THE EFFECTS OF TASK INTERRUPTION AND INFORMATION PRESENTATION ON INDIVIDUAL DECISION MAKING

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ABSTRACT

Research examining factors that influence decision-making performance has a rich tradition across multiple research disciplines. Very little of this research effort, however, has been directed at examining the influence of the decision making environment on performance. The environment of decision makers can be characterized as one with disjointed activities and frequent interruptions. Thus, an examination in an interrupted work environment would capture decision-making performance under more realistic environmental conditions than are typically examined.

The effect of different information presentation formats on decision-making performance has received a great deal of research attention. Cognitive Fit Theory suggests that a match between the information presentation format and the task processing requirements results in greater decision accuracy and time. Previous research suggests that decision makers rely on perceptual cues that are readily available when under environmental stress. For certain task types, the availability of perceptual cues may increase information retrieval accuracy when using graphs over tables regardless of the fit between the task and the presentation format. Therefore, it is anticipated that interruptions may moderate the relationship between the information presentation format and specific task types to affect decision accuracy and time.

Two experiments were performed to examine the influence of interruptions on decision-making accuracy and time. The first experiment examined the effects of interruptions on different task types and the interaction between task type and information presentation format. The first experiment was a 2 X 2 X 4 factorial design: work environment (no interruptions and interruptions), information presentation format (tables and graphs), and task type (simple-symbolic, simple-spatial, complex-symbolic and complex-spatial). The second experiment examined specific dimensions of an interruption to better understand their influence on performance. The second experiment was a 2 X 2 X 2 factorial design: interruption frequency (4 interruptions per task and 12 interruptions per task), interruption content (interruption similar to task and interruption dissimilar to task), and task type (complex-symbolic and complex-spatial). The dependent variables in both experiments were decision accuracy, decision time, and measures related to perceptions of the task and information used in the task.

Interruptions were generally found to facilitate the performance of simple tasks and inhibit the performance of complex tasks. Interruptions also moderated the relationship between information presentation formats and specific task types. Finally, some evidence was found for the inhibitory effects of interruption frequency and the similarity between task and interruption content.

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CHAPTER 1

INTRODUCTION AND RESEARCH PROBLEM

1.1 Introduction

> The economic challenge of the post-capitalist society will ... be the productivity of knowledge work and the knowledge worker. (Drucker, 1993, page 12)

Drucker's (1993) identification and acknowledgment of knowledge worker importance has mobilized research efforts in a number of disciplines to examine factors influencing knowledge worker effectiveness. A key component of knowledge work that has received a great deal of attention has been individual decision making (Davis and Olson, 1985; Drucker, 1993). Research streams in both Psychology and Management Information Systems (MIS) have investigated factors that influence individual decision-making performance (Payne, 1982; DeSanctis, 1984). Factors examined include individual differences, decision task characteristics, and information presentation formats.

The work environment of the knowledge worker is also a critical factor when examining the decision-making process (Cohen, 1980). The work environment in which many knowledge workers operate is characterized by unexpected telephone calls and colleagues walking into offices requesting information (Mintzberg, 1973; Kotter, 1982; Stephens, Ledbetter, Mitra, and Ford, 1992). These unexpected events frequently interrupt tasks on which knowledge workers are focusing. For example, Watson, Ranier, and Koh (1991) indicate that many executives are permitted very little uninterrupted time when using executive decision-support technologies. Interruptions, therefore, are the norm in the knowledge worker's environment rather than the exception (Mintzberg, 1973; Kurke and Aldrich, 1983).

Interruptions force decision makers to ration their cognitive resources across more than one task. This rationing can change the way tasks are performed (March, 1994) and the manner in which information is used (Baron, 1986). Ultimately, these changes can affect performance, resulting in decreased task recall accuracy (Schuh, 1978), increased time to solve problems (Shiffman and Griest-Bousquet, 1992), and decreased task accuracy (Cellier and Eyrolle, 1992).

Given the pervasive nature and possible detrimental influence of interruptions, it may be advantageous to build features into information systems to mitigate the effects of interruptions (Rouncefield, Viller, Hughes, and Rodden, 1995). One such feature that was examined in this research is information presentation formats. Different information presentation formats were examined to determine if certain formats facilitate recovery from interruptions.

The manner in which information is presented when interruptions occur has been shown to affect decision making. Interruptions encourage decision makers to focus their attention on information that is most readily available or stands out from other pieces of information (Berlyne, 1970). For example, information that is a novel stimulus is more likely to engage an individual's attention and be acted upon when recovering from an interruption. In the context of knowledge worker environments, information is often presented in either tabular or graphical formats. Graphs are higher in perceptual cues and enable a decision maker to apprehend more information in a given time frame than tables. Therefore, interruptions may result in decision makers using graphical information more accurately and quickly than tabular information.

