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No. 373<sup>u</sup>

TASK DOMAIN KNOWLEDGE AS A MODERATOR OF  
INFORMATION SYSTEM USAGE

DISSERTATION

Presented to the Graduate Council of the  
University of North Texas in Partial  
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Thomas E. Marshall, B.S.

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Information system (IS) support of human problem solving during the complex task of auditing within a computer environment was investigated. 74 computer audit specialist professionals from nine firms participated in the field experiment. Task accomplishment behavior was recorded via a computerized activity-logging technique. Theoretical constructs of interest included: 1) IS problem-solving support, 2) task domain knowledge, and 3) decision-making behavior. It was theorized that task domain knowledge influences the type of IS most functionally appropriate for usage by that individual.

IS task presentation served as the treatment variable. Task domain knowledge was investigated as a moderating factor of task accomplishment. Task accomplishment, the dependent variable, was defined as search control strategy and quality of task performance. A subject's task domain knowledge was assessed over seven theoretical domains. Subjects were assigned to higher or lower task domain knowledge groups based on performance on professional competency examination questions.

Research hypothesis one investigated the effects of task domain knowledge on task accomplishment behavior. Several task domain knowledge bases were found to influence both search control strategy and task performance. Task presentation ordering effects, hypothesis two, were not found to significantly influence search control strategy or task performance. The third hypothesis investigated interaction effects of a subject's task domain knowledge

and task presentation ordering treatments on task accomplishment behavior. An interaction effect was found to influence the subject's search control strategy. The computer-specific knowledge base and task presentation ordering treatments were found to interact as joint moderators of search control strategy. Task performance was not found to be significantly influenced by interaction effects.

Users' task accomplishment was modeled based upon problem-solving behavior. A subject's level of task domain knowledge was found to serve as a moderating factor of IS usage. Human information-processing strategies, IS usage, and task domain knowledge were integrated into a comprehensive IS user task model. This integrated model provides a robust characterization scheme for IS problem-solving support in a complex task environment.

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## CHAPTER 1

### INTRODUCTION

Information systems (IS) are frequently criticized for their inability to significantly contribute to the decision-making process (28). More specifically, IS that support other than well-structured tasks are most frequently criticized (9, 10) and a variety of IS faults prompting these criticisms exist. Explanations of IS deficiencies include issues of organizational support for the IS (14), user involvement in the design process (8), inability of the user to completely identify information requirements (1), and the robustness of IS development methodologies (30).

The importance of achieving effective IS for organizational success and the inherent difficulties in accomplishing this goal are well-documented in the research literature (7). However, a consensus as to the appropriate methodology to achieve this objective does not exist. King (10) suggested that IS success at upper-managerial levels requires IS designers to expand their horizon to include the organization's overall goals and missions. King's approach appears to be a macro-level perspective. Others (2, 13) proposed a micro-level focus on the decision-making process from the perspective of the decision maker. Davis (4) stressed the importance of both organizational and individual perspectives in attaining IS success.

Research involving organizational perspectives has included constructs for IS support and human problem solving. Simms and Peterson (23) used the information

processing model to structure the organization's decision-making system. They used a process-oriented model to view an "organization as a collection of information processing units...". Leblanc and Kozar (12) identified decision support system (DSS) use as a predictor for estimating the organization's objective performance.

Many IS research investigations from the individual perspective have included constructs for IS support and human problem solving. Weitzel and Graen identified problem-solving competence of the user and IS project team members as a moderating factor for IS project effectiveness (30). Kotteaman and Remus (11) investigated the fit between the IS and the task the IS serves as a contributing factor to IS success. The linkage between human information-processing theory and computational support was addressed by Rao and Jarvenpaa (21). Decisional guidance during DSS use was theorized as a means of achieving higher levels of support for decision making (22). IS decision strategy support based on a cognitive cost-benefit paradigm was proposed by Todd and Benbasat (28). Minch (16), from an individual perspective, broadened the role of the IS by postulating the efficacy of using the IS to identify and support individual problem-solving strategies.

What is elicited by these criticisms and suggestions in the literature is the need for a better understanding of the expected role of IS. Implicit within this proposition are: 1) an organization's requirements of IS, 2) an individual's expectations of IS, and 3) a means of designing IS to satisfy these needs. Therefore, the breadth of the IS research domain is extremely wide. Diverse issues such as organizational missions and strategies and individual IS user needs compound the complexities involved in achieving overall IS success. This research acknowledges the broad scope of relevant IS research issues. In

order to perform a more focused investigation, this research is limited to constructs germane to IS support of human decision making. By investigating human decision making this research supports the theory that effective use of information is becoming increasingly critical to organizational success (6). Further, this research suggests that effective IS must address individual user needs. This research seeks to contribute to the organizational perspective of IS success by developing a deeper understanding of relevant constructs involved in IS support of human decision making from the individual perspective.

#### Purpose, Problem, and Significance

An overview of the purpose, problem, and significance of this research is provided in this section. This research investigates information system usage during human problem solving. The effect of task domain knowledge as a moderator of IS usage is specifically addressed. The primary research question is "Does an individual's level of task domain knowledge contribute to the delineation of the appropriate IS structure for that individual?"

#### Purpose

The purpose of this research is to improve information system support during human problem solving. This research investigates human problem-solving behavior in association with an IS. IS support in decision making, task domain knowledge, and individual decision-making behavior serve as principal constructs of interest. In this effort, it is proposed that an individual's level of task domain knowledge contributes to the type of IS most appropriate for usage by that individual. The delineation of this contribution also provides a basis for design of that particular IS.

The objective of this paper is to investigate critical aspects of IS support during the decision-making process from a micro-level perspective. In this pursuit, the process of information acquisition through the IS by the system user is analyzed. Simon (24) suggested that improvements in the IS information acquisition process will occur in the initial design stages of system evolution. A decision support system (DSS) serves as the target system type in this study. Operational guidelines for improving DSSs are suggested by Sprague and Carlson (25) and include system capabilities that:

- 1) amplify a user's judgment,
- 2) suggest alternative considerations, and
- 3) exhibit intelligent characteristics.

In The New Science of Management Decision, Simon (24) stated the importance of IS in managerial problem solving. IS use in decision-making support will be guided by a heuristic base of past problem-solving activities (24). This research posits that a better understanding of the human problem-solving process must be achieved in order to attain desirable levels of IS support.

The research objective can best be accomplished through extending and combining theoretical bases of: 1) task support 2) task effects, and 3) human information processing (HIP) during decision making. Research investigating the influence of IS support for decision-making enhancement is often contradictory and inconclusive (11). Previous research in human problem-solving behavior indicated the influence of task characteristics on human solution strategies employed (19, 18). Driver and Mock (5), Mintzberg, et al. (17), and others have recognized the wide variety of individual decision-making styles. Human abilities in general and within a specific task domain often serve as moderating factors in human problem-solving behavior (3). This research contends that IS support

for human problem-solving tasks requires the adequate integration of these research constructs (20, 27). These theoretical bases are operationalized into a decision-making environment as: 1) task presentation, 2) task domain knowledge, and 3) task accomplishment.

This study integrates three theoretical bases into the IS domain in such a manner as to form a comprehensive unit of analysis. Through investigation, the interactions between these theoretical constructs is examined and accounted for in the research conclusions. It is a premise of this research that failure to adequately incorporate these three theoretical bases into one holistic study risks the omission of detecting relevant interactions between these constructs. Hence, many of the results and conclusions from previous research investigations may be incomplete, inconclusive, and ultimately incorrect with respect to the IS decision-support function.

#### Problem

The problem addressed in this research is that IS support of human decision-making processes frequently fails to significantly enhance the decision outcome (28, 11, 26). Research addressing managerial decision styles readily acknowledges the wide variety of individual approaches utilized in problem solving (17, 29). Within the IS framework, a theoretical or methodological basis for accommodating differing decision-making approaches precipitates much debate. IS success in decision support systems requires the accommodation of both theoretical and operational dimensions. Due to the tactical and strategic nature of many DSS applications, effective use of a DSS has the potential to significantly contribute to organizational success. It is hypothesized that

through task behavior characterization schemes, the cognitive model of the decision maker can be suggested and used as a predictor of IS usage.

### Significance

The significance of this research is two-fold. First, this research addresses the theoretical bases of IS decision support and individual decision making. Contributions to these theoretical bases serve to improve both the IS product delivered to the user and overall decision-maker effectiveness. In this manner, this research contributes to critical individual and organizational objectives. Second, the research results are operationally realizable within the IS arena based upon the chosen research technique of data collection through computer activity logs of actual IS use. This statement is based upon the premise that computer activity logs of task behavior can provide operational guidelines for organization of the IS function and required IS capabilities (16, 15). Combining these two aspects of theory and operation, this research provides a theoretical basis for IS design accompanied by an operational mode of application.

Other benefits from this research associated with the task domain knowledge orientation include the inherent recognition of organizational expertise and the ability to more effectively leverage that expertise. As the availability of new technology continues to burgeon, the potential contribution of technology to organizational success correspondingly expands. However, new technology and its application have associated risks. These risks can be effectively reduced by the development of a theoretical base of knowledge useful for application design. By utilizing the correct decision support model, the IS can be customized to more appropriately fill an individual's information needs. The organization, in general, benefits from the delineation of an individual's information

needs based on task domain knowledge. These benefits include the recognition of and design for individuals exhibiting higher levels of task performance. Additionally, in association with a knowledge orientation, organizations can more appropriately address other knowledge-intensive applications.

### Organization of Subsequent Chapters

This paper details the theoretical and methodological approach followed in executing the research thesis. The purpose, along with the problem and significance of the research, has been presented in detail in this chapter. Chapter 2 identifies prior research related to the research thesis of IS-supported decision making and presents the literature base of previous theoretical contributions within the topic domain. The theoretical bases of IS support, task domain knowledge, and individual decision-making behavior are delineated and integrated into a unitary comprehensive structure in Chapter 3. The third chapter provides a theoretical design for further investigating the research thesis and presents the substantive hypotheses. Elaborating on the theoretical design, a research framework and research methodology are delineated in Chapter 4. This research framework identifies the specific research constructs of interest. The procedural and operational surrogates of the research framework are presented in the methodology section. Limitations along with several key premises of the study are also presented. Chapter 5 presents the findings of the experimental study with respect to the research hypotheses and concludes with theoretical interpretations supported by the data analysis. Chapter 6 presents conclusions and recommendations based on the findings presented in the fifth chapter. Chapter 6 concludes with a summary of the significant contributions

of the study and identifies other potential research themes related to the study. For ease of reference a glossary of terms used in the paper are included as Appendix A.



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## CHAPTER 2

### PRIOR RESEARCH

IS research focusing on human problem solving has, in general, generated inconclusive findings and contradictory conclusions. Furthermore, the theoretical value of much of the IS research involving human problem solving has been questioned (4, 25).

#### Cognitive Style vs. Cognitive Process

More specifically, Huber voiced strong criticisms of cognitive style research as it relates to IS design (23). Huber based his conclusions on two major factors. First, he found the available literature on cognitive style to be an "unsatisfactory basis for deriving operational guidelines for MIS and DSS designs." Second, in his opinion, "further cognitive style research is unlikely to lead to operational guidelines for MIS and DSS designs." The bases of Huber's criticisms are:

- 1) the inadequate theory of cognitive style,
- 2) weaknesses of the research measurement instruments,
- 3) poor research designs, and
- 4) the inherent complexity of cognitive style as an IS research construct.

In conclusion, Huber contended that by the time a sufficient theoretical foundation of cognitive style is achieved, IS design will no longer require the knowledge associated with the cognitive style construct (23).

While the recognition of the need for further research into how individual differences affect IS is widely acknowledged, the appropriate research methodology to investigate this construct is highly debated (19). Much of the early IS research concen-

trated on static models emphasizing input/output paradigms of performance (45). This previous research often focused on three classes of variables: cognitive style, personality, and demographic/situational variables (49). In his analysis of the literature, Zmud found that "individual differences do exert a major force in determining MIS success." Additionally, Zmud stated that "much remains unknown regarding the specific relationship involved and the relative importance of individual differences" (49).

Robey and Taggart (38) stated that individual differences should be addressed by IS research. They stressed the necessity of broadening cognitive style research to include intuitive decision-making styles. In addition, Robey and Taggart emphasized the necessity of recognizing "the appropriate division of labor between the electronic computer and the human bio-computer" (38). The importance of designing the IS to support the type of human processing required by the task was stressed by Robey and Taggart. They stated that much of this research has as an objective "to characterize the nature of human information processing so that the role of computer systems that support human decisions might be better understood" (38). Robey and Taggart presented a strong argument justifying individual-focused research. However, they did not present a specific research methodology for investigating human information-processing constructs.

Recently, Ramaprasad (37) contributed to this IS research debate. For purposes of IS design, Ramaprasad suggested that cognitive style research is inappropriately focused on the individual and proposed cognitive process-focused research as a viable means of investigating human information processing. Cognitive style research focuses on an individual's general traits or predispositions of cognition. It has a macro-level focus on the individual, and as such, is incapable of providing specific characteristics of

human information processing (37). Cognitive process research, however, focuses on the micro-level, is state-based, and addresses specific influences in human information processing (37).

According to Ramaprasad, "the current thrust of most MIS and DSS design is to augment the strategies and structures of managers, not complement or counteract traits or states of managers" (37). He concluded that the objectives of cognitive style research, which focuses on traits, cannot completely satisfy the operational requirements of IS design. On the other hand, cognitive process research does focus on these decision-maker strategies and structures (37). Based upon this compatible match between research objectives and design needs and the progression of cognitive process research in general, Ramaprasad proposed that cognitive process research can provide valuable guidelines for IS design. He contended that cognitive style, as a construct, is incapable of providing such guidelines (37).

### Decision Modeling

Many approaches to investigating decision making have been suggested in the literature. Decision modeling has been the central focus of much of this research. A common paradigm of decision modeling is based on the input/output paradigm (3). Libby presents a cogent discussion of the "Brunswik Lens" model (25). The essence of these models is to determine a "factor of importance" to an information source (43, 25). The "factor of importance" is represented by a regression weight that is based on a criterion of information cue significance to decision outcome (25, 3). However, the methodology for integration of these information cue weights varies between paradigms. A broad taxonomy of these methods of integration involves linear and nonlinear approaches (3,

43). Based upon the emphasis of the relationship between the input (information cue) and output (decision outcome), this approach is termed a structural model (1).

### Structural Modeling

Structural modeling, as a representation of decision choice, has provided valuable insights for decision researchers. The ability of the simple linear-addition model to robustly predict decision choice has been supported in many research efforts (22). Limitations of structural modeling frequently center on issues underlying the resulting decision choices. These underlying issues concern the actual cognitive processes used by the individual during decision making (20). However, structural models provide only limited inferences of underlying cognitive processes (33). Furthermore, many researchers have criticized structural models as more representative of the task and less of the cognitive process (42). Others have suggested that structural modeling is most appropriate for ascertaining a decision maker's general decision strategy (15). Bowman (7) suggested the use of structural modeling as a means of identifying deviant decision choice when compared to a normative model. Kotteman and Remus (24) investigated the relationship between decision model and task performance through structural modeling. They suggested that structural modeling is the most appropriate manner of investigating aspects of general decision strategies (24). Kotteman and Remus (24) and Einhorn and Hogarth (15) argued the value of both structural modeling and cognitive process modeling in investigating decision behavior.

### Process Modeling

Process modeling focuses on the cognitive processing that occurs during the decision process. Payne, Braunstein, and Carroll (34) addressed the criticality of research

focusing on the psychological processes underlying the decision choice. With respect to investigating these psychological processes, they stated that "unfortunately, the input-output analyses that have been used by most decision researchers do not appear fully adequate to develop and test process models of decision behavior" (34). Einhorn, Kleinmuntz, and Kleinmuntz (16) also suggested the need for process-tracing models when investigating the cognitive processes underlying decision choice.

Payne (33) recognized the need for process trace-based paradigms in order to develop a more comprehensive decision behavior model. Newell and Simon's (31) research into general human problem-solving strategies provides a structure for process models of decision behavior. In decision-process modeling, the information search behavior of the decision maker often provides the basis for inferring decision strategies. Human information-processing (HIP) characteristics related to information search that are often of interest include search: 1) duration, 2) activity, 3) depth, and 4) sequence (20).

The measurement of task process performance constructs necessitates a process-oriented task taxonomy. Sternberg (44, p. 269) suggested that the foundational structure of information-processing components in intelligent behavior involves:

- 1) metacomponents (executive planning strategies),
- 2) performance components (execution of an overall strategy through encoding, inference, and application), and
- 3) knowledge acquisition components.

Further, according to Sternberg, three perspectives must be considered in research investigating cognition and intelligent behavior. First, an individual's mental model and information-processing strategy must be incorporated into research paradigms. Second, research tasks must extend beyond many present artificial laboratory settings. Tasks incorporating everyday performance demands are better behavioral benchmarks (44).



Third, current technologies of testing must be improved. A perspective of symbiotic benefits between domain competency and testing must be pursued. As an objective and ultimate goal of cognitive assessment, Sternberg suggested a focus on the psychological phenomenon of intelligent behavior (44).

#### Normative Modeling

Research into human problem-solving behavior includes issues regarding the efficacy of normative models and behavior. Ackoff's work (2) exemplifies the normative debate. Managers, i.e., human problem solvers, are often unaware of, or unable to identify, the most pertinent information sources for decision making (2, 21). This inability to identify pertinent information has also been evidenced in group decision-making research (29). In Miner's research, subjects as groups failed to reach a consensus regarding the most pertinent information source and the optimal alternative choice or solution. Miner's findings provide support to the perspective that managers are frequently unaware of the strategies they employ during problem-solving tasks. Simon's (41) concept of bounded rationality relates to this phenomenon and also suggests that many decision makers are unaware of their operational bounds.

In this view, the greatest improvements to human problem solving will result from providing the decision maker with normative models. These normative models are often associated with management science optimization models or engineering-based design approaches. The inability of optimization models to adequately address poorly structured tasks is a source of decision-maker discontent with the normative approach (13).

Einhorn and Hogarth (15) and others have investigated the value of the normative approach based on empirical observation of decision making. Einhorn and Hogarth

specifically criticized normative decision models. They found through empirical research that decision makers infrequently utilize such models in the decision process. In their view, the attention drawn to the discrepancies between actual decision processes and normative decision processes is a main benefit of normative models (15).

