was seen, in turn, as a building block in efforts to develop a theory to guide the design and implementation of Decision Support Systems for unstructured tasks. The findings of the study, although far from clearcut and only quite tentative, have some important implications for the issues underlying the study. The purpose of this chapter is to review some of the implications.

The chapter is organized into two main sections: one deals with the implications for the design, implementation, and use or impact of Decision Support Systems; the other deals with some of the implications for further research in the area.

The discussion that follows is no longer bound to the issues surrounding the development, use, and impact of the Portfolio Composition System available in the specific research setting considered. The implications are explored in terms of the larger class of Decision Support Systems in general. This is done with full cognizance of the fact that only further research, both in terms of the findings themselves and their external validity, can really justify such a generalization. At this point, the only thing that seems certain is that there are a number of situations and contingencies where the generalizations will prove not to be valid.
Implications for the Design, Implementation, and Use of DSS's.

First a brief review of the notion of a Decision Support System and the state of knowledge concerning the design and implementation of such systems. It serves to focus the discussion on the primary areas of both interest and relevance.

Decision Support System is a label that has been proposed to designate systems that are designed to be used by managers in unstructured or unprogrammable tasks (Gorry and Scott Morton, 1971). As the label implies, the primary function of a Decision Support System is support of the manager in his decision making, as opposed to replacement of a more or less limited aspect of decision making previously performed manually. The distinction between replacement and support reflects a concern for what should be the appropriate level of aspiration of systems designed to be useful and used in unstructured tasks.

Implicit in the notion of decision support is the view of man and machine (or system) working together being able to outperform either working alone. Although not always the case, such a view suggests that system and manager will make decisions differently from those made by manager alone. For example, in the case of the Portfolio Composition System considered, one desired and anticipated change was from the stock-oriented decision making of portfolio manager alone to a portfolio-oriented decision making for manager using the system.

Restated, a key characteristic of Decision Support System development is that the effort seeks to change the decision making process of the manager that is to be supported. This is a central concern of Gerrity's pro-
posed methodology for the design of Man-Machine Decision Systems that will now be briefly reviewed. Not only was his methodology applied to the Portfolio Composition System considered in this study, but it is of further interest in that it represents one of the few explicit statements of a design and implementation methodology specifically oriented towards Decision Support Systems.

Gerrity proposes an evolutionary and decision centered approach to the development of Decision Support Systems (ref. principle 1 and principle 3 of his design methodology [1970, pp. 159-160]). Few can disagree with, or use, such generalities. The key points emerge in his elaboration of these more general terms. For our purposes, this elaboration can be summarized by the following statements:

1. Decision Support System development should be an evolutionary process which starts from the point of supporting the existing decision making of the manager.

2. Decision Support Systems are designed to support a process as opposed to the support of a specific decision.

The second point is in fact never explicitly made. However, it is implicit in the framework chosen for decision modelling: Newell, Shaw, and Simon's theories of human problem solving. As elaborated by Gerrity, this framework contains two elements: the decision process, viewed primarily in Intelligence, Design, Choice terms, and the information processor components viewed in terms of memory, operators, and programs.

The view of Decision Support System development embodied within these principles is one of computerizing the information processing primitives or operators of the decision maker, and hoping that, over time, the manager
will evolve programs or procedures composed of these primitives which represent the desired changes in the decision making process. Or as stated by Gerrity,

...One approach to building a familiar base would be to identify programmable operations or data manipulations in what the decision maker now does and implement those in an accessible fashion with the appropriate data base. These familiar operations provide for positive transfer from the current decision process for the user. Once he is over this threshold of using the system, then he may begin to explore and incorporate new procedures implemented from a normative rather than descriptive model .... (1970, p. 162, underlining added).

The key hypothesis that the proposed evolutionary strategy rests on would seem to be that the manager will begin to explore and incorporate new procedures or programs. The finding of this study of portfolio managers concerning the undeveloped nature of information source perception and understanding seems directly relevant to this hypothesis concerning change. The finding implies that it is quite unlikely that such a development will naturally take place within the manager's working environment, once he is over the threshold of using the system. In other words, growing systems from a situation where they support the present decision making process to where the system is used to support the normatively desired process is a difficult task. It is probably, at best, a very slow process.