Much of the prior research examining graphs and tables in decision making has been theoretically grounded in Cognitive Fit Theory (Vessey, 1991). Cognitive Fit Theory suggests that the effectiveness of a specific presentation format depends on the type of task being performed. Therefore, the influence of interruptions on decision-making performance must be examined across different types of tasks.

Examining the influence of interruptions on task performance is an important first step in this study. However, interruptions vary widely on a number of dimensions. For example, they have different characteristics (e.g., frequency and duration) and occur in different social contexts (e.g., who is being interrupted and who is the "interrupter"). Therefore, a necessary second step in understanding the influence of interruptions on decision-making performance, is to examine each of these characteristics independently and in association with other characteristics. The specific dimensions examined in this research study were interruption frequency and interruption content.

1.2 Research Questions

The objective of this research is to improve our understanding of the influence of interruptions on decision making. Specifically, the following research questions are investigated:

RQ1: *What is the effect of interruptions on the performance of certain types of tasks?*

RQ2: *When a decision maker is interrupted, do different information* *presentation formats facilitate decision-making performance on certain types of tasks?*

RQ3: *Does the frequency of interruptions affect decision-making performance on certain types of tasks?*

RQ4: *Does the content of the interruption affect decision-making performance on certain types of tasks?*

This research reports the results of two laboratory experiments addressed these questions. The experiments tested hypotheses developed from integrating theories on human cognitive processing, individual decision making, and information presentation into a testable research model.

1.3 Importance of the Research

This research is important from both theoretical and practical perspectives. Theoretical importance focuses on the way in which this research builds and tests theory. Practical importance focuses on the relevance of this research to practitioners.

1.3.1 Theoretical

This research has two objectives: 1) to construct and evaluate a theory for understanding the effects of interruptions on decision-making performance, and 2) to extend the theoretical understanding of the influence of information presentation formats on decision-making performance to different environmental contexts. Together, these objectives will make a significant contribution to the current theoretical understanding of interruptions.

Prior research has not examined extensively the influence of interruptions on decision making. This research effort developed an overall theoretical model that supported the creation and building of testable hypotheses (Dubin, 1978). In addition, specific dimensions of interruptions (frequency and content) were examined empirically to better understand their influence on performance.

Vessey (1991) has laid the foundation for examining the effects of information presentation on decision making in developing Cognitive Fit Theory. Extending this foundation to include existing conditions in the work environment is also important (Vessey and Galletta, 1991). It has also been suggested that Cognitive Fit Theory needs to address more complex tasks than has been examined to date (Vessey, 1994; Vessey and Galletta, 1991; Wilson and Addo, 1994). This research, consequently, will examine the role of task complexity in decision making by examining how different information presentation formats influence both simple and complex tasks under interrupted conditions.

Well-defined streams of research examining information presentation formats have been developed in both the MIS and Human Factors areas. These areas have developed independently without any cross-fertilization, yet share similar theoretical underpinnings and results. These two information presentation streams will be integrated in this dissertation as an effort to bridge these two research areas.

1.3.2 Practical Importance

Improving knowledge worker productivity is an important management issue. Time management books are filled with prescriptions about minimizing interruptions by holding phone calls and directing administrative personnel to intercept potential interruptions (Sethi, Caro, and Schuler, 1987). In addition, technological innovations such as answering machines and e-mail filters have provided decision makers with tools to mitigate the influence of interruptions. To date, however, there is limited empirical research examining the effect of interruptions on decision-making performance. Should this research study demonstrate the deleterious effects of interruptions on decision making, it might encourage organizations to designate certain time as "interruption-free" to allow decision makers to work on important tasks.

Unfortunately, prescriptions for minimizing interruptions cannot always be realized. Nor can all interruptions be removed from the workplace all the time. Therefore, it is important to examine factors that might help a decision maker to recover when the inevitable interruptions occur. Information is a critical component in decision making, as is the way it is presented. Examining the effect of information presentation formats on decision making with interruptions will, therefore, be one focus of this research.

The results from this research will influence the design of decision aids. For example, information presentation formats are an important component of decision support systems (DSSs). Results from this study may suggest the use of specific information formats to improve decision accuracy and decision time when certain tasks are interrupted. Findings from this research may provide guidance to MIS personnel and end users in developing individual and organizational DSSs and executive information systems.

1.4 Structure of the Dissertation

This chapter outlined the general nature of the problem area examined in this research study. The remaining chapters proceed as follows.