### Descriptive Modeling

Descriptive decision models seek to identify actual decision environments as opposed to the normative, optimal approach. Driver and Mock (13) discussed three classes of descriptive models that relate to IS decision support: general, unique, and differential. These descriptive models vary on a continuum from the highly abstract general model to the specific individual-based unique model. Between these two extremes, the differential model categorizes decision makers based on identified traits or characteristics. Each model possesses strengths for theorizing about decision-maker behavior. Unfortunately, theoretical strengths are often accompanied by operational deficiencies. To a degree, the appropriate descriptive model for IS decision support purposes is a functional tradeoff between parameters of theoretical values and IS operational concerns.

Elaborating on these three descriptive models, the general model classifies all individual differences into a pool of random error. Based on this precept, the information-processing traits of a specific individual can be generalized across all individuals. The practicality of this model facilitates the development of human information-processing theory (25). Shannon's Information Theory (40) and G. A. Miller's memory load theory (26) are based on the generalists' perspective. Operationally, organizations have found the generalists' approach inadequate and

unacceptable as a basis for IS design. Frequent criticisms of the general model include its lack of variety and failure to accommodate specific individual behavior responses.

The unique model reconciles the existence of a wide variety of differences between individuals (13). According to Driver and Mock, the unique perspective accommodates for individuality but also inhibits theoretical development of HIP. Individual decision-process characteristics are considered to be an integral component of the decision maker. The unlimited number of variations implied by the unique model renders it impractical for operational guidelines of IS.

The differential model promises the greatest operational potential for IS while retaining a basis for theory development. The foundational construct of the differential approach is that cognitive approaches between individuals' problem-solving efforts may be differentiated based on similarities (13). One of the IS operational benefits of the differential model, when compared to the unique model, is the limited number of categories or individual classes it assumes. The theoretical strength of the model stems from the generalizability within a class of individuals (13).

#### Memory-based (Task Domain Knowledge) Modeling

This research uses task domain knowledge as a differentiating factor between classes of problem solvers. Task domain knowledge has been found to serve as a moderating factor in difficult tasks (32). Subjects possessing a rich knowledge in a specific domain have been observed to perform tasks in a similar fashion based upon semantic function (14, 10). Experienced database designers were found to use more complex reasoning forms than novice designers (36). Additionally, experienced database designers were found to perform substantially better when compared to inexperienced

designers not using these complex reasoning forms. The ability to use complex reasoning forms for memory recall has been associated with level of experience (48). Memory capacity has been hypothesized as a major influence in cognitive processing (26). Others have investigated tendencies of individuals to use memory chunking to lessen cognitive processing demands (18, 48).

Previous research has found information presentation effects to influence the decision process (15, 47). Information load, as influenced by information presentation, has been the focus of numerous research efforts. Information load, as per Biggs et al. (5), is the effect that additional information elements have on a subject's performance. Weber (48), investigating computer auditors, observed the ability of subjects to assemble information cues into semantic categories. Weber considered the individual's ability of information cue ordering as a surrogate measure of subject expertise within a specific task domain. Other related research indicates that decision-making strategies are influenced by information load (5, 15). However, a comprehensive theory of information load is yet to be developed.

The role of domain-specific knowledge in problem solving has been investigated by Bonner (6) and Brown and Solomon (8). Bonner (6) investigated task-specific knowledge as a moderator of performance across two related tasks. Task-specific knowledge was found to influence task performance in Bonner's research (6). Brown and Solomon (8) found instances of domain-specific knowledge influencing the manner in which decision makers acquired and processed information. Both Bonner (6) and Brown and Solomon (8) conclude the importance of domain-specific knowledge as a moderator of task performance.

Craik and Lockhart (11) proposed a framework for memory research. They identified several inadequacies in the multistore memory paradigm used in many other memory research investigations. The Craik and Lockhart framework is based on an individual's depth of cognitive processing. Initial cognitive stimulus processing in this framework involves perceptions of physical and sensory recognition. Later stages of stimulus processing "are more concerned with matching the input against stored abstractions from past learning: that is, later stages are concerned with pattern recognition and the extraction of meaning" (11, p. 675). The authors stated that the analysis process is a continuum from initial pattern recognition to semantic-associative stimulus enrichment. The ability of an individual to perform deeper levels of cognitive processing is a function of the individual's memory storage capacity. Memory storage capacity involves the complexity of the individual's elaboration scheme within the relevant domain (11).

Based on the current research objectives, the Craik and Lockhart framework provides a rich model for IS user differentiation. In accord with the Craik and Lockhart framework, experts should be better able to perform stimulus semantic association and enrichment. This ability is an artifact of the expert's more complex memory storage elaboration scheme. Das et al. (12) associate these levels of processing with "successive processing" and "simultaneous integration," respectively. Piaget's (35) cognitive process of "reciprocal accommodations" fits well into the categorization of deeper processing levels.

### Static vs. Process Modeling

In the past, IS research concentrated on static models of input/output analysis (39, 45). Libby (25) considers the development of a general descriptive framework of how decisions are made to be the first step towards the goal of improving decision making. Todd and Benbasat stressed that IS research must address issues of why and how such IS are effective. In their view, "research techniques are needed that permit us to examine the pre-decisional behavior that takes place when groups and individuals use these systems" (45).

Todd and Benbasat (46) more recently proposed cognitive processing effort as a basis for IS-supported decision-making research. The implicit tradeoffs between cognitive effort and decision quality during IS problem-solving support form the basis of their model. They propose that "... specific features can be incorporated within a DSS that will alter the effort required to implement a particular strategy, and thus influence strategy selection by the decision maker." A conclusion reached by Todd and Benbasat is that DSS users tend to adopt strategies that reduce cognitive effort. Further, they suggest that DSS users do not select strategies exclusively to optimize decision quality (46). The cognitive effort paradigm by Todd and Benbasat is a generalized model and as such it fails to incorporate differences in individual cognitive-processing abilities as identified by Craik and Lockhart (11). However, the cognitive effort model does contribute to the theory of using process modeling to enhance decision-maker performance.

Process modeling, as a representation of behavior, is suggested to be superior to static models of behavior (37, 45). Static models of behavior provide only surface representations of relationships, where process modeling addresses the actual mental

process of decision making (25). This ability to represent the actual mental process of decision making supports process modeling as superior to static modeling for IS research.

Ramaprasad's (37) theoretical foundation for cognitive process modeling is based, in part, on Piaget's (35) theory of "cognitive equilibration." The cognitive equilibration theory considers knowledge to be the product of behavioral or cognitive adaptation. The cognitive adaptation process is a functional cycle between states of assimilation and accommodation. As stated by Piaget (35, p. 3):

... equilibration will refer to a process that leads from a state near equilibrium to a qualitatively different state at equilibrium by way of multiple disequilibria and reequilibrations.

The equilibration process is the dynamic constructing and maintaining function of cognitive structures. Piaget's theory, based upon a micro-level perspective of individualism, relates an organism to its environment. A foundational precept of Piaget's equilibration theory is that "cognitive systems are both open in the sense that they involve exchanges with the environment and closed in the sense that they constitute 'cycles'" (35).

Naylor et al. (30) proposed a "cognitive theory of behavior" as a linkage between the individual and the individual's behavior in organizations. The individual is assumed to be rational and, in general, to exhibit behavior that represents "conscious, thinking acts on the part of the individual." Naylor et al. delineate behavior as:

... an ongoing act or process. It is the doing of something by an individual and should actually be viewed more as the verb "behaving" than as the noun "behavior." The basic unit of behavior in the theory is called the act. An act has two defining characteristics or dimensions. They are (a) amplitude, which is the total commitment to an act ... and (b) direction, the specific kind of activity or process being carried out or performed. (30, p. 5)

The dimension of amplitude represents the individual's allocation of time and effort to an act. In the development of their behavioral theory, Naylor et al. state that the process of judgment directs the behavior process. According to the authors (30, p. 68), behavior is the process that results from activities of: 1) information acquisition and storage, 2) judgments, and 3) acts. Combining Piaget's "cognitive equilibration" with the concept of intended behavior, as presented by Naylor et al., provides a paradigm for performing empirical IS research that addresses cognitive processing.

### Task Analysis

Previous research addressing human cognitive processing has yielded valuable insights into human problem-solving processes. Card, Moran, and Newell (9) applied cognitive psychology principles in human performance and task analysis. According to Card et al., more functional information systems can be derived from this type of analysis. Ericsson and Simon (17), using verbal protocol analysis, proposed that human cognitive processing should be the basis of analysis for further developing human information-processing theory. Newell and Simon (31) analyzed subjects' problem-solving strategies using verbal protocol analysis as a means of explaining high levels of task performance. Miller (27) proposed that task analysis can be performed through cognitive behavior observation and suggested that task analysis provides a way of determining task structure. Miller (27, p. 204) elaborated on this theme by stating:

The behavior structure of tasks is offered as a guide for organizing a way of looking at task and task information that is compatible with a way of organizing knowledge in experimental psychology according to task settings.



One of the benefits of behavior-based task analysis, according to Miller (27), is the elimination of much randomness in determining task information requirements.

Newell and Simon's work, Human Problem Solving (31), is considered a seminal work in the area of human cognitive process analysis (10, 25). The heuristic search process model applied in Newell and Simon (31) views decision making as a state-space environment with processes of solution. The decision maker is theorized to apply cognitive operators in a manner consistent with means-ends analysis. The rational decision maker uses a search control strategy to achieve the goal state by applying cognitive operators to the current state-space. In this manner the heuristic search process model provides a basis for further investigating IS support for decision making (28).

#### Summary

Prior research has addressed human problem solving in a variety of ways. Debates over the efficacy of cognitive style and cognitive process as IS research constructs have been numerous. The complexities associated with modeling human problem solving are manifest in both the variety of proposed modeling approaches and the discussions over the merits of these respective approaches. The merits of various modeling approaches continue to be debated. However, a growing consensus seems to be forming in acknowledging the importance of IS research addressing human problem-solving support. The next Chapter presents the study's theoretical design for further investigating human problem-solving support from an IS perspective.

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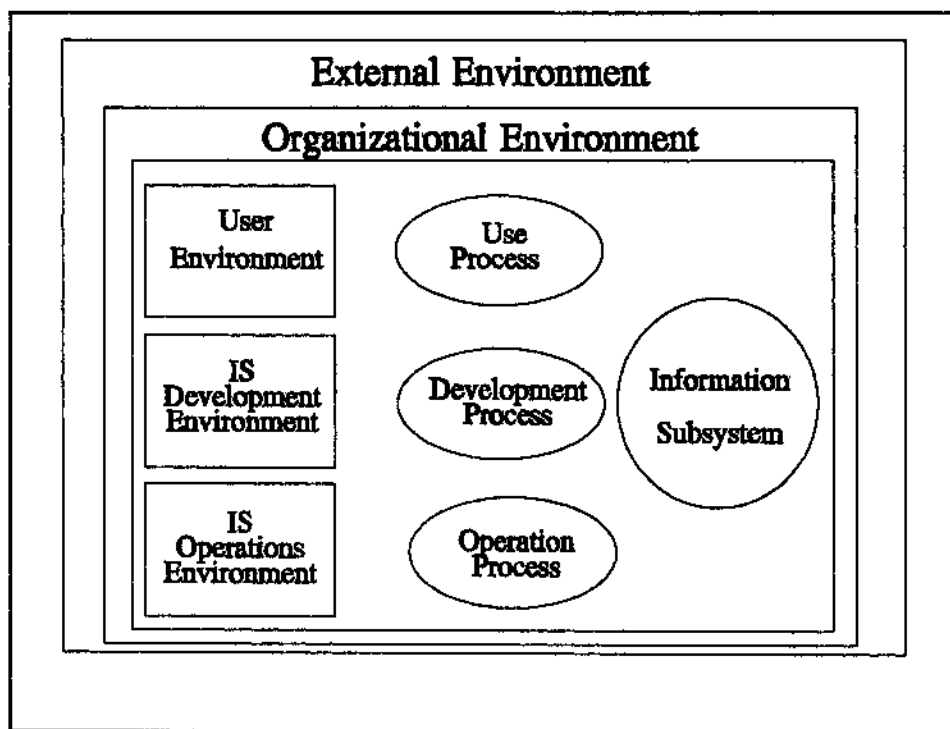
## CHAPTER 3

### THEORETICAL DESIGN

Ives, Hamilton and Davis proposed a global research model for IS (see Figure 1) (12). This model encompasses IS aspects from the environments of the user, IS development, and IS operations. Ives et al. (12) developed this model to be "a comprehensive framework broad enough to facilitate categorization of all previous MIS research, but at the same time detailed enough to suggest specific areas of study." Their research model proposes three groups of variables: environment, process, and information subsystem. IS research variables of interest in this study include the information subsystem, the user environment, and the use process (see Figure 1 and Appendix B). Ives et al. describe a combination of research constructs from each of the variable groups as a "relationship among variables," and further suggest that a combination of research variables, such as this, is appropriate for investigating "individual differences between users." They also state that this "relationship between variables" perspective facilitates research investigating IS designed for optimum performance (12).

The theoretical framework for this research includes constructs of IS support, task domain knowledge, and individual decision making. Individual decision making is represented by the problem-solving components presented by Newell (14). Luconi, Malone and Scott Morton (13) proposed an IS framework that included the decision-making strategy as developed by Newell (14) and Newell and Simon (15) (see

Figure 2). The Luconi et. al framework is an extension of the Gorry and Scott Morton (11) framework and emphasizes decision-making strategies. These decision-making components are linked to the IS through the Luconi et. al (13) framework and are delineated as data, procedures, goals and constraints, and flexible strategies (Figure 2).



**Figure 1 - The Ives et al. Model for Information Systems Research**

This research hypothesizes that task domain knowledge, the element which is missing from the Luconi et al. model, serves as a moderator of the process of decision making with IS support. In this study, task domain knowledge will be controlled by limiting the task environment to a single task domain. The research task chosen is one that requires a variety of knowledge bases to adequately achieve the assigned task objective (1, 24, 8). Knowledge bases of domain knowledge, meta knowledge, and

planning knowledge have been used as theoretical foundations for task performance in this specific task (1).

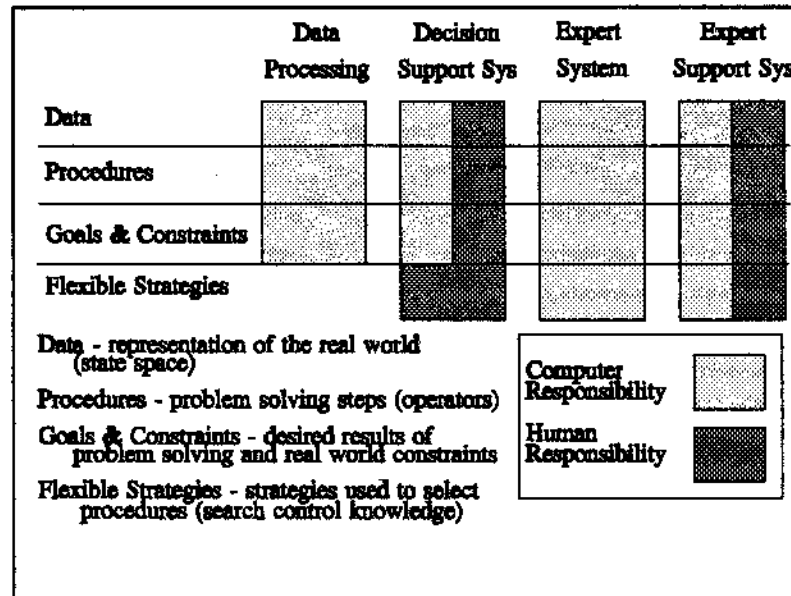


Figure 2 - Luconi, Malone, and Scott Morton Framework

This research is based on the premise that task domain knowledge serves as a moderating factor in IS-supported task accomplishment (16) and proposes that the correct means of analysis for this research objective is one of process orientation (21). Cognitive process constructs, for the purposes of task-based IS research, have been suggested to be superior to cognitive style traits (22, 18, 23). This research proposes the differential modeling approach to decision making as most appropriate for satisfying IS design and operational constraints. Previous research inconsistencies along these theoretical lines may be the result of methodological artifacts. In this research, differential classes are delineated by an individual's level of task domain knowledge. Cognitive process constructs serve as delineation characteristics between and within these differential classes, and these constructs represent the problem-solving behavior of an individual.



Thus, the individual's behavior is taxonomized by the problem-solving components as suggested by Newell (14).

Through the integration of the research constructs of IS usage, task domain knowledge, and individual decision-making strategies, a more valid representation of the individual's task model is ascertained. This research paradigm enables the development of a theoretical base that also satisfies operational constraints of IS. Issues of concern to information scientists, such as task performance enhancement and problem-solving support, can be more directly addressed through this research paradigm.

In summary, this research investigates the process of individual decision-making behavior within the context of a specific task domain. The IS characteristics of data, procedures, goals and constraints, and flexible strategies as they relate to IS user task accomplishment are the main focus of this study. The concept of process characterization, as suggested in the differential model, is based upon Sternberg's information-processing components. As such, this paper contributes to the theory of IS design by incorporating a paradigm based on IS support, task domain knowledge, and individual decision making.

### Research Paradigm

The IS Usage Model serves as the research paradigm in this study and includes three subsystems: human-computer interaction, cognitive model, and decision behavior. The individual models are: 1) the Human-Computer Model, 2) the Cognitive Model, and 3) the Differentiated IS Model. Theoretical constructs of IS support and individual decision making are represented in the human-computer model. Task domain knowledge,

as a research construct, is embodied in the cognitive model. The following sections describe these subsystem models as they relate to the objectives of this study.

### Human-Computer Model

In 1980, Sprague delineated the components of a DSS as an interconnection of a data subsystem, a model subsystem, and a dialog subsystem (19). The facts describing the phenomena of interest are contained within the data component of the IS. Thus, the data component contains the task-specific information available to the decision maker. The model subsystem provides the user with the capabilities to access data, integrate model "building blocks," and provide appropriate linkages through the data set (20). The dialog subsystem articulates the capabilities of the information system to the system user (20). These components serve as the paradigm of an IS within this study.

The human system model used in this study is based upon Card, Moran, and Newell's work in The Psychology of Human-Computer Interaction (3). Card et al. model the human processor as consisting of a cognitive system, a perceptual system, and a motor system. Combining the Card et al. model with the Sprague DSS model forms the IS unit of analysis in this study (see Figure 3).

Through empirical observation, the interactions between the information system model and human system model define an IS user session. These interactions determine a generalized user IS model. Yovits et al. (25) apply the principle of a generalized IS model and suggest that, given a sufficient set of information alternatives, the decision maker will, over the long run, choose the information set deemed most useful within the context of the actual decision. In this study, session interactions provide the basis for decision-making investigation.