This conclusion would seem to be particularly true in a situation where the Decision Support System is designed to support all stages of the decision making process as opposed to being focused on a specific choice problem. This distinction in system focus can be labelled as the difference between a decision process-oriented system and a decision-oriented system. The Portfolio Composition System in this study is an example of the former; the system has several functions that give multiple perspectives on
portfolios, a capability useful at a number of points in the decision-making process. An example of a decision-oriented system for the same task could be a system designed around the concept of presenting information on the consequences of a set of specific trades in terms of portfolio performance for the next N years. Obviously this is not a clear-cut distinction, but rather one of emphasis and primary focus.

With an emphasis on overall process support, combined with a large component of the system designed to support the existing decision making process, there is not enough focus or direction to bring about the desired change. In the compromise between "... current decision system and a normative decision process..." (Gerrity, 1970, p. 161), the normative decision process loses out completely. There are a number of forces working to keep the decision making process unchanged, and these are strengthened in an environment where a primary concern is accommodation of user requests and adaptation at all costs of system-to-user rather than user-to-system adaptation. Specifically, in the case of the Portfolio Composition System, such a system-to-user adaptation led to the inclusion of features within one of the graphical reports which made the system more suited to support a security-oriented process. In an initial version, the system produced histogram reports which represented the distribution of assets along different major security classifications. The report indicated only the overall percent or value in each security class. In response to demands from the portfolio managers, the report has now been changed to indicate which are the specific securities contained under each of the bars of the histogram report.
The non-homogeneous and undeveloped nature of manager information source perception suggests that communication with a large user community is difficult, as there is a priori no common terms or language. Furthermore, it suggests that asking managers for guidance in the design of new functions, both in terms of new functions or choosing among a set of proposed functions, will not contribute a lot to the design and implementation effort. This implication is supported by data collected in the specific setting considered, where manager perceptions of what was the most useful functions changed radically over a one-year period of use. It is an issue suggested by Ackoff in his article on Management Misinformation Systems (1967), and it is evident in the experience of at least one other Decision Support System effort where what turned out to be the most used functions were not what managers initially predicted (Ness et al., 1971).

This is not to say that the manager is not a good source of information in the design process. Rather, it implies that his strengths and weaknesses must be recognized and taken into consideration. In particular, asking what function he thinks is the most useful or how a function might be improved, should always be followed up with a question of why he thinks so.

Finally, some implications for the issue of the relation between managerial understanding of the Decision Support System or formal model made available to him and his ability to integrate the information provided with that of other sources of information such as his own judgement and intuition. The tentative findings of the study suggest that managers do not have a large capacity to "understand" the output of a model and in most cases therefore reject it outright. Complexity Theory suggests that one might also have cases where the low level of understanding leads to outright
uncritical acceptance of the output of the model.

As argued by Little (Little, 1970, pp. 467-468), understanding a model or understanding a Decision Support System, does not necessarily mean knowing the details of the underlying computer program. However, his examples of what level of understanding that is required perhaps misses the point that it is not a question of knowing effective teams (models) from ineffective teams (models), but rather a question of understanding the strengths and weaknesses of a model vis a vis other models or other sources of information. As stated by one of the more cognizant portfolio managers of this study, it is a question similar to knowing about how somebody thinks so that you can adjust his recommendations or opinions for biases and special assumptions.

The undeveloped nature of information source perception suggests that managers have problems integrating output of other sources with the output of a Decision Support System. In particular, they seem to find it difficult to follow Soelberg's prescription that

"...A manager should work on integrating formal models of rational decision making with his intuitive, judgemental common sense manner of solving choice problems... (Soelberg, 1967, p. 28).

The finding of this study therefore reinforces Little's suggestion that models should be simple. It supports Hall's contention that models should be explicitly causal (Hall, 1973) and therefore easy to understand. However, it also would seem to imply that in attempts to develop more complex models to deal with complex phenomena, the route to go is to build systems where the system is designed to help the manager integrate information and knowledge from a number of sources. Simply stated, the system should attempt to integrate the output of the model with the judgement of
the decision maker, rather than being oriented towards presenting the output of a formal model to the decision maker and letting him take care of the integration. The decision framework or problem space of the system should approach the choice problem faced by the manager at a level which includes what might be the judgemental inputs relevant to the problem. For example, in the case of the portfolio composition problem, the system might be designed to include input of manager's judgement of the development of the overall economy over the relevant planning horizon.