Chapter 2, *Significant Prior Research on Individual Decision Making* contains three sections examining relevant prior literature. The first section reviews the importance of knowledge workers and their work environment.

Section 2 reviews factors that influence individual decision making. Finally, Section 3 describes the way in which information presentation influences decision-making performance.

Chapter 3, *Theory Development on Interruptions, Research Model, and Propositions* develops theory related to interruptions. A theoretical research model guiding this research is also presented, as are propositions derived from the model. Section 1 examines the influence of interruptions on cognitive processing. Section 2 describes characteristics of interruptions and develops a framework as a basis for guiding research in this area. Section 3 presents the general research model and propositions.

Chapter 4, *Research Methodology and Hypotheses,* describes the research approach taken to address the issues under examination and the conduct of the laboratory experiments. Independent, dependent, and control variables are described, as is the manner in which these variables were operationalized, measured, or controlled. The hypotheses tested in the laboratory experiments are also presented.

Chapter 5, *Analytical Procedures and Results,* presents the statistical procedures used to assess each dependent measure and the results of the experiments.

Chapter 6, *Discussion of Results,* interprets the meaning of the results with respect to the theory examined. Practical implications of the findings are also presented.

Chapter 7, *Limitations, Future Directions, and Conclusions,* reviews the limitations of this study, presents suggestions for future research, as well as a summary of the most salient results.

CHAPTER 2

SIGNIFICANT PRIOR RESEARCH ON INDIVIDUAL DECISION MAKING

This section describes significant prior research related to individual decision-making performance. This section is divided into four sub-sections focusing on 1) the knowledge worker environment, 2) individual decision making, 3) information presentation research, and 4) a chapter summary. Prior research examining knowledge workers indicates that improving knowledge worker productivity is a critical concern of managers. Further, knowledge worker environments are where most business-oriented individual decision making events occur and must be understood to better influence productivity. The second section describes important issues related to individual decision making. The third section describes the research stream examining the effects of different information presentation formats on decision making. Different information presentation formats influence decision-making performance under conditions of environmental stress and, therefore, are an important factor to examine in association with interruptions. This chapter concludes with a brief summary of the major findings.

2.1 Knowledge Workers and Work Environment

Work requirements in developed countries have facilitated the move from labor-intensive to information-intensive jobs over the last three decades. Manual labor represented 70 percent of the U.S. workforce in 1900, but had diminished to 30 percent by 1977, and to 25 percent by 1986 (Chase and Acquilano, 1995; Kelley, 1985; Porat, 1977). As the number and role of knowledge workers has grown, a great deal of interest has been placed on understanding their activities (Dahms, 1988; Kotter, 1982; Kurke and Aldrich, 1983; Mintzberg, 1973) and influencing their efficiency (Campbell, Dunnette, Lawler and Weick, 1970; Dahms, 1988; Drucker, 1993).

Davis, Webb Collins, Eierman, and Nance (1995) defined knowledge work as

> "consisting of one or more tasks involving human information processing in which the dominant activities:
> * are expected to generate useful information
> * depend on knowledge accessible by the individual performing the task
> * require significant attentional information processing" (processing that requires conscious mental attention and effort) page 10).

They indicate that knowledge workers are not defined by the position they hold, but by the work they perform. Therefore, all jobs involve knowledge work to some degree. Jobs that are considered to be high in knowledge work include those of a manager, engineer, professor, and marketing or financial analyst (Kelley, 1985; McLeod, 1990). Clerical workers may also have some components of knowledge work inherent in their jobs (Davis and Olson, 1985).

Gaining an understanding of the work environment is essential to improve knowledge-worker efficiency (Eierman, Niederman, and Adams, 1995). Mintzberg (1973) depicts knowledge work as consisting of fragmented activities that occur at an unrelenting pace. Others characterize knowledge work as consisting of a stream of interruptions. Early studies (Carlson, 1951; Guest, 1956; Stewart, 1967) depicted work days filled with disjointed activities and interruptions. Carlson (1951), examining the work life of managers, stated:

> "All they knew was that they scarcely had time to start on a new task or sit down and light a cigarette before they were interrupted by a visitor or a telephone call". (page 73-74).