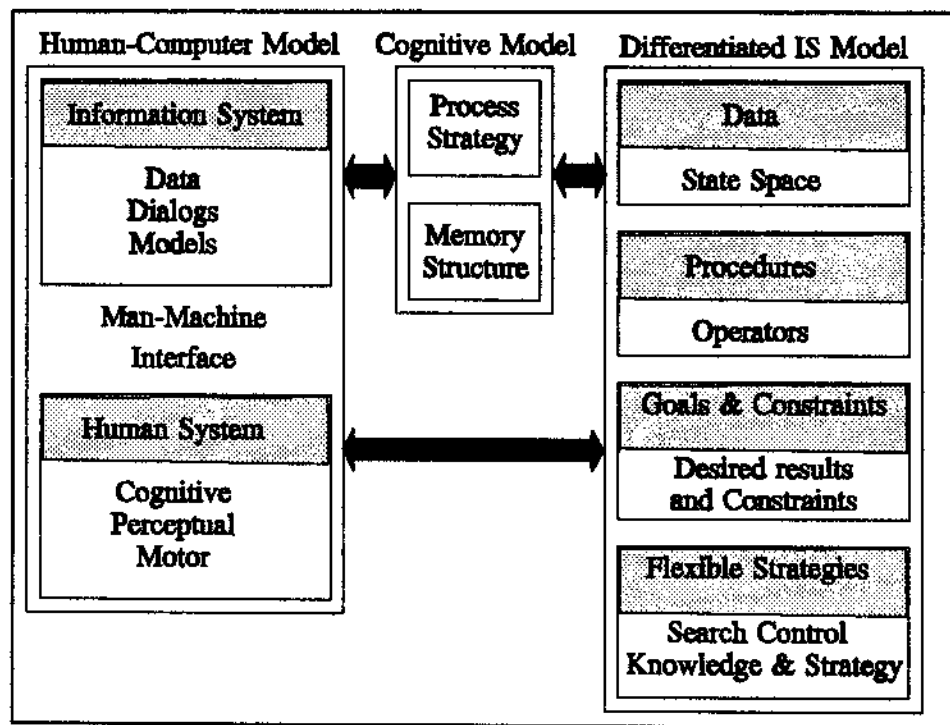


Figure 3 - IS Usage Model

### Cognitive Model

The cognitive model construct of interest in this research is the level of task domain knowledge possessed by the IS user. Thus, task domain knowledge level is used to differentiate between IS users. In this study, the cognitive model is based on the information processing activities of the IS user. In an information processing perspective of human cognition, "one assumes that cognitive processes are a sequence of internal states or mental representations successively transformed by a series of information processes" (9). Implicit in this theory is the recognition that information is stored in different memories. Additionally, these memories possess differing cognitive processing characteristics (5, 9).

According to the Craik and Lockhart theory, simple memory structures only provide the capability of shallow processes such as stimulus recognition (5). Deeper cognitive processes, such as semantic association and stimulus enrichment, require a more complex memory scheme represented by a broad knowledge base of the subject matter. Therefore, in this view, the ability of an individual to perform deeper cognitive processes is a function of that individual's memory structure. The degree of complexity of an individual's memory structure will be represented by that individual's level of task domain knowledge. One objective of this research is to characterize decision behavior between levels of cognitive processing, i.e., deep processing versus shallow processing, as described by Craik and Lockhart (5). Additionally, deep processing capabilities will be associated with higher levels of task domain knowledge and shallow processing capabilities with lower levels task domain knowledge.

#### Differentiated IS Model

The dependent variable of interest in this research is the exhibited decision-making behavior of the IS user. Exhibited behavior of the decision maker in this research involves both decision behavior as exhibited by search control strategy and decision outcome as exhibited by task performance. This perspective emphasizes the importance of extending decision research beyond the static input/output paradigm. Issues of central focus in this research are what information a decision maker has acquired, when this information is acquired, and how this information is used.

This research uses Newell and Simon's (15) heuristic search process approach in combination with Newell's (14) problem-solving steps as a means of investigating problem-solving behavior. Utilizing the Luconi et al. IS framework, the components of

an IS are logically linked to the problem-solving behavior exhibited through IS usage (see Figure 3). This IS usage can then be extended to other types of IS as displayed in the Luconi, et. al framework (Figure 2).

The source of evidence for process-trace analysis in this study is the IS itself. Attributes of interest, with respect to IS system usage, include information acquisition characteristics of duration, activity, depth, and sequence as identified by Ford et al. (10). The research paradigm is formed through integrating the components in the IS usage model (see Figure 3). The human-computer model captures the IS use and procedures invoked during task accomplishment. Task domain knowledge serves as a surrogate for the user's cognitive model within this task domain. The differentiated IS model is derived through analysis of task accomplishment and task domain knowledge.

#### Substantive Hypotheses

This research investigates theoretical constructs of IS use and procedures, task domain knowledge, and human problem solving. Research variable groups of information subsystem, user environment, and use process as identified by Ives et. al will be operationalized to address these constructs (see Figure 1). Ives et. al suggested integrating variable groups as a means of investigating individual differences and performance criteria. The research variable groups, research variables, and variable surrogates of interest in this study are presented in Appendix B.

Einhorn and Hogarth (7), Newell and Simon (15), and Chi and Glaser (4) have suggested the critical effect of task presentation on human problem solving. Einhorn and Hogarth (7) consider the representation of the problem to have a dramatic effect on decision behavior. Newell and Simon (15) suggest that ordering affects the decision

maker's cognitive representation of the task. This representation in turn influences the strategy that a subject utilizes to solve the problem. Chi and Glaser state "researchers have found that the representation is very important in determining how easy a problem is to solve" (4).

Task-specific knowledge has been suggested to be a relevant factor in identifying performance differences (2). Prietula and March (17) found experienced database designers to employ complex reasoning forms. These complex reasoning forms contributed to higher standards of performance by experienced designers (17).

Based upon these premises, the following research hypotheses are investigated. The first hypothesis (H1) investigates the relationship of a subject's task accomplishment to their level of task domain knowledge. The second research hypothesis (H2) addresses task presentation effects on subject task accomplishment. The third hypothesis (H3) concerns the combined influences of level of task domain knowledge and task presentation effects on subject task accomplishment. Each of these hypotheses is further refined into strategy and performance sub-components in order to more fully investigate task accomplishment.

- H1: Subjects' task accomplishment behavior is not different between groups delineated by their level of task domain knowledge.
- H1a: Subjects' search control strategy is different between groups delineated by their level of task domain knowledge.
- H1b: Subjects' task performance is different between groups delineated by their level of task domain knowledge.

This first research hypothesis is based, in part, on previous research that has indicated that experts and novices often utilize different problem-solving strategies (17, 4, 6). In addition, it is a contention of this research that these different problem-solving strategies

are evidenced through the subjects' computer usage. Further, a positive relationship between task performance and level of task domain knowledge is expected.

The second hypothesis involves the effects of task presentation ordering treatments on a subject's task accomplishment. It is anticipated that task presentation ordering treatments will affect both the search control strategy and task performance of a subject.

The second hypothesis is:

- H2: Subjects' task accomplishment is not different between groups delineated by task presentation ordering treatments.
- H2a: Subjects' search control strategy is different between groups delineated by task presentation ordering treatments.
- H2b: Subjects' task performance is different between groups delineated by task presentation ordering treatments.

The third hypothesis (H3) addresses the combined effects of the constructs of level of task domain knowledge and task presentation ordering treatments. The interactions of these two constructs are investigated as a means of explaining task accomplishment. The third hypothesis is a combination of hypothesis one and hypothesis two and represents interactions between hypothesis one and hypothesis two.

- H3: Subjects' task accomplishment is not different between groups delineated by the joint effects of their level of task domain knowledge and task presentation ordering treatments.
- H3a: Subjects' search control strategy is different between groups delineated by the joint effects of their level of task domain knowledge and task presentation ordering treatments.
- H3b: Subjects' task performance is different between groups delineated by the joint effects of their level of task domain knowledge and task presentation ordering treatments.

Therefore, this research offers two theoretical propositions. First, it is proposed that a decision-maker's computer usage provides artifacts evidencing their problem-solving

operators (14, 13). Additionally, this research proposes that effects of information presentation ordering are evidenced in subjects' task accomplishment (4, 6). Furthermore, the influence of the task presentation ordering treatment effects will be measurable in the decision-maker's computer usage.

### Summary

The research paradigm facilitates the characterization of decision-maker behavior based on their level of task domain knowledge. Research constructs of IS support, task domain knowledge, and individual decision-making behavior are analyzed to infer an individual's cognitive process model of a task. Through an experimental design involving three hypotheses, the influences of task presentation effects and task domain knowledge on task accomplishment will be examined. The investigation proceeds from considering these influences individually, to analysis of their combined influence on task accomplishment.



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## CHAPTER 4

### RESEARCH METHODOLOGY

#### Task Environment

A task-based case presentation method was used as a means of addressing the research objectives. The substantive content of the task was an audit procedure within a computerized environment. As an objective of the audit task, the subjects were asked to determine the level of risk exposure of a material misstatement in financial statements as a consequence of system control failure. The focus of the task was to assess control risk potential over the function of Accounts Receivable and Sales in the revenue cycle.

The accurate assessment of the level of control risk exposure is critical in the process of audit planning. The task lends itself to delineation based on specific attributes within more general aspects that describe the case environment via the task content (see Appendix C). The essence of the attribute-aspect delineation is to superimpose a hierarchical infra-structure on the task based on semantic content (24). Hierarchical infra-structures provide organization in complex task environments (24). The specific infra-structure used in this study was based on the organizational structure provided in the original case (1).

This infra-structure consisted of five workpaper reference sections representing 15 aspects with a total of 45 individual attributes (see Appendix C). General task data content included information on the organizational environment, computer controls, and

application procedure controls (see Appendix D). Authoritative analysis identified two broad categories of task data as environmental information and function-related specific information (Accounts Receivable and Sales applications). Critical evidence for accurate risk assessment in this case scenario was determined to be concentrated in the function-related computer and application control sections of the simulated audit workpapers. This task structure was determined by the task authority to be a realistic representation of field audits in the accounting industry.

This type of decision task, often characterized as diagnostic in nature, has been compared to a physician's patient diagnostics within the medical field (9). The types of knowledge often utilized in this task environment include domain, meta, and planning [(2). Decision-maker processes in this type of task have been previously delineated as task structuring, information acquisition, analytical/evaluative, and action (2). The information acquisition process (duration, activity, depth, and sequence) exhibited by the decision maker is of particular interest in this study. Information acquisition processes are often used as a basis for decision-making analysis (11, 13). The actual content of the case task used in this study is an adaptation of a case format employed in a professional audit guide text (1).

### Sample

The sample for this study was selected from a population of Certified Public Accounting firms. Subjects were collected across several different public accounting firms located in the Southwestern United States. As such, the sampling method is a convenience sample, thereby suggesting limits on the generalizability of the experiment beyond the present study. The sample individuals volunteered to participate in the

experiment and therefore an unknown level of respondent bias may exist. Sample size comprises 74 subjects. All participating subject firms were offered a summarized evaluation of the findings of the research study as an inducement to participate.

### Experimental Design

A field experiment was used as a means of investigating the research constructs. The experimental design entailed one independent variable, task presentation, one moderating variable, the subject's task domain knowledge, and one dependent variable, the subject's task accomplishment (see Figure 4 and Appendix B). The dependent variable, collectively termed task accomplishment, represents both search control strategy and task performance. The experimental treatment varied the task presentation by manipulating the available information-based navigation paths. The content of the task, represented as the "data-state space," was the same for both the experimental and control groups. In part, the subject's search control strategy and task performance were theorized to be the result of experimentally manipulating the navigation paths.

Subjects were randomly assigned to either the experimental or control group. Both experimental and control groups were provided with the ability of navigating the information base within the context of the case's content. The control group was provided with a navigation path supported by a serially-based information acquisition mechanism only. The experimental group was provided a more dynamic information base navigation scheme, through a meta-structure. The meta-structure enabled the subject to traverse the information base using a more abstract navigation path, resembling a keyword or table of contents structure. Therefore, the experimental group was provided with a

more dynamic information acquisition mechanism, while the control group was limited by a serially-based acquisition mechanism.

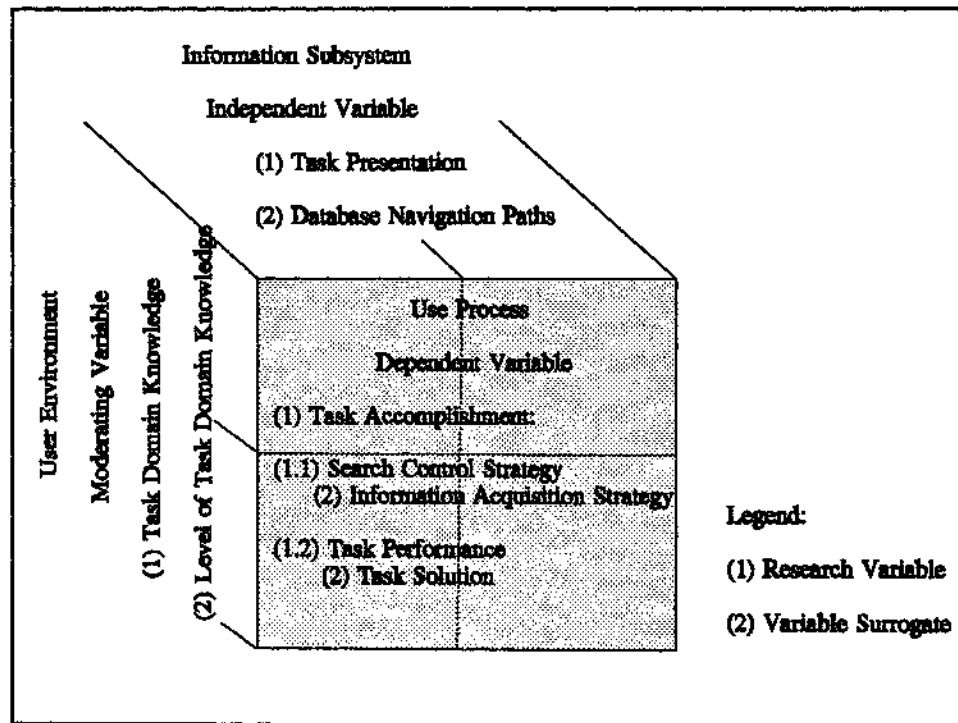


Figure 4 - Experimental Design

The experimental treatment in this study varied the task information presentation by controlling the ability of a subject to select and directly access a particular information cue. While not of primary interest in this experiment, it is theorized that subjects limited by a serial access mode will experience a higher information load as a result of having to process more information cues.

Moderating variables in the experiment consist of the level of task domain knowledge exhibited by the subject and personal demographics. Task domain knowledge is used as a confounding variable in the experimental design. The subject's level of task domain knowledge is theorized to be a surrogate of decision-maker intrinsic constraint

(20). This type of constraint is often evidenced by a novice subject's inability to create an accurate representation of a task's state space, which directly influences a subject's task performance (23, 5). Within the current experimental setting, the goals of the individual subjects are considered to be sufficiently similar not to warrant specific measurement.

The dependent variable of the experiment, task accomplishment, consists of the search control strategy and task performance exhibited by the subjects. The exhibited information acquisition strategy (duration, activity, depth, and sequence) represents the subject's search control knowledge (20). Theoretically, the search control strategy employed by a subject represents the cognitive operators applied to the task in pursuit of the subject's goal achievement (17, 20). IS procedures, exhibited by a subject's invocation of computer functions, serve as surrogates for the cognitive operators applied in task accomplishment by the decision maker. The operational representation of these cognitive operators entails the specific IS procedures invoked by the subjects during the information acquisition phase of task accomplishment. This search strategy behavior, defined by information acquisition characteristics, provides a basis for inferring the subject's search control strategies. In the subject's execution of this strategy, the subject is assumed to take actions that provide maximum benefits toward goal or subgoal achievement (19, 30).

#### Procedure

Each subject participating in the field experiment provided three sets of data: personal demographics, level of task domain knowledge, and simulated task execution. A questionnaire was used to capture general demographic data regarding each subject's



personal data, professional training, and professional responsibilities. The level of task domain knowledge for each subject was assessed through responses to a collection of multiple choice questions. The specific questions were an extraction of questions from previously administered professional certification examinations. The exam questions utilized were qualified as appropriate by an expert authority. Each subject received the same set of professional competency questions. The third data set collected involved the subject's task accomplishment on the simulated computer audit case.

The simulated computer audit case was based on a case presentation prepared as an audit guide by the American Institute of Certified Public Accountants (AICPA) (1). The experimental case was adapted in order to more appropriately satisfy the current research needs. The specific adaptations were made under the advisement of individuals possessing high levels of expertise in computer auditing.

The computer audit case was structured into a series of task aspects and aspect attributes (see Appendix C). Similar task-structuring approaches have been utilized in other studies investigating decision-making behavior (27, 7, 13). This task structuring contributes to the ability of the researcher to characterize the search control strategy of the subject. The task was operationally delivered to the subject through a hyperbase information system on microcomputers. Hyperbase information systems are considered to be extremely appropriate for tasks involving "on-line presentation of large amounts of loosely structured information" (21). Other IS research has used the hyperbase structure to represent the mental models of individual decision makers (4). Upon invoking the hyperbase information system the subject was randomly assigned to either the control

group or the experimental group. The treatment assignment was based on the computer's internal clock.

Through completion of the simulated task the subject provided the basis for the task accomplishment assessment of the experiment. Task accomplishment was defined as search control strategy and task performance (Appendix B). No time constraints were placed on subjects to complete the experiment.

#### Variable Measurement

The dependent variable of the experiment, task accomplishment, is composed of the search control strategy employed by the subject during task accomplishment and the exhibited quality of task performance. Operationally, search control strategy is represented by a subject's information acquisition process and task performance is represented by task solution. The search control strategy of the subject is synthesized from the operators utilized during task completion. The task solution operators employed are represented by IS usage during task accomplishment. Therefore, IS usage characteristics serve as operational surrogates of human information-processing problem-solving steps. Task-solving procedures available to both the control and experimental group subjects during problem solving included continuation along the same aspect or attribute, selection of a new attribute along the same aspect, selection of a new aspect, and selection of a new attribute along a new aspect (see Stimulus Selection in Figure 5). The control group was required to traverse across attributes in a serial mode, while the experimental group was able to move directly to a desired attribute (see Appendix C for a description of task aspects and attributes).