With such a view, building Decision Support Systems is no easy task as it requires not only developing and designing "good" models, but also requires the anticipation of what judgemental inputs might be considered relevant and how best to integrate these inputs with the outputs of more formal models.

The ramification of changing information processing technology is furthermore not restricted to the direct man-machine components and relationships, but has added complexity in terms of impact on supporting organizational activities. It is a case analogous to the impact of a classical Management Information System on the other departments not directly involved in the implementation of a new computerized routine. However, the inter-relationships are not as obvious and more subtle, dealing with issues of perception and emphasis. The experience in the case of the Portfolio Composition System, where the investment research function seemingly has not changed the information generation process to reflect the new information processing capacity of the managers, is a good example. There are probably a number of other such factors that affect the impact of a Decision Support System. One such factor is the role of the managers' perceptions about
what is their legitimate and appropriate function in terms of decision making and reliance on others for direction and data input. Specifically, for certain portfolio managers in the Trust department there was a clear view about where the responsibility of the analysts ends and their responsibility starts: the analyst should only generate estimates of future earnings of individual securities, while the portfolio manager is seen as responsible for the determination of the appropriate Price/Earnings ratios. The impact of such a role definition on a system that does not enable the manager to input his own estimates seems obvious.

To summarize, developing Decision Support Systems to be used in unstructured tasks is an even more unstructured task. It not only requires the designer to understand the present decision making task, but also requires a good understanding of the future decision making task and of how to move from the present state of affairs to the desired state of affairs. Formulated in these terms, it seems obvious that it is beyond anyone to grasp and deal with simultaneously all the facets of such a complex task. This view confirms Gerrity's position that the approach must be evolutionary and incremental, compensating feedback from experience for ignorance and lack of understanding. The discussion has identified a number of points about what might be key operationalizations of such an evolutionary design and implementation process. They are presented in what follows as a number of propositions about a Decision Support System development methodology. They should not be considered as a rejection, but rather as an elaboration with a shift of emphasis from Gerrity's methodology.
Propositions concerning the Development of DSS's

1. The development of Decision Support Systems is a highly structured task, where the problems encountered are accentuated by the limited capacity for change of the managers involved.

Strategies that both help structure the development task and help deal with the issue of limited manager capacity can be divided into strategies that increase the managers' inherent capacity for change, and strategies that reduce the load of a desired change on the managers involved.

Strategies that increase manager capacity.

2. Improved manager conceptualization of both his task and the information sources available to him is a key leverage point for increasing manager capacity for change.

Improved conceptualization captures notions of manager involvement, awareness, and training, but gives a more explicit operationalization of these notions. Furthermore, it suggests that a strategy for increasing capacity for change must operate at a number of levels of conceptualization. Specifically, managers should be involved at the level of understanding the rationale for the DSS, and not only at the level of approving functions or training in function usage. It says that users should be involved in the diagnosis of the present decision making environment. Such an involvement serves to unfreeze the user, preparing the ground for the moving desired and anticipated with the DSS. Obviously, such an involvement can give important input in defining both direction and pace of such a change.

In the case of the Portfolio Composition System studied, one applica-
tion of such a strategy would be to make the presentation and discussion of the diagnosis and design concepts underlying the system an integral part of the system introduction and training program. Specifically, the program should elaborate on the issue of a security-oriented versus a portfolio-oriented decision making process; the data that suggests that the managers, at present, are primarily security-oriented should be presented and discussed.

From another perspective, user participation in the diagnosis is a part of a process of getting him actively involved in a conscious effort to understand his information processing environment -- in other words, have him enter the seldom entered Information Source sub-task.

Proposition 2 suggests that a key concern in the management of a DSS development effort is the management of manager (=user) conceptualizations or concepts. At the outset of this investigation it was proposed that the key variable to monitor in terms of DSS impact were process changes. The position taken above reflects a belief that manager knowledge or concepts should also be monitored as a set of key mediating variables. In other words, changes in process are mediated by changes in knowledge and perceptions.

In a recent paper, this idea has been extended and elaborated to the level of a continuing component of the DSS design and implementation effort (Stabell, 1974). The Role Construct Repertory Interview is proposed as an instrument to sample and monitor manager perceptions of information sources, and thereby provide data to guide and evaluate the development process.
Strategies that reduce the load of a change.

3. In a transitory phase, manager work load from other sub-tasks and volume of main task involved should be reduced.

This strategy seeks to deal with the problem that the demands of their present task are such that managers have little physical capacity for experimentation and self-development of new decision making procedures that capture the potential of the new information processing technology.

Although it is typically difficult to physically shift the work load on individual managers in a transition period, in actual fact this can be achieved by a temporary shift in priorities. Managers are made aware that their management puts emphasis on self-development activities, even though this might impair their performance of other sub-tasks. Such load reduction via priority shifts is an example of how top management involvement in the development effort might be the key to the success of the effort. The operationalization of top management involvement is visible and public priority shifts.

The key to the success of a temporary priority shift is management and manager ability to evaluate the progress of self-development activities. This requires data to monitor manager decision making processes and models that enable one to predict the nature of the emerging decision making process. Such predictions should not only deal with Decision Support System use and relative use of the different functions available, but should also deal with how the use of the system should impact the use of other sources of information available. The analysis of information source use in Chapter 8, which amongst others made extensive use of the log of the Portfolio Compo-
sition System use, is an example of how such a modelling, monitoring, and evaluation effort might proceed.

In many ways, attempting to change decision making in unstructured tasks has much in common with a research effort. It should therefore be approached very much as an experiment to test and refine our understanding of the process to be affected.

4. A key component of a Decision Support System should be decision-oriented models.

In an effort to give direction and focus to the DSS evolution decision-oriented models seem useful. A decision-oriented model is one that deals with a relative specific choice problem in terms of the actionable variables available to the manager and in terms of the consequences of different choices for the primary variables that capture the objectives of the choice problem. Decision-oriented models are here considered in contrast with a decision process-oriented system, where the system is not designed to support a specific phase of the process, but rather designed to be useful in all phases.

The key to the success of the evolutionary development effort is that the DSS may be somewhat out in front of the manager in terms of the evolution, but at the same time not too far out. It is a compromise between support of the existing process and support of the desired decision making process. Obviously it is difficult to hit the balance directly. Rather, fine tuning is a major component of the evolutionary process.

5. A primary function of an advanced Decision Support System should be active support of manager integration of information and knowledge from a wide variety of sources.
In particular, the system should be designed to accept manager judgments and intuition as inputs. It is a difference between the system only dealing with and operating on formally generated information, versus the system operating at a level which includes manager judgement and intuition as a valid data base.

Summary.

Underlying most of the implications reviewed is the interpretation of the data collected that suggests that manager perception of information sources is rather undeveloped. The basic implication is that a Decision Support System design and implementation process must explicitly recognize and deal with the issue of managers' lack of capacity for change.

It is evident that very few of the implications reviewed explicitly are based on findings concerning the main hypothesis of the study. In other words, Complexity Theory has not formally been explored in terms of implications for Decision Support System use and development. However, concepts such as manager ability to integrate information from a wide variety of different sources of information, and concern for the development of manager conceptual systems relevant to the perception of information sources, are clearly anchored in the perspective of Complexity Theory. The limited support of the hypothesis derived from Complexity Theory seemingly justifies the use of this perspective.

This brings us to a point where it seems appropriate to evaluate the overall research framework used, with a concern for implications for future and further research in the area. The discussion will also review some
specific theoretical and empirical issues that have been identified or are suggested by the findings.

Implications for Further Research.