Todd and Benbasat suggest that both process and performance analysis of IS use are required in order to assess "how and why" systems contribute to the decision-making process (26). Observation metrics are classified as process observations and performance observations (10). Process observations reveal insights into individual processes or subprocesses executed by the subject during task accomplishment (10). Performance observations are intended to reflect the subject's behavior over the entire task. Process observations and performance observations are delineated by level of task domain knowledge in this study.

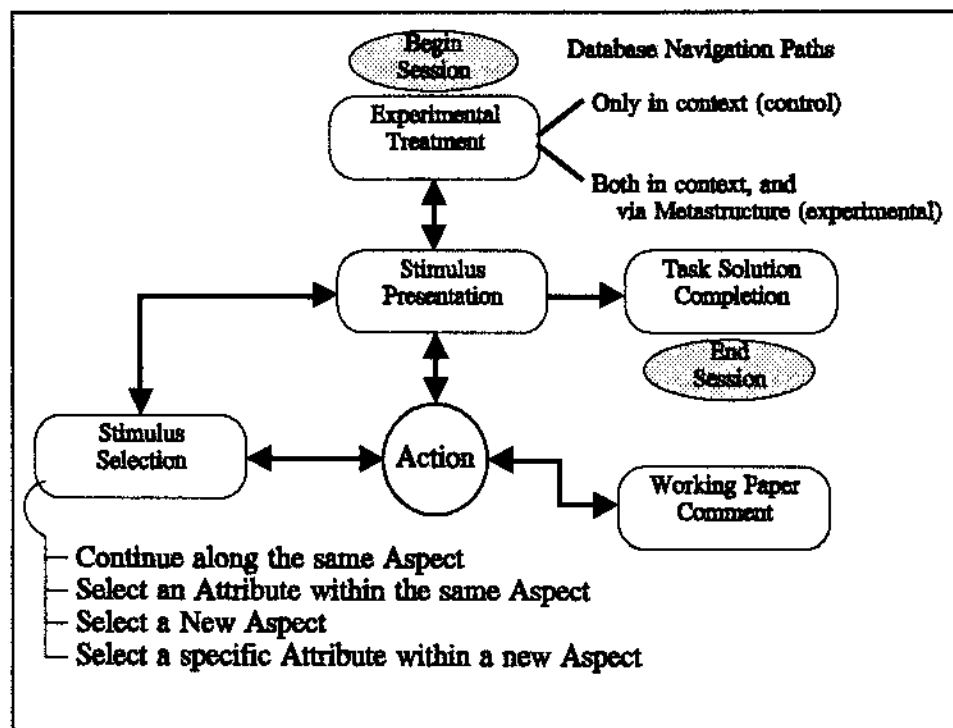


Figure 5 - Information Processing Flowchart

A subject's search control strategy is operationally represented by the IS usage of the subject in the information acquisition phase of task accomplishment. Surrogate process and performance variable measures include the duration, activity, depth, and

sequence of the specific information cues requested by the subject. Duration is the amount of time a subject spends in a set of information displays. Activity is defined as the number of times a subject visits a particular set of information displays. Depth as an operational metric is the percentage of the case that the subject views.

Quantitative analysis of sequence is partially addressed through the use of a navigation index based upon Payne's (22) method. Payne's navigation index provides an indication of the sequence of a subject's information acquisition activity between and within aspects. The navigation index provides evidence regarding the complexity of the information acquisition strategy employed by a subject during task accomplishment. Payne's index was computed as:

$$\text{Index} = \frac{(\text{Aspect} - \text{Attribute})}{(\text{Aspect} + \text{Attribute})}$$

Aspect: the number of instances in which the  $n$ th + 1 piece of information searched is of the same aspect as the  $n$ th, and

Attribute: the number of instances in which the  $n$ th + 1 piece of information searched is of the same attribute as the  $n$ th.

Process observation variables include metrics of duration per aspect and activity per aspect (see Appendix C). Performance observation variables computed over the entire task include metrics of duration, activity, depth and sequence. Duration metrics of elapsed time on the system and elapsed time during problem solving were collected. Total activity, defined as the summation of activity over all task aspects, was computed. Depth of task space covered and the sequence of information acquisition between aspects and attributes were also generated. These process and performance observation metrics of information acquisition provide a partial basis for investigating a subject's task accomplishment.

Task performance as a sub-component of task accomplishment is operationally represented by the quality of the task solution provided by the subject. The quality of the solution is based upon the subject's identification of the level of control risk present in the case scenario. The level of control risk was considered a discrete range of values represented as maximum risk, moderate risk, and low risk. A subject's task performance was computed by summing the absolute value of the difference of the subject's individual solutions from the recommended solution as assigned by a task authority. Correct assessment of control risk is crucial to successful performance of the professional duties in this task domain.

#### Data Collection

Three sets of data were collected in this study. Personal demographics and assessed task domain knowledge were collected through questionnaires included in the experimental packet (Appendix D). The third data set, the problem-solving process, was captured using a computerized activity-logging technique. Computer logging has been suggested as a means of monitoring a subject's cognitive model (28), analyzing and evaluating interactive systems (12), and as a basis for a theory of information flow and valuation (30). Todd and Benbasat state that "the use of computer logs to monitor interactive decision-making activity is particularly relevant to DSS research" (26). The advantages of computerized activity session logs include the comprehensiveness of the method, its unobtrusive nature, and its characteristics of providing explicit and quantifiable measures. These attributes qualify computerized activity logs as an appropriate data collection technique within a wide variety of research objectives.

### Analysis Procedures

As previously mentioned, the computer logging mechanism used in this study provides a basis for both qualitative and quantitative data analysis. Observation metrics used in this study are designed to provide information on the task accomplishment of the subject. Task accomplishment has been delineated as a subject's search control strategy and task performance. Surrogates for these variables are the information acquisition strategy and task solution, respectively.

IS usage (duration, activity, depth, and sequence) by an individual was analyzed in order to infer the subprocesses of problem solving. IS usage by duration and activity over individual task aspects constituted process observations of a subject's search control strategy. Performance observations of search control strategy address the entire task and were represented by metrics of duration, activity, depth, and sequence. This analysis permits investigation of cognitive processes within information displays and between information displays. These process and performance observations provide evidence of the overall cognitive process models used by the subject (26, 8).

Statistical analysis procedures applied to the performance observations include general descriptive tests, analysis of variance (ANOVA), and two-way ANOVA with interaction. The ANOVA model is used to suggest general decision strategies employed during task performance (14). As an exploratory study, the alpha level of .10 was chosen as the criterion value for statistical significance. The individual statistical hypotheses, the related research metric(s), and the applied statistical procedure are presented in Appendix E.

This approach of process and performance analysis was performed for the first hypothesis, the effect of the level of task domain knowledge, the second hypothesis, task presentation effects, and the third hypothesis, the joint effects of task domain knowledge and task presentation effects (see Appendix E). The research constructs of IS support, task domain knowledge, and individual decision making are investigated through the integration of these hypotheses into a comprehensive study. Through the integration and extension of the research constructs the theoretical bases of: 1) task support 2) task effects, and 3) human information processing in decision making are addressed in such a manner as to satisfy the present research objectives.

#### Limitations and Key Assumptions

Based in part upon the complexity of the chosen task, data analysis is methodologically difficult. This level of difficulty exposes the research to numerous criticisms regarding the validity of conclusions which can be statistically defended. However, this exposure to criticism is tempered by the realism of the task to the operational demands placed upon the subject population (1, 2).

The individual's task activity within a field setting is emphasized in this study in accordance with Sternberg's call for a more idiographic focus for investigating intelligent performance. This study acknowledges the statistical difficulties of combining cognitive performance results across individuals (25, pp. 302-303). Furthermore, it is suggested that cognitive performance investigations, as they relate to IS, require the researcher to extend beyond the artificial laboratory domains associated with many previous IS studies. Extensions beyond the controlled laboratory setting have often been characterized as "soft" research lacking in scientific rigor (29). According to Yin, "paradoxically, the

'softer' a research technique, the harder it is to do" (29). Justification for pursuing this type of research stems from the external validity strengths associated with context-rich research (3, 29, 6). Overall, research generating contextually rich data provides a closer relationship between the researcher and society, contributes to theory building, and addresses scientifically unaddressable problems (3, 29, 18). In part, based upon these factors, this research suggests that the benefits associated with contextually rich data overshadow weaknesses associated with statistical analysis difficulties. Furthermore, it is contended that these associated weaknesses are mitigated through the use of quantifiable idioms associated with computer activity logs.

The inability to randomly select subjects for this experiment poses a potential threat to the validity of the study. Lacking random selection from the target population of computer-supported problem solvers limits the inferential power of the findings of this study across groups. Of the subjects volunteering to participate, the potential threat of individual bias to the study exists. Random assignment of treatments was employed as a means of mitigating the effects of individual differences between the experimental and control groups. Subjects utilized in this study were individuals whose professional responsibilities directly or indirectly address the substantive task content of the experiment. The professional affiliation of the subjects to the substantive task content contributes to the validity of the study. Unfortunately, there are numerous constraints associated with the professional environment as it relates to experimental studies. Among these constraints is the limited time available for a professional to dedicate to a simulated experimental task. The artificial nature of the task may not be sufficient stimulus to evoke the necessary response of the subject being addressed by the research. In the



professional environment, it was not possible to schedule a single session for testing of all subjects. This condition may present threats to the experiment's validity based on history, subject interaction, and maturation factors.

Limitations on the number of subjects available to participate also places constraints on the study. Due to the limitation of the number of professional subjects available to participate in the experiment, a simple experimental research design was necessitated. The simple experimental research design, when compared to more complex designs, does not inherently provide control of numerous sources of validity threats, such as history and interaction effects. Additionally, the statistical inferential power of the findings may be limited by the small sample size. These potential limitations, implied when using professionally affiliated subjects, are offset by the fact that the substantive research objectives of this study will be more effectively addressed through the use of professionally-based subjects.

Assumptions made in this study include the premise that cognitive operators (20) used in problem solving can be reliably associated with a subject's computer usage behavior (see Figure 2). Previous research has indicated that cognitive operators of problem solving can be associated with computer usage behavior (16). Luconi, Malone and Scott Morton's (15) IS framework supports the proposition of this association, as do Yovits et al. (30). The appropriateness of the experimental task to be used in the study is closely related and germane to the previous assumption. The task must be sufficiently robust as to evoke a traceable problem-solving strategy of the subject. An expert evaluation of the experimental case was used to qualify the appropriateness of the assigned task. Additionally, as the applied task was a modified version of a

professionally-developed case presentation, designed specifically to enhance a subject's ability in this domain, this task-associated risk may be of only minimal impact. Based upon these factors, task appropriateness was assumed.

### Summary

A simulated audit task was designed to address the research objectives. The simulated audit task incorporated professional competency issues critical to planning an audit engagement. The actual content of the simulated audit task was based on a case used in a professional audit guide text.

A field experiment involving a simulated audit task was designed to address the research objectives of the study. Task presentation, the independent variable, manipulated the database-navigation paths available to the experimental subject. The database-navigation paths were characterized as serial-based or dynamic-based. The moderating variable, task domain knowledge, assessed the extent of task domain knowledge possessed by the subject. It was theorized that task domain knowledge serves as a constraint of the subject's task-solving process capability. Task accomplishment, the dependent variable, was dichotomized into dimensions of search control strategy and task performance. Search control strategy provided a basis for analyzing how task accomplishment was performed. Task performance provided a measure of how well the task was accomplished.

A convenience sample of subjects from nine large accounting firms was used in the study. Seventy-four professional accountants chose to participate in the study. Three sets of data were collected in the field experiment. The first data set of personal demographics was collected via a questionnaire. Performance on a series of professional

competency examination questions was collected for the second data set as a means of assessing task domain knowledge. The third data set represented the subject's task accomplishment and was collected through a computer activity-logging technique.

Various quantitative idioms were used to measure a subject's search control strategy. Metrics of duration, activity, depth, and sequence were collected by monitoring a subject's task-solving processes via the information flowchart technique. Solution quality was determined by comparing a subject's solution with the recommended solution provided by an authority in the task environment.

Data analysis was performed first by structuring the analysis metrics into process and performance observations. Process observations (duration and activity) focus on individual subprocesses executed during task accomplishment. Performance observations (duration, activity, depth, and sequence) reflect a total task perspective upon completion of all the task requirements. The quality of a subject's task solution was computed as the absolute value of the difference between a subject's audit assertion assessments over four assertions and an authority's recommended assessment level. Overall, total solution quality was computed by adding the individual assertion differences together to form a grand total.

Based upon the structure of the data collected a variety of analyses were supported. Specifically, the research design and methodology enabled the investigation of how the task-solution process evolved and the effectiveness of the task solution. The characteristics of the subject's information acquisition process provided a basis for investigating the search control strategy used during task accomplishment. The surrogate measure of task solution quality supported analysis of the effectiveness of a subject's

decision process. The next chapter presents both the statistical data analysis performed on the collected data and presents the theoretical interpretations supported by the data analysis.

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## CHAPTER 5

### ANALYSIS AND DISCUSSION

Initially this chapter presents a general description of the individual data sets pertinent to this study. Significant interactions between task domain knowledge and task accomplishment (H1) are then addressed, followed by the effects of task presentation on task accomplishment (H2). Joint effects of the interactions between task domain knowledge and task presentation on task accomplishment (H3) are addressed. Finally, interpretations and conclusions made from analysis of the collected data are presented.

Three sets of data were collected from the subjects. Hypothesis one (H1) investigates the effects of user environment on use process. Data sets representing a subject's task domain knowledge and task accomplishment provide the basis of analysis for hypothesis one (H1). The second research hypothesis (H2) addresses the effects of the information subsystem on use process. Variables of interest for hypothesis two are the task presentation and task accomplishment of the subject. The final hypothesis (H3) involves the joint effects between the research variables of task domain knowledge and task presentation as moderators of task accomplishment.

#### Respondent Description

Firm responses are presented in Table 1. Ten firms were contacted regarding participation in the experiment. One firm chose not to participate based upon the unavailability of qualified subjects. Eighty-one responses were returned by nine firms



providing 74 usable responses. The seven unusable responses were rejected based upon the fact that one or more sections of the data sets returned were incomplete.

TABLE 1  
FIRM RESPONSES

Firm	1	2	3	4	5	6	7	8	9	Total
Returned Responses	13	16	8	10	7	6	12	7	2	81
Usable Responses	12	15	7	10	6	4	12	6	2	74
Rejected Responses	1	1	1	0	1	2	0	1	0	7

The personal demographics data is of secondary interest to this study and provides a general profile of the subject pool. Selected personal demographic data are presented in Table 2. Table 2 also provides an average profile of the participating firms. Two of the demographic variables of direct interest to this study are "Days Training in Auditing" and "Days Training in Computers." These demographic variables represent the firms' commitment to continuing professional education indicated by the days of training each subject's respective firm has provided. The task domain knowledge bases assessed in the experiment involve both auditing and computer expertise. Requisite areas of expertise for adequate performance in the experimental task include both audit and computer knowledge. The data also suggest that the firms more aggressively support the auditing area of performance. The demographic data indicate that, on the average, 17 days of audit training were provided, compared to less than four days of computer training. Overall the subjects average nearly four years of auditing experience. The professional

association with the firm is slightly below the period of audit experience, suggesting that several of the subjects had prior associations with another auditing firm.

TABLE 2  
PERSONAL DEMOGRAPHICS BY FIRM

Firm	N	Subject Age	Years with Firm	Years Audit Experience	Computer Related Courses	Days Training in Auditing	Days Training in Computers
1	12	28.0	4.5	4.5	9.7	31.1	6.0
2	15	27.0	3.8	4.1	2.9	17.6	6.0
3	7	28.7	4.1	4.1	3.8	13.0	2.7
4	10	26.4	3.5	3.6	2.9	19.5	6.4
5	6	25.3	2.6	3.6	4.1	15.0	4.6
6	4	31.0	4.0	5.2	2.3	11.0	2.5
7	12	24.5	2.2	2.4	2.5	13.7	1.8
8	6	24.5	2.3	2.3	3.5	16.3	1.5
9	2	28.5	4.0	5.0	2.0	16.0	2.5
AVERAGES	8	27.10	3.44	3.87	3.74	17.02	3.78
TOTALS	74						

Task domain knowledge assessed in this study was first dichotomized into groups addressing content areas involving audit and computer knowledge. Each group was further classified into subcategories addressing specific as opposed to more general knowledge within the respective audit and computer knowledge domain groupings. An additive combination of the audit and computer knowledge groups provided a measure of overall task domain knowledge. Table 3 presents the assessed knowledge domains, the

average percentage of correct multiple choice answers for each of the areas, and the resulting task domain knowledge groupings.

#### Task Domain Knowledge Assessment

The performance mean scores as presented in Table 3 were used as criteria measures for assigning a subject into lower or higher task domain knowledge groups. Any subject performing greater than or equal to the mean score was assigned to the higher performer group; all others were assigned to the lower performer group. In this manner, the assessed level of task domain knowledge was based on performance criteria within the specific experimental task domain. The subject group counts resulting from the task domain knowledge assessment are presented in Table 3. These groupings provide the basis of analysis for addressing the interaction effects between task domain knowledge and task accomplishment (H1) and joint effects of task domain knowledge and task presentation on task accomplishment (H3).

TABLE 3  
ASSESSSED TASK DOMAIN KNOWLEDGE GROUPS

Assessed Task Domain Knowledge Base	Mean Score	Higher Group N	Lower Group N
Computer Audit Specialist - General (CASG)	.51	36	38
Computer Audit Specialist - Specific (CASS)	.54	43	31
Computer Audit Specialist - Overall (CAS)	.52	37	37
Computer - General (CG)	.67	47	27
Computer - Specific (CS)	.49	44	30
Computer - Overall (C)	.54	38	36
Computer Audit Specialist and Computer - Overall (K)	.53	42	32

### Task Accomplishment Behavior

The dependent variable of the experiment, task accomplishment, consists of the subjects' search control strategy and task performance (see Figure 4 and Appendix B). The variable surrogates for these constructs are "Information Acquisition Strategy" and "Task Solution," respectively. Operational measures of these variable surrogates are the "IS Procedures and Use" and "Quality of Solution," respectively.

#### Search Control Strategy

Metrics of "IS Procedures and Use" capture the duration, activity, depth, and sequence of the subjects' coverage of the task space. In addition to these process metrics, specific IS procedures invoked during the problem-solving process were investigated. Table 4 presents several of the IS procedures and use variable values. The average subject used the IS for approximately 45 minutes (2638 seconds). The IS procedure of navigating the database by using the "Table of Contents" procedure was invoked slightly less than eight times (7.69). The elapsed time while using this IS procedure is approximately two minutes (121 seconds). An average of 84 system records (hyperbase screens) were viewed. With the total number of 45 hyperbase records in the task, several individual records were viewed multiple times. The average subject viewed 68 percent of the hyperbase; conversely, 32 percent of the task space was not viewed. Elapsed time in the audit case was approximately 35 minutes (2110 seconds). Payne's navigation index (the sequence of information acquisition) indicates that, on average, subjects utilized an Attribute or "within Aspect" search strategy.