The key decision in terms of research strategy was to focus on individual differences in managerial decision making processes. This choice reflected a belief that improving our understanding of managerial use of Decision Support Systems would profit from an extension of existing theories of organizational decision making. These theories, most of which are closely attached to the work of Herb Simon and his associates at Carnegie, have been largely based on an analysis of similarities in managerial decision making processes. In an attempt to elaborate the theories of the Carnegie School, looking at individual differences seemed as a fruitful avenue of attack to make the theories more useful from a normative perspective. By getting some of the dimensions of man's bounded rationality, leverage points could be found that would give some understanding of what one might do if one desired to change the state of the world to one more desired. Such an extension might meet some of the criticisms (Argyris, 1973) leveled against what basically has been a uni-dimensional descriptive theory with few normative implications other than that any successful effort to increase the cognitive capacity of decision makers will potentially extend the bounds on his or her bounded rationality.

Specifically, a decision was made to explore Complexity Theory as a basis for identifying important dimensions of the problem solving processes along which managers differ, and, as a basis for understanding the cause of
these differences. The theory introduces the mediating variable conceptual system structure between the more abstract notion of man's limited cognitive capacity and the bounded rationality evident in problem solving and decision making behavior.

In retrospect, it seems that the choice of Complexity Theory as theoretical base had important and fortunate consequences for the fashion the study progressed at a concrete level. Of all the places where this research has generated a sense of excitement and feel of opening interesting perspectives, the most striking is in terms of the general approach that has been explored.

First, Complexity Theory suggested that the use of a Conversational Computer System in unstructured tasks should be considered within the context of the use of the larger array of sources of information available to the manager. Without this wider perspective, it probably would have been difficult to understand the findings concerning system use.

Secondly, Complexity Theory recognizes that characteristics of an individual's information processing and decision making behavior might not be a general characteristic of behavior, similar in all situations, environments, or tasks. Within Complexity Theory, the issue is empirical and not theoretical. As a consequence, Complexity Theory forced the study to explicitly recognize the issue of cognitive domain or what in the study is captured by the notion of a model of the task studied.

Finally, the key independent variable in Complexity Theory is the structure of the conceptual systems. In the process of measuring this variable, a link was established between the concrete situation being studied and the more abstract concepts of the theory: the managers' per-
ceptions of relevant objects. Although such a clear link might be interpreted as resulting in measures of both dependent and independent variables being quite similar, the link made possible an analysis that could move between a number of levels of abstraction. The ability to do so was critical for the attempt to "understand" some of the unexpected findings of the study.

In fact, the study progressed through an analysis that moved from a focus on differences to a focus on similarities. It also moved between an analysis of structure to an analysis of content. It now seems clear that when dealing with phenomena of a richness similar to those studied, such shifts in perspective are required. Otherwise the knowledge gained is extremely limited as no single point can be strongly asserted. It is only as a part of a complex mosaic that findings have any credibility.

Another lesson that the study suggests is that a meaningful theory of managerial information use is neither desirable nor feasible. The theory must become too generalized to be relevant for the explanation of more specific situations and phenomena. Instead, the theoretical framework must be considered primarily as a methodological framework, no more; and certainly not as a general "theory of managerial information use". As such, Complexity Theory seems to have served well and has potential for further research. Furthermore, the framework has the added advantage of being a useful framework for organizational diagnosis. Although the general concepts of the theory are quite abstract, it does contain the potential of providing a useful link to practice. From the experience gained in this study, in part interacting with the specific organization involved, Complexity Theory seems to be a case in point for Lewin's position that
there is nothing as practical as a good theory.

At least a couple of negative points are now evident concerning the consequence of using Complexity Theory as a theoretical base. First, given the theory's strong roots in personality theory, previous research led to a focus of too much attention on the measurement of conceptual system structure. This resulted in insufficient effort in terms of defining and measuring the components of information processing behavior.

Secondly, although Complexity Theory recognizes the issue of domain specificity, previous research has not dealt with the issue explicitly in any significant fashion. Although it was evident at the outset of the study that this was an important issue, the lack of concern for the issue in previous research led to underestimating the importance of the issue. Specifically, at the outset there was a lack of appreciation for the importance of modeling the concrete task studied.

This brings us to one of the key implications of this study for future research in the area. First, however, it seems useful to note that the implications for future research can be divided into two main categories:

1. Research that is primarily oriented towards the elaboration of Complexity Theory.

2. Research that is primarily concerned with the more applied aspects of Decision Support System development and use.

Not that these two categories are completely independent. The distinction reflects rather a belief that research interest, strategy, and methodology will and should differ.
Implications for Research in Complexity Theory.

Some of the key implications of this study in terms of further research in the area of Complexity Theory were already presented in the two measurement chapters (Chapters 5 and 6). Briefly, the study clearly suggests that there is a need to develop more explicit formal models of conceptual systems in order to clarify the apparent multi-dimensional character of conceptual system structure. At a more specific level, the findings of the study imply that further research should investigate the validity, both theoretical and methodological, of the measure of conceptual system structure developed in this study.

The measurement of Level-of-Information-Processing suggested that both theory and methodology need to address the issues of what constitutes a distinct source of information, what are the dimensions of the variable "information use", and what is the appropriate time window to use in the analysis of process characteristics. At a more general level, the study has implications for how one might develop an experimental or laboratory environment that is a more realistic simulation of tasks encountered by managers in organizations.

As briefly mentioned above, and shown in Chapter 8, a third key issue for future research is that of modelling the task studied. This study suggests not only that this might be an important issue for the behavior-to-conceptual system mapping, but that the importance of different conceptual domains might vary at different stages in the process. Specifically, the development of the theory must consider the issue of whether, for example, the structure of Information Source perception is a key deter-
ominant of information processing behavior in the Intelligence phase of a decision making process, while perhaps the structure of the primary task entity (such as securities in the investment process) perception is the dominating determinant of Level-of-Information-Processing in the Design and Choice phases. It is not an easy issue to address empirically, as it suggests that one must be able to separate out components of behavior and clearly assign them to one or more stages of a multi-stage, hierarchi
cal decision making process (for an example of what might be done, see Cravens, 1970).

The study does suggest that any attempt to explain differences in use of a Decision Support System in terms of conceptual system structure or style differences must be careful to first eliminate differences that are imbedded in task characteristics. Stated somewhat differently, until a Decision Support System covers the totality of a manager's unstructured task, task characteristics are likely to dominate use of the system.

Implications for Research on the Development and Use of DSS's.

Based on this study, three issues seem particularly interesting and important to address:

1. As already mentioned, there would seem to be value in determining if the structure of the conceptual system relevant to the primary task area is a more important determinant of differences in process characteristics. In the case of portfolio management, this implies that one should look at the structure of perceptions relevant to individual assets.
2. Given that the study suggests that manager perception of information sources is undeveloped, a key issue to address is to what extent is one able to help develop a more abstract conceptual system. Specifically, what kind of training environment is the most suitable and how can it be implemented in an organizational setting? Can one operationalize and use Schroder et al.'s notion of an interdependent environment (1967, pp. 48-49) to set the stage for such a development process?

3. Any attempt to develop more abstract conceptual systems must obviously be concerned with the effects of such an effort. Will it in fact lead to a use of Decision Support System that reflects both the strengths and weaknesses of this information processing technology?

What is the impact on the development of other conceptual systems relevant to the task of the manager? Given the manager's limited cognitive capacity, will attempts to develop one conceptual system have beneficial or detrimental effects on other areas -- is there a fundamental trade-off here?
BIBLIOGRAPHY.


Hall, W.K.(1973), "Strategic planning models: are top managers really finding them useful?", Journal of Business Policy, 3(2), 33-43.


APPENDIX 1.

Summary of Constructs used to develop the Standard Portfolio Role Construct Repertory Interview Constructs.

The bi-polar and uni-polar constructs listed below were generated in nine Portfolio Role Construct Repertory Interviews administered over a three year period prior to the main data collection effort for this study. Some of the constructs have been grouped, indicating that they have been interpreted as quite similar. Constructs are listed only once where several managers used identical labels. Only constructs relevant or partially relevant to portfolio objectives and assets are considered.