TABLE 4  
IS PROCEDURES AND USE

Operational Metric	Average	Minimum	Maximum
Elapsed time in experimental system (seconds)	2638.00	428.00	8740.00
Table of Contents procedure envocations (count)	7.69	0.00	57.00
Elapsed time using Table of Contents (seconds)	121.42	0.00	620.00
Number of records viewed (count)	84.12	9.00	222.00
Audit task space viewed (percentage)	68.00	13.00	100.00
Elapsed time in Audit Case (seconds)	2110.00	298.00	7423.00
Sequence of Information Acquisition (Payne's Index) ( +1 = Maximum Aspect Search ) ( -1 = Maximum Attribute Search )	-0.24	-1.00	0.80

#### Task Performance

The quality of a subject's task solution was defined as the appropriateness of the subject's assessed level of control risk for four audit assertions. The research metric of "Total Solution" was computed as the summation of the appropriateness of a subject's solutions across the four audit assertions. Table 5 presents these audit assertions and the number of subjects assigning a particular level of risk to each assertion. The first, second, and fourth assertion assessments indicate the subject pool generally selected between two of the three risk levels. This agreement represents a concordance in interpretations along the first, second, and fourth assertions. The third assertion displays a more even distribution across all three risk levels indicating a wider range of interpretations on this assertion as compared to the other three assertions.

**TABLE 5**  
**ASSESSED LEVELS OF CONTROL RISK BY AUDIT ASSERTION**

Audit Assertion	Subject Assessed Levels of Control Risk			Expert Recommended Assessment Level
	Maximum	Moderate	Low	
Existence and Rights (Ownership)	3	35	36	Low
Completeness	4	34	36	Moderate
Valuation - Gross Value	15	40	19	Moderate
Valuation - Realizable Value	35	32	7	Maximum

#### Task Domain Knowledge Effects (H1)

The experimental design in Figure 5 presents task accomplishment as dependent upon task domain knowledge and task presentation. The first hypothesis (H1) concerns the interaction effects of task domain knowledge and task accomplishment. Task domain knowledge is delineated through the subject's assessed level of task domain knowledge. Task accomplishment is captured through metrics involving the subject's search control strategy and the subject's task performance.

#### Search Control Strategy (H1)

The results of the ANOVA test for the task domain knowledge levels with task accomplishment metrics indicate several statistically significant differences between the higher and lower domain knowledge groups. The experimental task was structured by content into fifteen general aspects that were further classified into more specific attributes within the aspect category (see Appendix C). The first two analyses of the information acquisition process using duration and activity metrics are based on the

individual aspects of the task. This analysis perspective implies an overall task structure predicated on the semantic content of the individual task components. The ANOVA analysis of task domain knowledge level by aspect duration provides evidence that the task domain knowledge bases differentiate between the groups (Table 6). Nine of the fifteen task aspects (60 percent) provide support that one or more of the knowledge base groups effectively delineate the subject pool. Analysis within the knowledge bases themselves shows five of the seven knowledge bases (71 percent) provide at least three instances of significant difference between the groupings. This analysis provides a total of eighteen statistically significant differences represented by 60 percent of the aspects (9 of 15) and 71 percent of the task domain knowledge bases (5 of 7).

The ANOVA analysis of domain knowledge level by aspect activity also suggests that task domain knowledge delineates a subject's search control strategy (Table 7). Seven of the fifteen aspects (47 percent) provide support of task domain knowledge as a moderator of search control strategy. Three of the seven knowledge bases (43 percent) provide at least two instances of statistically significant differences between knowledge base groupings for a total of eight statistically significant differences.

Overall task analysis on metrics of IS procedures and use provide evidence that the task domain knowledge construct does serve as a delineator of search control strategy. Table 8 presents the ANOVA p-values of significance for these various IS procedures and use metrics. Measures of audit time (duration), percentage of case viewed (depth), and Payne's index (sequence) each provide one or more instances where task domain knowledge does indicate significance. From this perspective of analysis, three of the seven knowledge groups (43 percent) significantly moderate IS procedures and use for

a total of four instances. H1a is accepted and the corresponding component of H1, addressing search control strategy, is rejected based upon the data analysis of duration, activity, depth, and sequence. Substantively, an individual's search control strategy is influenced by their task domain knowledge.

TABLE 6  
ASPECT DURATION BY TASK DOMAIN KNOWLEDGE  
SIGNIFICANT ANOVA P-VALUES

Aspect	CASG	CASS	CAS	CG	CS	C	K	Signif Count
1	.232	.116	.226	.160	<u>.085</u>	.117	.262	1
4	.225	.773	<u>.073</u>	<u>.043</u>	.335	.252	.195	2
5	.113	.335	.212	.797	.822	.511	<u>.021</u>	1
7	.116	.424	.115	<u>.078</u>	.217	.327	<u>.048</u>	2
10	.530	.142	<u>.024</u>	.124	<u>.006</u>	<u>.016</u>	<u>.071</u>	4
11	.419	.758	.159	.360	<u>.016</u>	<u>.035</u>	.137	2
12	.115	.209	<u>.025</u>	.234	<u>.031</u>	<u>.027</u>	<u>.020</u>	4
14	.128	.560	.115	<u>.055</u>	.554	.346	.400	1
15	.522	.328	.143	.310	.861	.708	<u>.081</u>	1
Signif Count	0	0	3	3	4	3	5	18

— Indicates significance for  $p < .10$



TABLE 7  
ASPECT ACTIVITY BY TASK DOMAIN KNOWLEDGE  
SIGNIFICANT ANOVA P-VALUES

Aspect	CASG	CASS	CAS	CG	CS	C	K	Count
1	<u>.030</u>	.912	.444	.819	.428	.419	.591	1
3	<u>.089</u>	.336	.172	.191	.167	.235	.321	1
11	.644	.950	.330	.151	<u>.035</u>	.407	.351	1
12	.577	.999	.203	<u>.004</u>	.321	.948	.270	1
13	.431	.381	.793	.669	<u>.015</u>	.299	.470	1
14	.512	.431	.861	.858	<u>.068</u>	.264	.580	1
15	<u>.092</u>	.474	.116	<u>.090</u>	.387	.201	.317	2
Count	3	0	0	2	3	0	0	8

— Indicates significance for  $p < .10$

TABLE 8  
IS PROCEDURES AND USE BY TASK DOMAIN KNOWLEDGE  
ANOVA P-VALUES

Know- ledge Domain	Duration			Activity		Depth	Sequence	Signif Count
	System Time	Audit Time	TOC Time	TOC Count	Records Viewed	% Case Viewed	Payne's Index	
CASG	.401	.320	.579	.912	.480	.109	.151	0
CASS	.716	.932	.859	.266	.533	.615	.903	0
CAS	.280	.131	.837	.332	.929	<u>.065</u>	.157	1
CG	.540	.312	.650	.263	.950	.229	.379	0
CS	.222	.193	.379	.692	.284	<u>.008</u>	<u>.008</u>	2
C	.246	.179	.257	.587	.700	.176	.269	0
K	.154	<u>.095</u>	.869	.931	.965	.224	.426	1
Count	0	1	0	0	0	2	1	4

— Indicates significance for  $p < .10$

### Task Performance (H1)

Based on the value distribution parameters of the solution quality metric, ANOVA procedures were only appropriate on the total solution metric. Table 9 presents the ANOVA p-values of significance for the subject's total solution quality by task domain knowledge groups. One of the seven knowledge bases did provide statistically significant differences for total solution quality. In order to further analyze the effect of task domain knowledge on task solution quality the Chi-square test was performed. Table 10 presents the significance values of the Chi-square test. Two of the individual audit assertions (50 percent), with respect to solution quality, are significantly related to an individual's level of task domain knowledge. This table presents evidence that six of the seven knowledge bases (86 percent) serve as statistically significant moderators of task solution quality for a total of seven significant differences. Therefore, H1b is accepted and the corresponding component of H1, addressing task performance, is rejected. Solution quality on two of the four audit assertions was found to be influenced by the individual's task domain knowledge.

TABLE 9  
SOLUTION QUALITY BY TASK DOMAIN KNOWLEDGE  
ANOVA P-VALUES

Task Solution Component	CASG	CASS	CAS	CG	CS	C	K	Signif Count
Total Solution	<u>.081</u>	.852	.518	.748	.202	.410	.630	1
Significance Count	0	1	0	0	0	0	0	1

— Indicates significance for  $p < .10$

Summary (H1)

Based upon analysis of the research data the first hypothesis (H1), in its entirety, is rejected. In this finding, an individual's task accomplishment behavior is influenced by the task domain knowledge of that individual. Both search control strategy and task performance exhibit measurable effects of task domain knowledge.

TABLE 10  
SOLUTION QUALITY BY TASK DOMAIN KNOWLEDGE  
PEARSON'S CHI-SQUARE LEVELS OF SIGNIFICANCE

Knowl- edge Domain	Accounting Assertion				Overall Task Solution	Signif Count
	Existence and Rights	Completeness	Valuation- Gross Value	Valuation- Net Value		
CASG	.1341	<u>.0003</u>	.4354	.9261	.1937	1
CASS	.1931	.3334	.4798	.6622	.7531	0
CAS	<u>.0283</u>	<u>.0147</u>	.3015	.7342	.6651	2
CG	.3865	<u>.0182</u>	.5309	.9745	.9109	1
CS	.2821	<u>.0093</u>	.3334	.8263	.3261	1
C	.2979	<u>.0839</u>	.7197	.7342	.2761	1
K	<u>.0464</u>	.2253	.1666	.7796	.2358	1
Signif Count	2	5	0	0	0	7

— Indicates significance for  $p < .10$

#### Task Presentation Effects (H2)

Hypothesis two (H2) investigates the effect of the information subsystem on the use process. Effects of task presentation ordering treatments on task accomplishment were analyzed in a progression similar to the analysis of task domain knowledge effects (H1). First, the effects of task presentation ordering treatments on search control strategy are addressed, followed by a discussion addressing task performance.

### Search Control Strategy (H2)

The ANOVA p-values for individual task aspects by duration and activity for the experimental treatment groups are presented in Appendix F. This data suggest that task presentation does not serve as a measurable delineator of IS use. Analysis of overall IS procedures and use, presented in Appendix F, also supports the conclusion that task presentation treatments do not affect the information acquisition component of task accomplishment. Therefore, the component of H2 addressing an individual's search control strategy cannot be rejected.

### Task Performance (H2)

The ANOVA and Chi-square significance values regarding the effect of the experimental treatment on task solution quality are presented in Appendix F. This data fail to provide evidence that would support rejecting the component of H2 concerning task performance. Therefore, the second hypothesis, in its entirety, cannot be rejected. Substantively, an individual's task performance is not found to be affected by the task presentation ordering treatments. Summarizing for H2 in entirety, a subject's task accomplishment was not found to be influenced by task presentation.

### Joint Effects of Task Domain Knowledge and Task Presentation (H3)

Hypothesis three (H3) concerns task accomplishment and the joint effects of a subject's level of task domain knowledge and the task presentation ordering treatment. The two-way ANOVA statistical procedure was used in this section of the analysis. The selection criterion for inclusion in the two-way ANOVA interaction analysis was that a significant difference existed between two research constructs as found in the one-way ANOVA analysis for the first two hypotheses.

## Search Control Strategy (H3)

Table 11 presents the summary of significant interactions resulting from the two-way ANOVA analysis. Three of the fifteen aspects of the task were found to have a statistically significant interaction effect between task domain knowledge and task presentation for a total of four instances. Analysis of general IS procedures and use determines that both the percentage of case viewed (depth) and Payne's navigation index (sequence) exhibit an interaction effect between task domain knowledge and task presentation (Table 12). Based upon these results, hypothesis three is in part rejected and H3a is accepted. This conclusion is that a subject's search control strategy is influenced by joint effects of level of task domain knowledge and task presentation ordering treatments.

TABLE 11  
ASPECT BY TASK DOMAIN KNOWLEDGE AND EXPERIMENTAL GROUP  
TWO-WAY ANOVA P-VALUES

Aspect	Knowledge Domain	IS Metric	Significance		
			K-Domain	Group	Interaction
3	Computer Audit Specialist - General	Activity	<u>.015</u>	.322	<u>.008</u>
11	Computer - Specific	Duration	<u>.006</u>	.275	<u>.071</u>
12	Computer - Specific	Duration	<u>.005</u>	.172	<u>.015</u>
	Computer - Overall	Duration	<u>.009</u>	.182	<u>.029</u>

— Indicates significance for  $p < .10$

TABLE 12

IS PROCEDURES AND USE BY TASK DOMAIN KNOWLEDGE  
AND EXPERIMENTAL TREATMENT GROUP

TWO-WAY ANOVA P-VALUES

Analysis Metric	Knowledge Domain	Significance		
		K-Domain	Group	Interaction
Percentage of Case Viewed (Depth)	Computer - Specific	<u>.000</u>	.442	<u>.000</u>
Payne's Navigation Index (Sequence)	Computer - Specific	<u>.002</u>	.979	<u>.030</u>

— Indicates significance for  $p < .10$

Task Performance (H3)

Analysis of the subject's total solution indicates that there is no statistically significant interaction effect between task domain knowledge and task presentation (Table 13). Therefore, the task performance component of H3 cannot be rejected. The conclusion is that a subject's task performance is not related to the joint effects of their level of task domain knowledge and task presentation ordering treatments.

Summary (H3)

A summary of hypothesis three indicates that only one component of a subject's task accomplishment is influenced by the joint effects of task domain knowledge and task presentation ordering treatments. Based upon the current data, the search control strategy of the subject is influenced by the joint effects of task domain knowledge and task presentation. Therefore, the component of H3 addressing search control strategy is rejected and H3a is accepted. The data does not provide evidence that task performance is influenced by the joint effects of task domain knowledge and task presentation.

Lacking measurable evidence of the interaction effect, the component of H3 addressing task performance is not rejected.

TABLE 13  
TOTAL SOLUTION QUALITY BY TASK DOMAIN KNOWLEDGE  
AND EXPERIMENTAL TREATMENT GROUP

TWO-WAY ANOVA P-VALUES

Total Assessment Solution				
Knowledge Domain	Metric	Significance		
		K- Domain	Group	Inter- action
Computer Audit Specialist - General	Quality	<u>.066</u>	.632	.582

— Indicates significance for  $p < .10$

Hypothesis Analysis Summary

In review, the analysis led to rejection of the first hypothesis and the qualified acceptance of both the alternatives for hypothesis one. Task domain knowledge was found to influence task accomplishment. The conclusion that the second hypothesis should not be rejected was supported by the data. Task presentation ordering treatments were not found to influence the subject's task accomplishment. The data concerning the joint effects of task domain knowledge and task presentation ordering treatments on task accomplishment provide a basis for a partial rejection of the third hypothesis. The alternative hypothesis (H3a) regarding the search control strategy was conditionally accepted. Therefore, it is suggested that search control strategy is influenced by the joint effects of task domain knowledge and task presentation. The alternative hypothesis (H3b) addressing task performance was not supported. Task performance is not measurably

influenced by the joint effects of task domain knowledge and task presentation ordering treatments.

An overall view of the findings provides several notable trends within the collected data. Process observations of duration and activity address decision-maker subprocesses within task accomplishment. In this manner, process observations provide a basis for decomposing the overall task into logical subcomponents. Minch (6) and Miller (5) suggest this approach as a means of relating the task to the task information. The analysis of the first hypothesis suggests that the task information does possess an infra-structure based on the relationship of the task information to the decision-maker processing of the information. Combining Tables 7 and 8, a total of 26 instances of measurable effects are identified. Categorizing these findings by aspects identifies 8 instances of measurable effects over Aspects 1 through 9 and 18 instances over Aspects 10 through 15. We find concordance for the distribution by relating these results to the task structure identified in Chapter 4, Research Methodology. In Chapter 4, the task data content was determined to be broadly categorized into environmental information and function-related specific information. The findings then contribute to the proposition that task domain knowledge does influence a decision maker's search control strategy. Extending further, it appears that the measurable effects of task domain knowledge become more obvious as the task information content becomes more critical to the task solution (see Table F.13).

Analysis of the knowledge domains that appear critical to the search control strategy also suggests the infra-structure of the task data between environmental information and function-related specific information. In the environmental information



aspects we find 3 instances of audit-related knowledge bases and 3 instances of computer-related knowledge. Within these aspects the general class of knowledge domain (CASG and CG) provides the majority of instances of measurable effects. In the function-related aspects (Aspects 10 through 15; Appendix C) there are three audit instances and 12 computer-related measurable instances. This data may be interpreted as an indication that within the critical areas of the task information (Aspects 10 through 15), the computer knowledge domains provide a greater influence on a subject's search control. A review of the IS procedures and use data (Table 8) shows that the computer-specific knowledge domain provides 2 of 4 instances of measurable effects. The significance value of these two instances of computer-specific knowledge bases also agrees with the supposition that the computer-related knowledge bases are critical in this task domain.

The data results with respect to hypothesis 3 provide additional support for the classification of the task information into environmental information and function-related information. Additionally, the critical knowledge domains are also somewhat in agreement with the previous analysis. Task presentation ordering treatments were not, in isolation, found to influence task accomplishment. However, an interaction effect with certain knowledge domains was evidenced. Analysis of process observations in Table 11 identifies audit knowledge interacting with task presentation within the environmental information aspects. In a qualified manner, it is not surprising to find either the audit-related or computer-related knowledge bases evidenced in this task information area (Aspects 1 through 9; Appendix C). However, it appears more predictable to find the instances of computer-related knowledge bases interacting over Aspects 10 through 15. This finding is in agreement with the previous suggestion that computer-related

knowledge may be more critical in the task data containing function-specific information. The analysis of performance observations addressing interaction effects (Table 12), again identifies computer-related knowledge as a contributor to the explanation of a subject's search control strategy.

Evidence to support absolute determination of the relationships between the research constructs is not present in the data findings. However, several trends can be identified and discussed. The task information structure, as addressed by Miller (5), suggests that indeed task domain knowledge and IS use provide a means of identifying information content critical to search control. Additionally, it appears that these areas of information content align themselves with specific classes of knowledge domains. We find that IS characteristics (task presentation ordering) interact with these respective knowledge domains in a manner consistent with the alignment of critical knowledge domain to task information area. Based upon these insights, it is suggested that task domain knowledge influences IS use. While this influence is neither absolute nor simplistic in nature, it is measurable and provides a rich basis for addressing the appropriateness of IS for decision-making support.