1. Has low liquidity need vs. has high liquidity need;
   - Net cash inflow;
   - Infrequent cash inflow;
   - Large cash flows;
   - Large income beneficiaries vs. small income beneficiaries;
   - Total dependence on assets vs. client can take care of himself;

2. Contains idea stocks vs. contains prudent trustee, stuffy stocks;
   - Pet securities;
   - Conservative holdings vs. typical total return oriented holdings;

3. High commitment to equity vs. low commitment to equity;
   - High in equity vs. low in equity;
   - Normal concentration in bonds vs. over-concentration in bonds;
   - High cash position;
   - Assets substantially in common funds;
4. Portfolio is very flexible & mobile *vs.* portfolio is very inflexible & immobile;

A portion of the funds are not under my control;
Company stock a major factor in account *vs.* company stock not a major factor in account;
Has a large portion of untouchable securities;
Constrained by requirements to hold certain assets;
Low marketability of investments;

5. Overconcentration *vs.* diversified;

No alignment problem *vs.* mixed alignment;
High concentration in particular assets;
Have to realign portfolio;
Overconcentration in a few assets;
Internal diversification needed;

6. Active account *vs.* inactive account;

7. Small portfolio *vs.* large portfolio;

8. Sole discretion *vs.* directed;

9. Advisory *vs.* Trustee;

10. Will accept little risk *vs.* will accept high degree of risk;

High risk;
Above average risk-reward relationship *vs.* preservation of principle;

11. Conservative *vs.* aggressive;

Aggressive account;
Client wants to become less aggressive *vs.* client wants to become more aggressive;

12. Income is primary goal *vs.* total return is primary goal;

Income oriented;
Total return objective *vs.* conservative, income oriented;
Income oriented *vs.* asset appreciation;
Maximum growth objectives *vs.* income oriented;
Client is receptive to total return;
Must balance growth and income;
Relatively high total return goal *vs.* relatively low total return goal;
13. Relative (to market & other money managers) performance oriented vs. absolute, composite performance oriented;

Pressure for performance;
Performance oriented vs. middle-of-the-road;

14. Long term performance goal;

15. Modern investment philosophy;

16. Client has vaguely defined goals vs. client has clearly defined goals;

17. Changing objectives;

18. Requires extensive explanation, seeking vs. accepts recommendations readily;

Requires very extensive investment contact with client vs. requires less frequent investment contact;

19. Low performance vs. high performance;

Good performance;
Well managed;
APPENDIX 2.

Composition of Role Construct Repertory Interview Sorts.

The different objects used in the sorts (ref. the construct generation phase) for the Information Sources Role Construct Repertory Interview and the Portfolio Role Construct Repertory Interview respectively are listed below. The objects are referred to by the Role number of the relevant Role Construct Repertory Interview (see Table 5.1 and Table 5.2).

Information Sources Role Construct Repertory Interview.

<table>
<thead>
<tr>
<th>Sort Number</th>
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<tbody>
<tr>
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<td>5, 6, 7</td>
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<td>9</td>
<td>4, 7, 12</td>
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<td>12</td>
<td>9, 11, 12</td>
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<tr>
<td>13</td>
<td>2, 8, 16</td>
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Portfolio Role Construct Repertory Interview.

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<th>Sort Number</th>
<th>Corresponding Roles</th>
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</thead>
<tbody>
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<tr>
<td>2</td>
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<td>5, 11, 15</td>
</tr>
<tr>
<td>7</td>
<td>5, 6, 9</td>
</tr>
</tbody>
</table>
APPENDIX 3.

Sample Role Construct Repertory Interview Rating Questionnaire.
Instructions for the Information Sources
Role Repertory Interview Scaling Exercise.

Introduction.

This scaling exercise builds on the information sources role repertory interview you have previously completed.
<table>
<thead>
<tr>
<th>Scale was difficult to apply</th>
<th>Scale was difficult to apply</th>
<th>Scale was difficult to apply</th>
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APPENDIX 4.

Information Sources and Communication Pat...
NOTE: PLEASE COMPLETE THIS QUESTIONNAIRE AS CLOSE TO THE END OF YOUR WORK DAY AS POSSIBLE.

1. Usage of Information Sources.

We have listed sources of information that possibly are helpful in supporting your portfolio decisions. Could you please specify how many separate references you made to, or communications you had with, each source today by writing the number of references in the appropriate place. If the referencing of, or communication with, any source was so continuous or frequent as to be uncountable, please write "\(>15\)" in the appropriate place.