#### Theoretical Interpretations

Interpreting the conclusions of the research and linking the current research findings to a theoretical base provide a richer understanding of the observed phenomena. These interpretations must accommodate for the theoretical bases of task support, task effects, and human information processing during task accomplishment.

Observations of the IS user session focus on the Human-Computer Model (see Figure 4). Holding the information system as constant, differences in IS use can be

isolated to the Human System in Figure 4. The human system components, as experimental research constructs, are extremely difficult to isolate and control. Measurable effects observed through data analysis are potentially a reflection of one or any combination of the constructs of cognitive, perceptual, and motor components. This study hypothesizes that the cognitive component of the human system is the major source of measured effects. Perceptual and motor components of the human system, as rival hypotheses, were addressed in the research design in an attempt to mitigate any confounding influences. The use of a standard worksheet format for information layout in the simulated task is an example of the effort to mitigate confounding perceptual effects. The IS capability of allowing the subject to use either a mouse pointer and/or keyboard device for task accomplishment is another example of the effort to eliminate possible confounding influences.

There can be no absolute assurance that rival hypotheses are controlled for in this type of research. However, the research design incorporated elements to reduce the potential of confounding influences. In this study, with design controls in place, the measurable effects of task accomplishment are considered to be derived, in principle, from the cognitive component of the human system. As a researcher, the possibility that rival hypotheses exist is accepted as a minimal risk. The following theoretical interpretations are made under the proposition that the cognitive component of the human system is the major source of observed behavior during task accomplishment.

The Differentiated IS model in Figure 4 is predicated on the moderating effects of an individual's cognitive model. The principal components of the cognitive model are Craik and Lockhart's (2) processing strategy and memory structure. In order to perform

the cognitive "deep processing" tasks of semantic association and stimulus enrichment a subject must possess a complex memory elaboration scheme. Individuals not possessing complex memory elaboration schemes are limited to cognitive processes more associated with the shallow processing tasks of stimulus recognition. Piaget's (10) theory of reciprocal accommodation compares well with Craik and Lockhart's (2) deeper processing. Das et al. (3) proposed that deeper processing allows individuals to perform simultaneous integration of information elements. Individuals limited to shallow processing are restricted to a more successive processing strategy. According to Craik et al., Piaget, and Das et al., cognitive processes associated with stimulus enrichment and semantic association often require longer periods of time when compared to stimulus recognition. These theories then, in part, provide a theoretical basis for the differences in information acquisition strategies between higher and lower task domain knowledge groups. The ability of a subject to cognitively enrich an information stimulus is predicated on the memory elaboration scheme of the subject on a particular information stimulus. In essence, shallow processing requires less time than those cognitive tasks associated with deep processing. It is suggested that the differences in information acquisition strategies between the groups is possibly an artifact representing these cognitive model principles.

The duration metric was found to be influenced by levels of task domain knowledge (see Table 8). This supports the recognized time differences in performance between deep versus shallow cognitive processing. It is theorized that level of task domain knowledge also influenced the individual's ability to integrate information cues. The activity metric of an aspect was influenced according to Das et al.'s (3) theory of

successive processing. In theory, individuals of different task domain knowledge groups will be required by cognitive processing limitations to view information cues in varying numbers. This variance in activity is potentially an artifact of subjects' compensating for their inability or limitations in simultaneously processing information. Finding significant differences in the data representing activity by task domain knowledge supports many of the theoretical propositions by Das, et al., Piaget, and Craik and Lockhart.

General IS procedures and use also contain artifacts of the individual's cognitive processing abilities. Naylor et al. describe amplitude as the "commitment to an act" during rational behavior within an organization (8). The overall time that an individual spent performing the audit task was found to be related to overall task domain knowledge. An interpretation of this finding is that individuals of varying levels of overall task domain knowledge possess differing views of rational behavior during task accomplishment. This rational behavior serves as a mechanism for controlling the overall effort or amplitude of the task accomplishment.

In a closely related construct, the percentage of case viewed (depth) was found to differ on some aspects of the lower and higher task domain knowledge groups (see Table 8). Simon's (11) rational boundary proposed that an individual will choose an alternative that is rational within the context of that individual's understanding of the subject being considered. The experimental task required both auditing and computer expertise for adequate task accomplishment. The assessed knowledge bases of computer auditing specialist-overall and computer-specific provided evidence of significant differences between the percentage of case viewed. This finding supports the interpretation that, within the experimental task environment, individuals of varying levels of task domain

knowledge across two separate knowledge bases possess a recognizable and measurable rational boundary. Further, this rational boundary can be represented by the point of decision where an individual determines that the pursuit of additional information cues provides insufficient contributions to task understanding and solution quality to justify the effort required to acquire additional information. Under this theory, it is at this point that the subject discontinued the information acquisition process.

The sequence of information acquisition is often used as a surrogate for the extent of integration in the decision process (4, 1). The experimental task presented consisted of a base content of auditing-related information with interspersed representations of computer system effects. Individuals dichotomized on computer-specific knowledge indicated a statistically significant difference in the sequence of their information acquisition. An interpretation of this finding is that individuals with higher processing capacity were able to simultaneously integrate information cues. Accordingly, their sequence of acquisition was more integrative in nature. This interpretation then recognizes the complexities between level of task domain knowledge and the specific content and structure of the task as they influence search control strategy.

Task solution quality was found to be influenced by a subject's level of domain knowledge in the computer audit specialist-general category (see Table 9). This fact can be interpreted according to Sternberg's theory of intelligent behavior (12). In Sternberg's theory of intelligent behavior, there is a positive relationship between cognitive assessment and intelligent behavior. Sternberg stressed the importance of focusing on the phenomenon of intelligent behavior in realistic task settings as opposed to cognitive

assessment in isolation (12). In this specific task, the knowledge base of computer audit specialist-general serves, in part, as a delineator of intelligent behavior.

The findings associated with the experimental treatment of presentation ordering effects indicate no significant differences between the treatment groups with respect to task accomplishment behavior (see Tables F.4, F.5, F.6 and F.7). Theoretically, in and of itself, the presentation treatment does not serve as a delineator of task accomplishment. The treatment effect of serial versus dynamic information acquisition schemes was apparently accommodated for by the individual's search control strategy. Mintzberg et al. discussed the numerous decision-making processes observed in decision-making behavior research (7). Payne elaborated on the cost/benefit paradigm central to most decision theories (9). It is theorized that, in general, subjects worked within the task model presented in a manner consistent with rational behavior. Rational behavior, in this perspective, recognizes the additional cognitive efforts imposed by the IS presentation treatment. In this recognition, the average individual, without regard to differences in task domain knowledge, does not receive sufficient benefit to noticeably moderate their particular strategy to match the IS presentation effect.

Analysis of the joint effects of task domain knowledge and task presentation provided evidence of several measurable differences between the higher and lower knowledge groups (see Table 11). An interpretation of these findings is that when task presentation is considered in conjunction with task domain knowledge, significant differences between the groupings were evident. The subject's information acquisition strategy, represented by duration and activity, was influenced by the joint effects. In

addition, the percentage of the case viewed (depth) and the sequence of information acquisition were delineated by the computer-specific knowledge base construct.

Quality of solution was not significantly influenced by joint effects of task domain knowledge and task presentation ordering treatments (see Table 12). An interpretation of this finding suggests an enhancement to the Naylor et al. (8) theory of behavior. Naylor et al.'s theory describes behavior as components of information acquisition and storage, judgments, and acts. The findings of this research indicate that information acquisition and storage components were influenced by the joint effects. Judgments, however, were not prone to this influence. This interpretation provides additional depth to the Naylor et al. theory by focusing on the sensitivity of the information acquisition and storage processes to the dynamic influences of task domain knowledge and task presentation.

The findings and interpretations of the research data indicate the complexity of modeling the phenomenon of intelligent behavior as supported by an IS. The constructs of the model include components of IS support, influences of task effects, and human information-processing abilities. This research suggests that these constructs interact in a highly dynamic manner. The ability to address, promote, and possibly enhance task accomplishment through IS support requires the development of a paradigm incorporating these constructs.

The next chapter presents conclusions and recommendations of the research. A summary of the research design is presented, followed by the theoretical framework and research methodology. The research hypotheses and findings are reviewed in a cursory



manner. Last, recommendations in light of the findings and future research directions are presented.

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## CHAPTER 6

### CONCLUSIONS AND RECOMMENDATIONS

This research investigated IS support of the human problem-solving process. The research was designed to assess IS support, task domain knowledge, and individual decision-making behavior. IS decision support was incorporated into the research paradigm through the application of structural modeling and process tracing. It was hypothesized that an individual's level of task domain knowledge contributes to the type of IS most appropriate for usage by that individual. The effects of task presentation ordering treatments and task domain knowledge on the problem solver's task accomplishment were a principal research premise.

Eighty-one auditors from nine major accounting firms participated in the experiment. Seventy-four of the returned experimental packets were determined to be usable for the purposes of the study. Each of the usable experimental packets provided three sets of data. These three data sets represented a subject's personal demographics, task domain knowledge, and task accomplishment.

The results of data analysis provided several instances of statistically significant effects. The first hypothesis (H1) theorized that an individual's level of task domain knowledge served as a moderator of that individual's task accomplishment. In this section of analysis, task domain knowledge was found to influence task accomplishment. The time (duration) that a subject devoted to a particular subset of the "data-state space"

was significantly influenced by level of task domain knowledge. The number of times (activity) that a subject viewed a subset of the task "data-state space" provided several instances of significant difference. With respect to general IS procedures and use, level of task domain knowledge again provided evidence that task domain knowledge served as a moderator of IS use. Analysis of the effects of level of task domain knowledge on task solution quality indicated that at least one of the seven assessed knowledge bases influenced total solution quality. Given the evidence collected regarding the first hypothesis, the first hypothesis was rejected in its entirety. The conclusion that task domain knowledge does influence task accomplishment was suggested by the data analysis.

The influence on task accomplishment by the IS as the experimental treatment was the focus of the second hypothesis (H2). Differences in task presentation ordering formed the basis of the experimental treatment. The experimental treatment with respect to duration and activity over individual aspects of the task state space provided no evidence of significant effects on an individual's search control strategy. The analysis of the experimental treatment on general IS procedures and use also failed to provide evidence of significant influence. Analysis of task solution quality moderated by experimental treatment group did not indicate a significant effect. Therefore, the evidence does not provide a basis for rejection of the second hypothesis. Task accomplishment behavior was not influenced by the experimental treatment of task presentation ordering effects.

The joint effects of task domain knowledge and task presentation ordering treatments on task accomplishment were addressed by the third hypothesis (H3). Between aspect metrics of duration and activity, instances of measurable joint effects were

identified. General IS procedures and use provided instances of measurable interaction effects. Both the depth and the sequence of an individual's information acquisition process were found to interact with the computer-specific knowledge base. With this evidence, a component of the third hypothesis was rejected. An individual's search control strategy was influenced by the joint effects of task domain knowledge and task presentation. Solution quality did not exhibit evidence of the joint effects of level of task domain knowledge and task presentation ordering treatments. Therefore, the component of hypothesis three addressing solution quality was not rejected. An individual's task performance was not found to be significantly influenced by the joint effects of task domain knowledge and task presentation.

#### Recommendations

This study examined the interacting effects of IS support, task domain knowledge, and individual decision-making behavior. In the experimental research design employed, several interacting effects between these research constructs were found to be statistically significant. The analysis of IS use as a dependent variable, dichotomized into search control strategy and task performance, provided a robust view of task accomplishment. In this perspective, a process analysis of pre-decisional behavior was possible. This process view provides an extension to many of the previous studies addressing IS decision support.

A descriptive approach was used to create a differential model of the individual decision maker. The differential model was based on a subject's level of task domain knowledge. This modeling approach provided a means of addressing differences between the problem-solver groups while simultaneously retaining its generalizability within

groups. A differential IS model based on process analysis permits the study of how IS are effective as opposed to simply whether the IS is effective.

Implications of this research include the recognition that the user's task domain knowledge does serve as a moderator of IS use. Additionally, and possibly more importantly, the research indicates that the individual's task domain knowledge dynamically interacts with the IS model during the problem-solving process. This finding supports the premise that the user's task domain knowledge does contribute to the delineation of the appropriate IS structure for that individual.

The findings of this study suggest a new approach to IS support of organizational problem solving. Organizational implications of this study address areas involving problem-solving support and enhancement. The analysis results suggest that an organization might address tasks as problem states that will be transformed into goal states through the application of problem-solving operators. The infra-structure to accomplish the problem-state to goal-state transformation involves task structuring and process control. Based upon information content, the task should be structured in a manner to facilitate identification of critical issues to be addressed. This structure improves the ability of the organization to align critical task requirements with appropriate organizational expertise. The alignment of task requirements to organizational expertise supports the processes involved in transforming the task from a problem state into a goal state. Through this task-structuring approach the most critical aspects of the task as a problem state are aligned with the most appropriate problem-solving resources.

The findings of this study suggest that the appropriate problem-solving resources dynamically interact with the critical task components. This interaction manifests itself

as a sensitivity to IS decision-support efforts. It also provides a focal point for application of IS support. Through the identification of this focal point, it is suggested that more effective IS decision support can be provided. In review, this task structuring approach involves critical task component identification, appropriate problem-solving expertise alignment, and enhanced opportunity for successful IS decision support. It is suggested that better critical task component identification and expertise alignment will result in enhanced problem-solving performance through IS support. With these suggestions in mind, the following future research is proposed.

The current research design should be replicated in other task environments. An investigation in this manner would contribute to the generalizability of the research paradigm across task domains. A related investigation would be to address the relationship of the three research constructs across multiple tasks within one task environment. This proposed research would be capable of identifying the effects of varying task content and structure in the use process. This would extend the scope of the research paradigm to include multiple tasks in multiple domains and the influence of these factors on task accomplishment.

An expansion of the research paradigm to include effects of training within the task domain could provide further research possibilities. An experimental design including a pre-test/post-test would be able to address the effects of training, if any, on the use process. In this manner, the influence of training, exhibited by a change in intelligent behavior, might provide a more robust measure of training effectiveness. This approach to integrating the IS with organizational training is one way to leverage the capital resources invested in the IS and improve organizational performance.



Research designs investigating ways to link task content to task-specific intelligent behavior are suggested. This focus might provide a methodology of human resource allocation to professional engagements. An emphasis on organizational expertise could allow for the expansion of DSS applications from their current narrow focus into broader domain applications.

The existence of different processing strategies was evidenced in this research. Future research might examine the effects on task performance as a result of influencing the subject's information acquisition strategy. One possible method for measuring this influence is the use of inference-based processing to control the depth and sequence of information acquisition. This type of investigation could provide a theoretical base for applying DSS inference-reasoning principles to the information acquisition process.

Further research has been suggested that includes constructs of IS support, task domain knowledge, and individual decision-making behavior. The objective of understanding how decision makers use the IS, and how this use might be enhanced presents a major challenge to the IS discipline. This objective should be rigorously pursued, but with caution. Research should be directed toward the goal of integrating the necessary constructs to promote intelligent behavior during problem solving. This research attitude promotes the IS as a support for intelligent behavior, resulting in improved performance by the individual and the overall organization.

**APPENDIX A**  
**GLOSSARY OF TERMS**

- aspect/attribute - a means of organizing information based on semantic content and granularity. Where an aspect might be analogous to a chapter and an attribute comparable to a section within a chapter.
- cognitive style - a predisposition or personality type that categorizes an individual's different methods of receiving, processing, and transmitting of information [Gul, 1984].
- data - recorded facts describing some phenomena that a person considers worth formulating and recording.
- data model - an intellectual tool that provides an interpretation of a given data set. An abstraction device that allows interpretation of a data set based on information content of the data as opposed to the individual values of the data [Tsichritzis and Lochovsky, 1982].
- Decision Support System - information systems that are characterized as interactive computer-based systems that help decision makers utilize data and models to solve unstructured problems [Sprague and Carlson, 1982].
- dialog - a component of a DSS that presents the DSS outputs to the user and collects the user inputs to the DSS. Dialog types include: Question- answer, command language, menu, input form/output form, and input-in- context-of-output [Sprague and Carlson, 1982].
- human cognition - as an information processing construct where "cognitive processes are a sequence of internal states or mental representations successively transformed by a series of information processes." [Ericsson and Oliver, 1988]
- model - a representation of some interpretation of an aspect of the world.
- schemata - a theoretical construct referring to the memory structures that incorporate clusters of information relevant to comprehension. This information is functionally associated into units and provides a basis for interpretation and inference [Gerrig, R. J., 1988].

**APPENDIX B**  
**RESEARCH VARIABLE TABLE**

<b>Variable Group</b>	<b>Research Variable</b>	<b>Variable Surrogates</b>	<b>Surrogate Measurement</b>	<b>Analysis Metric</b>
<b>Information Subsystem (Independent)</b>	<b>Task Presentation</b>	<b>Database Navigation Paths</b>	<b>Serial/dynamic access modes</b>	<b>Classification 0 = Control 1 = Experimental</b>
<b>User Environment (Moderating)</b>	<b>Task Domain Knowledge</b>	<b>Level of Task Domain Knowledge</b>	<b>CPA Exam Question Performance</b>	<b>Classification 0 = Lower 1 = Higher</b>
	<b>Personal Demographics</b>	<b>Education, Firm, Responsibility</b>	<b>Questionnaire Data</b>	
<b>Use Process (Dependent)</b>	<b>Task Accomplishment - Search Control Strategy</b>	<b>IS Usage / Information Acquisition</b>	<b>Duration, activity, depth, &amp; sequence</b>	<b>Positive Real Positive Integer Real 0.0 to 1.00 Real -1.0 to 1.0</b>
	<b>- Task Performance</b>	<b>Task Solution</b>	<b>Quality of Solution</b>	<b>Integer 0 to 2</b>

**APPENDIX C**  
**TASK ASPECTS**

ASPECT	ATTRIBUTE
1) Assigning Authority and Responsibility.....	Data Processing Entity
2) Board of Directors and Audit Committee.....	Entity - 1 Entity - 2 Entity - 3
3) External Influences.....	Entity - 1
4) Internal Audit Function.....	Entity - 1 Entity - 2
5) Management Control Methods.....	Data Processing Entity - 1 Entity - 2 Entity - 3
6) Management Philosophy.....	Operating Style - 1 Operating Style - 2 Operating Style - 3
7) Organizational Structure.....	Accounting and Data Processing Entity
8) Personnel Policies and Practices.....	Entity - 1 Entity - 2 Entity - 3
9) Computer Background Information.....	Applications Computer Organization and Management - 1 Computer Organization and Management - 2 Computer Organization and Management - 3 Hardware and Systems Software - 1 Hardware and Systems Software - 2
10) Computer General Control Procedures.....	Access to System Resources - 1 Access to System Resources - 2 Access to System Resources - 3 Application Development Application Maintenance - 1 Application Maintenance - 2 Computer Operations
11) Control Procedures Questionnaire.....	Order Entry Function - 1 Order Entry Function - 2 Order Entry Function - 3
12) Control Procedures Questionnaire.....	Shipping Function
13) Revenue Cycle.....	Billing Function - 1 Billing Function - 2 Billing Function - 3 Billing Function - 4 Billing Function - 5
14) Control Procedures Questionnaire.....	Cash Receipts Function - 1 Cash Receipts Function - 2
15) Revenue Cycle.....	Collection Efforts Function

**APPENDIX D**  
**EXPERIMENTAL PACKET**



## EXPERIMENTAL PACKET

### Table of Contents

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#### Section \_\_\_\_\_

- I.    Introductory Letter
- II.   Personal Demographics Questionnaire
- III.  Audit Decision Task Instructions
- IV.  Professional Examination Questions
- V.   Participant comments (optional)

### Instructions

---

Please carefully follow these instructions. Begin with Section I and proceed to Sections II, III, IV, and V only after the completion of the previous section. Complete all Sections (I, II, III, IV, and V) of the study during one continuous session if at all possible. Section V is optional.