Please use the space that is free to specify any other major source that you referenced, and that is not explicitly listed below.

Please consider only use with your most recent work.
2. Communication Pattern.

We have listed below, organized under the major groupings within the Trust Department, the individuals who constitute your major possible contacts in terms of your job as portfolio managers. Could you please specify how many separate, personal (face-to-face or by telephone) communications you had with each of them today on matters directly relevant to the management of your accounts from an investment point of view. If communication with any one individual today was so continuous or frequent as to be uncountable, please write "> 15" in the appropriate place.

Please use the space that is free to specify any other individual within the bank, that you have communicated with on matters directly relevant to the management of your accounts, and that is not listed below.

You need only indicate the individuals which you had actual communications with – i.e., a blank is equivalent to a non-existent communication.
<table>
<thead>
<tr>
<th>GROUP 6</th>
<th>Number of Communications</th>
<th>Number of Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>H. E.</td>
<td></td>
<td>REAL ESTATE</td>
</tr>
<tr>
<td>D. L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P. T.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LIMITED MARKET GROUP, CLOSELY HELD, SHELTER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>J. P.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>J. R.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>J. W.</td>
</tr>
<tr>
<td>EQUITY RESEARCH</td>
<td></td>
<td>MARKETING AND ADMINISTRATION (TRADERS)</td>
</tr>
<tr>
<td>A.</td>
<td></td>
<td>G. L.</td>
</tr>
<tr>
<td>M. N.</td>
<td></td>
<td>K. A.</td>
</tr>
<tr>
<td>B.</td>
<td></td>
<td>W. D.</td>
</tr>
<tr>
<td>E.</td>
<td></td>
<td>S. C.</td>
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<tr>
<td>P. V.</td>
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<td>T. J.</td>
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<tr>
<td>B.</td>
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<td>R. F.</td>
</tr>
<tr>
<td>B.</td>
<td></td>
<td>D. R.</td>
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<tr>
<td>D. J.</td>
<td></td>
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</tr>
<tr>
<td>G. E.</td>
<td></td>
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</tr>
</tbody>
</table>
B. PORTFOLIO COMPOSITION PROCESS

3. In this question, we seek to get a picture of the securities that you have been considering in the past two days. We have distinguished between securities that are potential candidates for a buy, securities that are potential candidates for a sell, and securities that merely are being actively followed.

Consider the different securities that you were concerned about, were actively reviewing, collecting information on, or discussing with colleagues and analysts, in the past two days. Using the NYSE symbol or any other appropriate symbol/identification, could you please list which of these securities

3.1. were potential candidates for a BUY for one or more of your accounts

3.2. were potential candidates for a SELL from one or more of your accounts

3.3. were being actively followed, but were not considered for any immediate action on your part
Charles B. Stabell was born on September 11, 1943, in Washington, D.C., the son of Mr. and Mrs. Bredo Stabell. He attended secondary school in Oslo, Norway and graduated in June 1961.

Mr. Stabell entered the Ecole National Superieur d'Electronique et de Radioelectricite (then Ecole d'Ingenieurs Electroniciens), Grenoble University, Grenoble, France in October 1961. He received his diplome d'Ingenieur in July 1965.

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Upon his return to Norway, Mr. Stabell was drafted by the Norwegian Armed Forces. He served in the Royal Norwegian Navy from June 1967 to September 1968, working most of the time as a research assistant in the Systems Group at the Norwegian Defence Research Establishment, Kjeller, Norway.

From September 1968 to September 1971, Mr. Stabell worked for IBM Norway, Oslo, Norway. During this period he worked as a System Engineer within the Government Branch Office, primarily involved with the implementation of prototype Data Base - Data Communications Systems for the Norwegian Government.

Mr. Stabell entered the Alfred P. Sloan School of Management at M.I.T. in September 1971 on a fellowship from the Norwegian Research Council, a Sloan Fellowship, and an educational grant from IBM Norway. From June 1973 to June 1974, he worked as a research assistant on a study of the Impact of Conversational Computer Systems. During the spring of 1973, Mr. Stabell taught a course on Management Decision Systems with Professors P. Keen and M.S. Scott Morton.
OF FILM REWIND