For the integrity of the study, **Please do not discuss any aspect of your participation in this experiment with any other person.**

After completion of all Sections, **Please place all materials in the envelope** and return to the administrator.

Thank you for your participation.

You are being asked to participate in an experiment investigating professional audit decision making. This research is part of a doctoral dissertation in information systems. The use of a new information system approach for information storage and access is being investigated. This new system approach is termed a Hyperbase system. Hyperbase systems attempt to provide both dynamic access to information and ease of use. Hyperbase systems are considered to be very appropriate for loosely-structured textual information.

The principal interest addressed by this research involves the appropriateness of a Hyperbase system approach for storage and retrieval of audit working papers. The ability of the Hyperbase system to affect the efficiency and effectiveness of audit-related decision making is being investigated.

A hypothetical set of audit working papers is stored in the Hyperbase system. The system user is asked to review the audit working papers contained in the Hyperbase system. The objective of the review is for the auditor to determine the level of risk exposure for the entity represented in the working papers.

As a participant in the experiment you are being asked to provide three sets of data. Your personal demographics will be collected through a written questionnaire for the first data set. The second data set is the use and risk determination from reviewing the working papers in Hyperbase format. Audit-related multiple choice question responses will provide the third set of data. At your option, comments regarding the study can be made on the last section of this packet.

Your participation in this experiment is greatly appreciated. Your conscientious input in this experiment is vital to the success of this research project. All collected data is considered to be strictly confidential. Analysis performed will only be referenced by an assigned participant code number that is strictly random and only known by the principal research investigator.

Thank you for participating in this study. Your firm will be provided a summary of the results of this study for your interest.

Sincerely,

Thomas E. Marshall  
University of North Texas  
Business Computer Information Systems Dept.  
Denton, Texas (817) 565-3110

PERSONAL DEMOGRAPHICS

Any information provided will be held strictly confidential. Complete and accurate information is important to the integrity of the study.

1. Age: \_\_\_\_\_
2. Gender (circle one)            Male    Female
3. Number of years with present firm \_\_\_\_\_  
     Prior affiliation with another CPA firm (number of years) \_\_\_\_\_
4. Your present job position \_\_\_\_\_  
     Number of years in your present position \_\_\_\_\_
5. Number of years of audit experience \_\_\_\_\_
6. Specialty areas of professional interest \_\_\_\_\_
7. Undergraduate degree \_\_\_\_\_  
     Major \_\_\_\_\_  
     Minor \_\_\_\_\_
8. Semester courses beyond undergraduate \_\_\_\_\_  
     Graduate degree (if any) \_\_\_\_\_
9. Approximate number of university courses related to computers \_\_\_\_\_
10. Professional certification(s) with year received (CPA, CMA, CISA) \_\_\_\_\_
11. Approximate days of firm-supported training beyond basic staff training in the areas of:  
     Accounting/Auditing \_\_\_\_\_  
     Computers \_\_\_\_\_
12. Do you make internal control evaluations as a regular part of your work? (circle one) Yes No
13. Do you routinely use computers as a part of your job function? (circle one) Yes No
14. If you do routinely use computers as a part of your job function, what kinds do you use?  
     Mainframes    Yes No,            If yes what kind(s) \_\_\_\_\_  
     Minicomputers Yes No,        If yes what kind(s) \_\_\_\_\_  
     Microcomputers Yes No,      If yes what kind(s) \_\_\_\_\_
15. Do you use a computer? (circle one) Yes No
16. If you use computers, indicate all of the software/hardware types used. (indicate with a check)  
     Dumb terminal            \_\_\_\_\_  
     IBM PC or clone        \_\_\_\_\_  
     Mouse devices           \_\_\_\_\_  
     Spreadsheet             \_\_\_\_\_  
     Word Processor         \_\_\_\_\_  
     Database                \_\_\_\_\_  
     Graphics                \_\_\_\_\_  
     Electronic Mail        \_\_\_\_\_  
     Communications        \_\_\_\_\_  
     Other(s) (list)         \_\_\_\_\_

## TASK ASSIGNMENT

Your task is to provide an assessment of the level of preliminary control risk for certain assertions of accounts (Accounts Receivable and Sales) in the revenue cycle.

The assertions of these accounts involve the:

- a) Existence and Rights (Ownership)
- b) Completeness
- c) Valuation - Gross Value
- d) Valuation - Realizable Value.

Control risk level is to be assigned a value, defined below, of:

- a) Maximum
- b) Moderate
- c) Low.

You may assign a level of risk to an assertion at any time during your review of the audit workpapers. However, you must assign a risk level to each assertion before exiting the Hyperbase system Audit Case.

## CASE ENVIRONMENT:

Assume the following:

### Audit Firm

You are an auditor with the firm of Thomas and Thomas. Thomas and Thomas follows the planning procedures outlined in SAS 55 and the audit guide of the same name (Consideration of the Internal Control Structure in a Financial Statement Audit). These planning procedures call for a preliminary control risk assessment after gaining an understanding of the control structure for each major transaction cycle. This preliminary control risk assessment is made before any tests of control procedures are carried out and evaluated. In fact, the preliminary control risk assessment is made assuming that the subsequently planned tests of controls will not find any deviations from the client's control structure. Based on this preliminary control risk assessment, the detailed audit program of tests of controls and substantive test procedures is prepared (or modified from the prior year audit program).

Thomas and Thomas has found that it is most efficient to assess the control risk for each assertion for each major financial component as Maximum, Moderate, or Low.

The following definitions are from the Thomas and Thomas audit manual:

Control risk - The risk that a material misstatement that could occur in an assertion will not be prevented or detected on a timely basis by an entity's internal control structure policies or procedures.

Maximum control risk - The greatest probability that a material misstatement that could occur in a financial statement assertion will not be prevented or detected on a timely basis by an entity's internal control structure. Substantive audit procedures will be used exclusively to gain audit assurance as to those assertions whose control risk is assessed as maximum.

Moderate control risk - The moderate probability that a material misstatement that could occur in a financial statement assertion will not be prevented or detected on a timely basis by an entity's internal control structure. Audit assurance as to those assertions whose control risk is assessed as moderate can come from substantive audit procedures, or a combination of substantive audit procedures and test of control audit procedures. It is up to the auditor to select the combination of audit procedures that are most efficient and effective.

Low control risk - The lowest probability that a material misstatement that could occur in a financial statement assertion will not be prevented or detected on a timely basis by an entity's internal control structure. Audit assurance as to those assertions whose control risk is assessed as low will normally come primarily from test of control audit procedures with limited substantive audit procedures. The substantive audit procedures would normally be analytical procedures.

### Client

The client is Vinco, Inc., a domestic wine distributor, whose stock is listed on the New York Stock Exchange. Vinco has been a client of your firm for several years. Past experience has indicated generally good segregation of duties and few audit adjustments. Vinco's documentation of controls has been extensive and complete. However, on past audits there were areas where weaknesses in the control structure were found.

Vinco processes all accounting transactions on a mainframe computer with centralized data processing. The data processing department has 27 personnel. The Revenue System is on-line entry, batch update, with on-line query capability.

The in-charge senior for Vinco, Paul Harmon, was competing in a triathlon last weekend and had a serious bicycle accident. You have been asked to go through Vinco's workpapers and prepare the preliminary control risk assessment for the assertions of the major accounts in the Revenue Cycle. The following workpapers are provided for your evaluation:

<u>Workpaper Reference</u>	<u>Workpaper Title</u>
C-10	Control Environment Questionnaire
R-20	Control Procedures Questionnaire - Order Entry Function
R-30	Control Procedures Questionnaire - Shipping Function
R-40	Control Procedures Questionnaire - Billing Function
R-50	Control Procedures Questionnaire - Cash Receipts Function
R-60	Control Procedures Questionnaire - Collection Efforts Function
G-10	Computer General Control Procedures Questionnaire (partially completed)

The questionnaires are standard forms used by Thomas and Thomas to document the auditor's understanding of the control structure (white text on a blue background).

The answers and the notes that apply specifically to Vinco appear as white text on black background.

In order to make this research case realistic, yet one you can solve in a reasonable time, the questionnaires are designed to be illustrative only and therefore may not cover every issue you would desire.

## HYPERBASE TABLE OF CONTENTS

<u>WP Ref.</u>	<u>ASPECT</u>	<u>ATTRIBUTE</u>
C-10,	Assigning Authority and Responsibility	Data Processing Entity
	Board of Directors & Audit Committee	Entity - 1 Entity - 2 Entity - 3
	External Influences	Entity - 1
	Internal Audit Function	Entity - 1 Entity - 2
	Management Control Methods	Data Processing Entity - 1 Entity - 2 Entity - 3
	Management Philosophy	Operating Style - 1 Operating Style - 2 Operating Style - 3
	Organizational Structure	Accounting and Data Processing Entity
	Personnel Policies and Practices	Entity - 1 Entity - 2 Entity - 3
G-10,	Computer Background Information	Applications Computer Organization and Management-1 Computer Organization and Management-2 Computer Organization and Management-3 Hardware and Systems Software - 1 Hardware and Systems Software - 2
	Computer General Control Procedures	Access to System Resources - 1 Access to System Resources - 2 Access to System Resources - 3 Application Development Application Maintenance - 1 Application Maintenance - 2 Computer Operations
R-20,	Control Procedures Questionnaire	Order Entry Function - 1 Order Entry Function - 2 Order Entry Function - 3
R-30,	Control Procedures Questionnaire	Shipping Function
R-40,	Revenue Cycle	Billing Function - 1 Billing Function - 2 Billing Function - 3 Billing Function - 4 Billing Function - 5
R-50,	Control Procedures Questionnaire	Cash Receipts Function - 1 Cash Receipts Function - 2
R-60,	Revenue Cycle	Collection Efforts Function

## HYPERBASE MANUAL

YOU ARE ENCOURAGED TO REFER TO THESE DESCRIPTIONS AS YOU GO THROUGH THE TUTORIAL CASE AND THE AUDIT CASE.

### Hyperbase Introduction

The audit workpapers (questionnaires) have been loaded into this Hyperbase system. Hyperbase systems allow the user to access information in a variety of ways. Text is placed in data records (Hypercards) with the user able to access the information records comparable to pages in a book. The workpapers have been organized into ASPECTS and ATTRIBUTES. ASPECTS are comparable to conventional chapters in a book with ATTRIBUTES being sections or subsections within a chapter. For example:

ASPECT:	Assigning Authority and Responsibility
ATTRIBUTES:	1) Entity
	2) Data Processing
	3) Accounting

Beyond this the user can select to view only Hypercards that contain a specified key word group. This dynamic access is termed a Hyperlink.

Thus, the Hyperbase system provides you with the ability to review the workpapers as if they were spread out on your desk. However, Hyperbase makes you more efficient in finding specific workpapers on specific items in a workpaper set. Using the Hyperbase system you can access the Vinco workpapers in the following ways:

1. Read the workpapers from the first through the last (sequentially, using ASPECT and ATTRIBUTE Down Arrows)
2. Skip around in the workpapers based on your desire to view certain items:
  - a. By ASPECTS and/or ATTRIBUTES (using the pull down menu, TABLE OF CONTENTS in the menu line).
  - b. By key word groups (key word groups are highlighted in white in the body of the Hypercard text).

You may return to view a workpaper (or portion thereof) or key word group as many times as you desire. Further, an online note pad is available at your command to make memo notes of your analysis (using the COMMENTS command).



### Hyperbase Login

You must log in before you are allowed access to the Hyperbase system. When asked for the USER ID please enter the Packet ID number found in the upper right corner on the envelope of the packet. You are limited to one login session, therefore please plan on completing the task in one session.

### Hyperbase Tutorial

In order to familiarize you with the Hyperbase commands, a tutorial case has been incorporated into the Hyperbase system. It is essential to the research that you become familiar with the Hyperbase system of accessing information BEFORE YOU START THE AUDIT CASE. Therefore, use this tutorial until you are familiar with all of the Hyperbase commands. In the tutorial case you are asked to assign officers of the Starship Enterprise to tasks. After completion of the tutorial case, please begin the Audit Case review which contains the workpapers for Vinco. Again, you are only allowed into the Audit case one time.

### Hyperbase Commands

Commands can in general be identified by their Bright-white color. Commands appear at the bottom of the screen on a command line. A command of this type is "active" when it turns Blue-on-white while the cursor is over it. When "active" the command can be invoked by pressing the RETURN key or the Left mouse button a single time; pressing a mouse button is referred to as a "click."

Refer to Hyperbase Screen Layout on Section III, page 10.

### Cursor Movement and Command Selection

Cursor movement can be controlled by using any combination of keyboard arrow keys or the mouse device.

#### 1) Mouse device

- a) Left mouse button click is interpreted as a RETURN (i.e., Selection).
- b) Right mouse button click is interpreted as an ESCAPE (i.e., Abort).

#### 2) Keyboard device

- a) F1 key moves the cursor between menus.
- b) Keyboard Arrow keys move the cursor within the current menu.
- c) RETURN key selects the currently activated command.
- d) ESCAPE key aborts the currently selected command.

PULLDOWN MENU Commands

The keyboard or the mouse can be used to position the cursor over the desired command. Pressing the RETURN key or Left mouse button (click) exercises the command.

Positioning the mouse cursor over the following will invoke the actions described:

<u>Mouse Control</u>	<u>Action</u>
<b>Down Arrow</b> -	click moves hi-light bar down one item. Causes scroll at bottom of pulldown menu.
<b>Up Arrow</b> -	click moves hi-light bar up one item. Causes scroll at top of pulldown menu.
<b>X</b> -	click cancels pulldown. (see "Cancel Menu").
<b>Select Item</b> -	click over an item selects that item.
<b>Cancel Menu</b> -	click outside of pulldown menu box, or right button click.
<b>First Line</b> -	click while cursor on top line moves to first item.
<b>Last Line</b> -	click while cursor on bottom line moves to last item.

Using the keyboard keys invokes the following actions:

<u>Keyboard Control</u>	<u>Action</u>
<b>Down Arrow</b> -	moves hi-light bar down one item. Causes scroll at bottom of pulldown menu.
<b>Up Arrow</b> -	moves hi-light bar up one item. Causes scroll at top of pulldown menu.
<b>Select Item</b> -	RETURN key over an item selects that item.
<b>Cancel Menu</b> -	ESCAPE key.

TABLE OF CONTENTS

- 1) Press RETURN key or Left click mouse over TABLE OF CONTENTS command on menu line. The menu line is the bottom line on the screen.  
  
Select ASPECT of interest by pressing RETURN or clicking Left mouse on item.  
Note: ATTRIBUTES are displayed under the ASPECT in a separate window box.
- 2) To get a table of contents of only aspects or only attributes, press RETURN or Left click mouse over vertical ASPECT / ATTRIBUTE vertical bars on right side of screen outside of text body.

NOTES

Press RETURN key or Left click mouse over Bright-white "NOTE" in the body of text for additional information regarding the individual questionnaire topic.

### RISK ASSESSMENT

Press RETURN key or Left click mouse over RISK ASSESSMENT command on menu line.

This command displays the current task solution on the top of the screen. On the lower half of the screen, the user is provided with PULL DOWN menus to:

- first, select an assertion, and
  - second, select a risk level to assign to the assertion.
- (note: these two actions alternate the cursor location between the two menu boxes. The current input menu box is signified by a Hot-pink border.)

### HELP

This command displays the text included in this section of the packet online. HELP allows the user to select either Textual help or Graphical help. Textual Help provides a narrative description of the Hyperbase system. Graphical Help provides a schematic description of the Hyperbase system.

Refer to Hyperbase Screen Layout on Section III, page 10.

### QUIT (Hyperbase Logout)

This command is used to exit Hyperbase (and the Audit case). Exercising QUIT will cause the current task solution to be displayed before prompting you to confirm the QUIT request. You will not be allowed to quit the Audit case until you have assigned a control risk assessment for each assertion.

### HYPERLINK

Press RETURN key or Left click mouse over activated Bright-white text (key word group) within body of workpapers.

Note: The TABLE OF CONTENTS appears in a window displaying the ASPECTS and ATTRIBUTES containing that key word group. You can then select items from this table of contents to view. Only records containing the selected HYPERLINK key word group will be available while the HYPERLINK is in effect.

Cancel HYPERLINK by pressing RETURN or Left clicking on CANCEL HYPERLINK on menu line.

### COMMENTS

An online notepad (text editor) is available to make memo notes during your case analysis.

### PROFESSIONAL EXAMINATION QUESTIONS

Please answer the following questions by clearly writing your answer next to the question.

- 1) When evaluating the effect of a client's computer processing in an audit of financial statements, auditors need **NOT** consider the
  - A) organizational structure of the computer processing activities.
  - B) differences in audit standards for computer auditing.
  - C) computer-assisted audit techniques to increase the efficiency of audit procedures.
  - D) need for specialized skills.
  
- 2) Control risk assessment when a computer is used would **NOT** involve
  - A) identifying specific control procedures designed to achieve the control objectives.
  - B) identifying the general control procedures which must function for an identified specific control procedure to be effective.
  - C) evaluating the design of control procedures to determine control risk.
  - D) performance of specific tests of control audit procedures.
  
- 3) In computer systems the general control procedures would **NOT** include
  - A) processing (application) control procedures.
  - B) segregation of various computer system functions.
  - C) documentation of the data processing system.
  - D) control over physical access to computer hardware.
  
- 4) In computer systems the processing (application) control procedures would **NOT** include
  - A) run-to-run totals.
  - B) master file changes.
  - C) file and operator controls.
  - D) limit and reasonable tests.
  
- 5) The data base administrator should **NOT** have the following responsibility:
  - A) program the applications in the data base.
  - B) design the content and organization of the data base.
  - C) protect the data base and software.
  - D) monitor the performance of the data base management system.

- 6) In micro-minicomputer systems the most important aspect for auditors to consider is the
- A) audit techniques.
  - B) computer technology.
  - C) control environment.
  - D) computer software.
- 7) In micro-minicomputer systems the processing control procedures would **NOT** include
- A) transaction logs.
  - B) control totals.
  - C) balancing input to output.
  - D) on-line editing and sight verification.
- 8) An auditor's approach to computer systems that consists of using visible evidence such as input source data and machine-produced error listing is referred to as auditing
- A) around the computer.
  - B) through the computer.
  - C) without the computer.
  - D) with the computer.
- 9) The reprocessing of live data to test program controls is called
- A) test data.
  - B) integrated test facility.
  - C) generalized audit software.
  - D) parallel simulation.
- 10) Techniques needed to select specific live data transactions of audit interest for testing would **NOT** include
- A) audit hooks.
  - B) test data.
  - C) trap doors.
  - D) transaction tags.
- 11) Generalized audit software could **NOT** be used for the following audit task
- A) test calculations and make computations.
  - B) evaluate control risk assessment.
  - C) summarize, resequence and reformat data.
  - D) compare audit evidence from manual audit procedures to company needs.

- 12) The processing phase of using generalized audit software would **NOT** include
- A) coding the application design into specific computer language.
  - B) verifying that the status of the client file has not changed.
  - C) obtaining a copy of the client file.
  - D) reviewing results and updating working papers.
- 13) Methods of limiting access to computer resources to prevent computer abuse would **NOT** include
- A) definition of duties.
  - B) department identification number.
  - C) access-code passwords.
  - D) analytical review of output.
- 14) Batch control totals are used as a basic method for detecting data input errors. Which of the following is **NOT** a batch control?
- A) Financial totals.
  - B) Check-digit totals.
  - C) Hash totals.
  - D) Document-count totals.
- 15) As compared to large computers, which of the following is **NOT** an advantage of small business computer systems (user-controlled systems)?
- A) Faster program development.
  - B) Productivity increases.
  - C) More affordable.
  - D) More efficient programs.
- 16) In a real-time sales order processing system, a salesperson enters inventory part numbers on a terminal, and the system retrieves and displays the corresponding part name for the salesperson to review. This is an example of:
- A) Record confirmation check.
  - B) Inclusion of verifying (redundant) data.
  - C) Data approval test.
  - D) Record identification tests.

- 17) An independent auditor considers an entity's internal control structure. The auditor's consideration includes two phases: (1) an understanding of the control structure and (2) tests of controls. The latter phase might include which of the following?
- A) Examination of systems flowcharts to determine whether they reflect the current status of the system.
  - B) Examination of the systems manuals to determine whether existing procedures are satisfactory.
  - C) Examination of the computer log to determine whether control information is properly recorded.
  - D) Examination of organization charts to determine whether electronic data processing department responsibilities are properly separated to afford effective control.
- 18) Auditors often make use of computer programs that perform routine processing functions such as sorting and merging. These programs are made available by electronic data processing companies and others and are specifically referred to as:
- A) User programs.
  - B) Compiler programs.
  - C) Supervisory programs.
  - D) Utility programs.
- 19) Where computers are used, the effectiveness of the control environment depends, in part, upon whether the organizational structure includes any incompatible function combinations. Which of the following is MOST incompatible in a computer environment?
- A) Documentation librarian and manager of programming.
  - B) Programmer and computer operator.
  - C) Systems analyst and programmer.
  - D) Processing control clerk and key-entry supervisor.
- 20) When erroneous data are detected by computer program controls, such data may be excluded from processing and printed on an error report. The error report should most probably be reviewed and followed up by the:
- A) Supervisor of computer operations.
  - B) Systems analyst.
  - C) EDP control group.
  - D) User department submitting the transactions.

- 21) Which of the following is a **detective** control?
- A) Well-designed terminal screens for input.
  - B) Personnel training.
  - C) Well-designed input source documents.
  - D) Verification of input.
- 22) The check digit is used to prevent transposition errors in input of:
- A) Amount fields.
  - B) Identification number fields.
  - C) Quantity fields.
  - D) Description fields.
- 23) The data dictionary is a documentation tool designed to provide a standard definition for all data elements (fields), segments (records), and data bases (files). Which of the following information is **NOT** included in the data dictionary?
- A) Input validation (edit) considerations.
  - B) Owner.
  - C) Security.
  - D) Pointers to the next record.
- 24) After a preliminary phase of the understanding of a client's computer control structure, an auditor may decide not to perform tests of controls related to the control procedures within the computer portion of the client's internal control system. Which of the following would **NOT** be a valid reason for choosing to omit tests of controls?
- A) The control procedures appear adequate.
  - B) The control procedures duplicate operative controls existing elsewhere in the system.
  - C) There appear to be major weaknesses that would preclude reducing control risk based on the control procedure.
  - D) The time and dollar costs of testing controls exceed the time and dollar savings in substantive testing if the tests of controls (compliance tests) show the controls to be effective.



- 25) The primary purpose of a generalized audit software package is to allow the auditor to
- A) Use the client's employees to perform routine audit checks of the electronic data processing records that otherwise would be done by the auditor's staff accountants.
  - B) Test the logic of computer programs used in the client's electronic data processing systems.
  - C) Select larger samples from the client's electronic data processing records than would otherwise be selected without the generalized program.
  - D) Independently process client electronic data processing records to extract information necessary for substantive testing.
- 26) System programmers create a unique control problem because of their regular duties. Which of the following is **NOT** a regular duty of system programmers?
- A) Maintain the security system.
  - B) Handle all technical matters relating to installation and maintenance.
  - C) Transform system specifications into source statement program instructions.
  - D) Keep abreast of the technical aspects of new product offerings.
- 27) The purpose of the check or parity bit is
- A) To insure that bits are not lost or gained in the transfer of data from one storage location to another.
  - B) To prevent transposition of digits on identification numbers when data entry occurs.
  - C) To make sure the eight bit coding of data conforms to either the ASCII or other standard coding system.
  - D) To keep the two nodes in sequence in data telecommunications.
- 28) One of the procedures accomplished by **task management** in the operation system is to determine if the printer is busy. If the printer is not free, the output is formatted into a "print image" and routed to disk storage for later printing. This technique is called:
- A) Interrupt Handling.
  - B) Spooling.
  - C) Dynamic Allocation.
  - D) Relative Addressing.

- 29) One of the exposures when the microcomputer is used as a terminal is that data transmitted may be captured by a competitor. Which of the following controls would **NOT** reduce this exposure?
- A) Encryption of data.
  - B) Password entry into the system.
  - C) Documentation of procedures with periodic updates.
  - D) Call-back procedures.
- 30) The purpose of the results stub in a decision logic table used for test data design purposes is:
- A) It documents the conditions that lead to a particular action.
  - B) It shows the rule for different conditional values.
  - C) It shows the expected results for the test data used for each rule.
  - D) It shows the actions to be taken when a rule is violated.

**APPENDIX E**  
**STATISTICAL HYPOTHESIS TABLE**

Statistical Hypothesis	Variable	Observation Type -Metric	Statistical Test
H1: There is a difference in task accomplishment between groups delineated by level of task domain knowledge.	Information Acquisition	Process	
		-Duration	ANOVA
		-Activity	ANOVA
		Performance	
		-Duration	ANOVA
		-Activity	ANOVA
		-Depth	ANOVA
-Sequence	ANOVA		
	Task Solution	Effectiveness	
		-Quality	ANOVA Chi-Square
H2: There is a difference in task accomplishment between groups delineated by task presentation treatment effects.	Information Acquisition	Process	
		-Duration	ANOVA
		-Activity	ANOVA
		Performance	
		-Duration	ANOVA
		-Activity	ANOVA
		-Depth	ANOVA
-Sequence	ANOVA		
	Task Solution	Effectiveness	
		-Quality	ANOVA Chi-Square
H3: There is a difference in task accomplishment between groups delineated by the interaction effects of level of task domain knowledge and task presentation treatment effects.	Information Acquisition	Process	
		-Duration	Two Way ANOVA
		-Activity	Two Way ANOVA
		Performance	
		-Duration	Two Way ANOVA
		-Activity	Two Way ANOVA
		-Depth	Two Way ANOVA
-Sequence	Two Way ANOVA		
	Task Solution	Effectiveness	
		-Quality	Two Way ANOVA

**APPENDIX F**  
**STATISTICAL ANALYSIS TABLES**

Assessed Task Domain Knowledge Base	Code
Computer Audit Specialist - General	CASG
Computer Audit Specialist - Specific	CASS
Computer Audit Specialist - Overall	CAS
Computer - General	CG
Computer - Specific	CS
Computer - Overall	C
Computer Audit Specialist and Computer - Overall	K

TABLE F.1

ALL ASPECT DURATION BY DOMAIN KNOWLEDGE LEVEL  
ANOVA P-VALUES

Aspect	CASS	CASG	CAS	CS	CG	C	K	Signif Count
1	.116	.232	.226	.085	.160	.117	.262	1
2	.441	.522	.972	.579	.602	.643	.587	0
3	.808	.638	.371	.740	.480	.916	.274	0
4	.773	.225	.073	.335	.043	.252	.195	2
5	.335	.113	.212	.822	.797	.511	.021	1
6	.779	.142	.466	.365	.236	.283	.152	0
7	.424	.116	.115	.217	.078	.327	.048	2
8	.117	.481	.372	.221	.438	.207	.297	0
9	.916	.246	.295	.529	.189	.513	.700	0
10	.142	.530	.024	.006	.124	.016	.071	4
11	.758	.419	.159	.016	.360	.035	.137	2
12	.209	.115	.025	.031	.234	.027	.020	4
13	.308	.152	.127	.157	.210	.113	.123	0
14	.560	.128	.115	.554	.055	.346	.400	1
15	.325	.522	.143	.861	.310	.708	.081	1
Signif Count	0	0	3	4	3	3	5	18

TABLE F.2  
ALL ASPECT ACTIVITY BY DOMAIN KNOWLEDGE LEVEL  
ANOVA P-VALUES

Aspect	CASS	CASG	CAS	CS	CG	C	K	Signif Count
1	.912	.030	.444	.428	.819	.419	.591	1
2	.472	.981	.332	.374	.392	.318	.492	0
3	.336	.089	.172	.167	.191	.235	.321	1
4	.888	.569	.812	.590	.468	.531	.856	0
5	.396	.465	.257	.169	.474	.401	.377	0
6	.231	.524	.642	.645	.226	.728	.936	0
7	.127	.341	.391	.478	.829	.182	.497	0
8	.567	.969	.888	.835	.853	.918	.669	0
9	.576	.481	.838	.616	.802	.930	.698	0
10	.370	.688	.341	.135	.997	.483	.694	0
11	.950	.644	.330	.035	.151	.407	.351	1
12	.999	.577	.203	.321	.004	.948	.270	1
13	.381	.431	.793	.015	.669	.299	.470	1
14	.431	.512	.861	.068	.858	.264	.580	1
15	.474	.092	.116	.387	.090	.201	.317	2
Count	0	3	0	3	2	0	0	8

TABLE F.3  
IS PROCEDURES AND USE BY KNOWLEDGE DOMAIN GROUPS  
ANOVA P-VALUES

Knowledge Domain	System Time	TOC Count	TOC Time	Records Viewed	Payne's Index	% of Case Viewed	Audit Time
CASG	.401	.912	.579	.480	.151	.109	.320
CASS	.716	.266	.859	.533	.903	.615	.932
CAS	.280	.332	.837	.929	.157	.065	.131
CG	.540	.263	.650	.950	.379	.229	.312
CS	.222	.692	.379	.284	.008	.008	.193
C	.246	.587	.257	.700	.269	.176	.179
K	.154	.931	.869	.965	.426	.224	.095
Count	0	0	0	0	1	2	1



TABLE F.4

## EXPERIMENTAL TREATMENT GROUP BY ASPECT ACTIVITY AND DURATION

## ANOVA P-VALUES

Aspect	Experimental Treatment Group		Signif Count
	Activity	Duration	
1	.268	.216	0
2	.491	.982	0
3	.438	.627	0
4	.821	.555	0
5	.572	.808	0
6	.832	.316	0
7	.383	.497	0
8	.915	.844	0
9	.733	.219	0
10	.884	.757	0
11	.117	.408	0
12	.242	.105	0
13	.156	.165	0
14	.579	.360	0
15	.660	.701	0
Count	0	0	0

TABLE F.5  
 EXPERIMENTAL TREATMENT GROUP BY IS PROCEDURES AND USE  
 ANOVA P-VALUES

Operational Metric	Group	Significance Count
Elapsed time in experimental system (seconds)	.501	0
Table of Contents procedure envocations (count)	.161	0
Elapsed time using Table of Contents (seconds)	.327	0
Number of records viewed (count)	.982	0
Audit task space viewed (percentage)	.840	0
Elapsed time in Audit Case (seconds)	.296	0
Sequence of Information Acquisition (Payne's Index) ( +1 = Maximum Aspect Search ) ( -1 = Maximum Attribute Search )	.765	0
Significance Count	0	0

TABLE F.6  
 EXPERIMENTAL TREATMENT GROUP BY TASK SOLUTION QUALITY  
 ANOVA P-VALUES

Task Solution Component	Group	Significance Count
Existence and Ownership	.776	0
Completeness	.983	0
Valuation - Gross Value	.113	0
Valuation - Realizable Value	.197	0
Total Solution	.748	0
Significance Count	0	0

TABLE F.7

EXPERIMENTAL TREATMENT GROUP BY TASK SOLUTION QUALITY  
PEARSON'S CHI-SQUARE LEVELS OF SIGNIFICANCE

	Accounting Assertion				Overall Task Solution
	Existence and Rights	Completeness	Valuation-Gross Value	Valuation-Net Value	
Experimental Treatment Group	.3865	.6551	.2686	.1604	.9109
Significance Count	0	0	0	0	0

TABLE F.8

ASPECT BY TASK DOMAIN KNOWLEDGE AND EXPERIMENTAL TREATMENT GROUP

## TWO-WAY ANOVA P-VALUES

Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Aspect 3, External Influences				
Computer Audit Specialist - General	Activity	.015	.322	.008
Aspect 11, Control Procedures Questionnaire - Computer Operations				
Computer - Specific	Duration	.006	.275	.071
Aspect 12, Control Procedures Questionnaire - Shipping Function				
Computer - Specific	Duration	.005	.172	.015
Computer - Overall	Duration	.009	.182	.029

TABLE F.9

IS PROCEDURES AND USE BY TASK DOMAIN KNOWLEDGE  
AND EXPERIMENTAL TREATMENT GROUP

## TWO-WAY ANOVA P-VALUES

Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
	Percentage of Case Viewed			
Computer - Specific	Depth	.000	.442	.000
	Payne's Navigation Index			
Computer - Specific	Sequence	.002	.979	.030

TABLE F.10

TOTAL SOLUTION QUALITY BY TASK DOMAIN KNOWLEDGE  
AND EXPERIMENTAL TREATMENT GROUP

## TWO-WAY ANOVA P-VALUES

Total Assessment Solution				
Knowledge Domain	Metric	Significance		
		K-Domain	Group	Interaction
Computer Audit Specialist - General	Quality	.066	.632	.582

TABLE F.11

**ASPECT BY TASK DOMAIN KNOWLEDGE AND  
EXPERIMENTAL TREATMENT GROUP**

**TWO-WAY ANOVA P-VALUES**

Aspect 1 - Assigning Authority and Responsibility				
Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Computer Audit Specialist - General	Activity	.019	.184	.530
Computer - Specific	Duration	.043	.148	.134

Aspect 3 - External Influences				
Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Computer Audit Specialist - General	Activity	.015	.322	.008

Aspect 5 - Management Control Methods				
Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Computer Audit Specialist and Computer	Duration	.039	.749	.546

Aspect 10 - Computer General Control Procedures				
Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Computer - Specific	Duration	.003	.866	.173
Computer - Overall	Duration	.011	.992	.326
Computer Audit Specialist - Overall	Duration	.057	.848	.305

## Aspect 11 - Control Procedures Questionnaire - Computer Operations

Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Computer - Specific	Activity	.022	.085	.242
Computer - Specific	Duration	.006	.275	.071
Computer - Overall	Duration	.015	.250	.220

## Aspect 12 - Control Procedures Questionnaire - Shipping Function

Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Computer - Specific	Duration	.005	.172	.015
Computer - Overall	Duration	.009	.182	.029
Computer Audit Specialist - Overall	Duration	.018	.134	.279
Computer Audit Specialist and Computer	Duration	.022	.166	.573

## Aspect 13 - Revenue Cycle - Billing Function

Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Computer - Specific	Activity	.010	.122	.320

## Aspect 14 - Control Procedures Questionnaire - Cash Receipts

Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Computer - Specific	Activity	.035	.455	.154
Computer - General	Duration	.068	.278	.679

TABLE F.12

IS PROCEDURES AND USE BY TASK DOMAIN KNOWLEDGE  
AND EXPERIMENTAL TREATMENT GROUP

TWO-WAY ANOVA P-VALUES

Percentage of Case Viewed				
Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Computer - Specific	Depth	.000	.442	.000
Computer Audit Specialist - Overall	Depth	.094	.751	.676

Payne's Navigation Index				
Knowledge Domain	IS Metric	Significance		
		K-Domain	Group	Interaction
Computer - Specific	Sequence	.002	.979	.030

TABLE F.13

**TASK CONTENT BY ACTIVITY AND DURATION SIGNIFICANCE COUNT  
FOR ALL TASK DOMAIN KNOWLEDGE GROUPS**

**CHI-SQUARE ANALYSIS**

Task Content	Non-Significant Differences	Significant Differences	Total Possible
Environmental Information Aspects 1 - 9	118	8	126
Function-specific Information Aspects 10 - 15	66	18	84
Totals	184	26	210
Chi-Square			10.57
Significance Level (df 1)			< .005



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