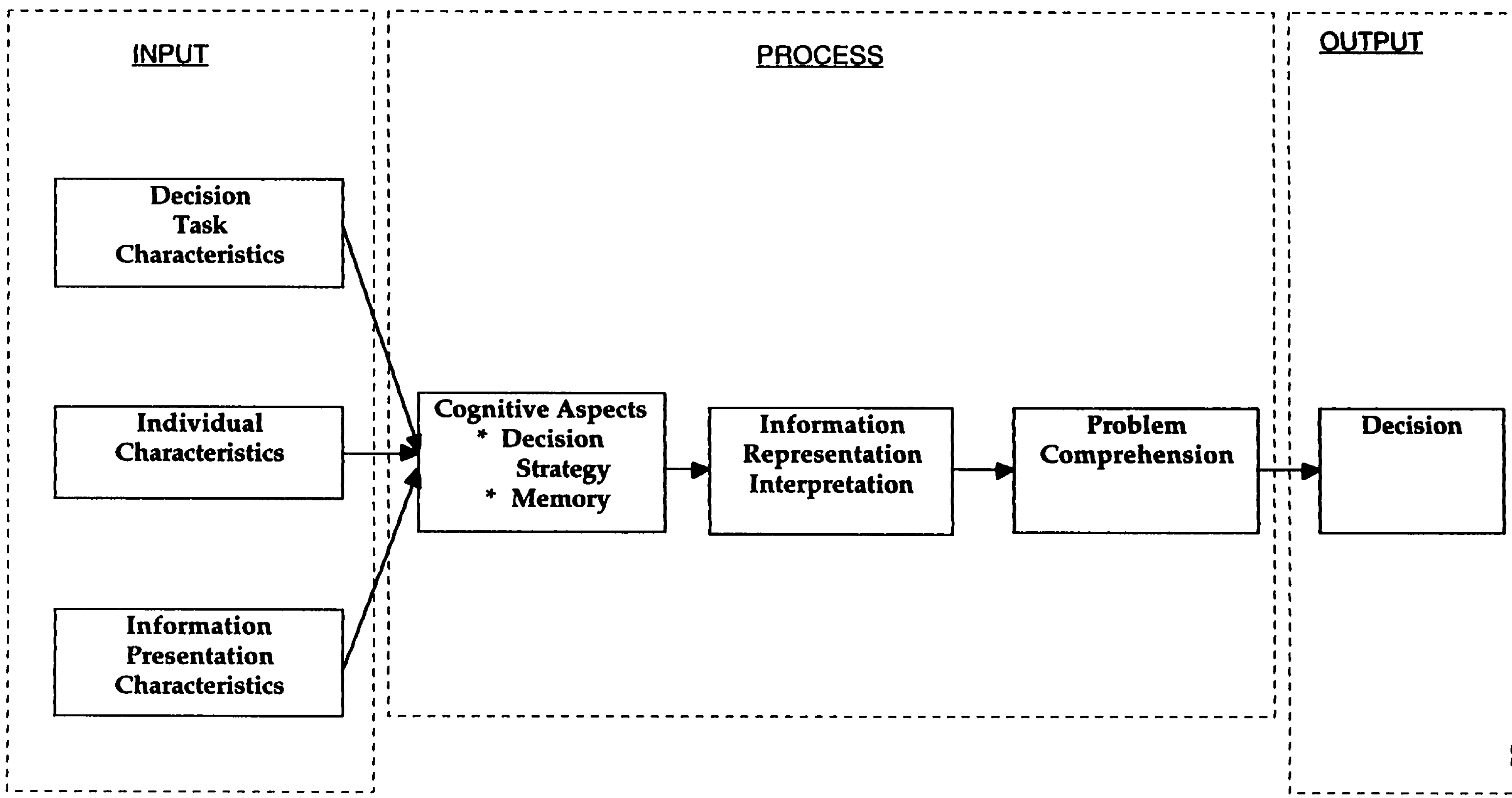
More recent studies continue to highlight the influence of interruptions on knowledge workers' activities. A comprehensive survey conducted by Dahms (1988) indicated that the third highest rated corporate time-waster was telephone interruptions, while drop-in visitors was tenth. Jones and McLeod (1986) implied that managers allow "disturbance handling" such as telephone interruptions to take precedence over other activities. Kelley (1985) suggested that the influence of the work environment (including interruptions) on decision making must be better understood to increase individual and organizational effectiveness.

2.2 Individual Decision Making

This section presents prior research examining characteristics that influence individual decision making. Decision task, individual, and information presentation characteristics (input) have main and interaction effects on an individual's cognitive processing (process) and therefore influence decision-making performance (output) (DeSanctis, 1984) (Figure 2-1). Each input characteristic and how the characteristics influence the decision-making process and decision performance are described in the sections below. Since information presentation characteristics are a critical component of this research study, prior research on this topic will be presented as a stand-alone section following this one. Consequently, this section will focus on describing relevant prior literature related to decision task and individual characteristics, two of the three primary input factors influencing the decision-making process and outcomes.

FIGURE 2-1

A Research Framework for Examining Information Presentation Formats in Decision Making (Adpated from DeSanctis, 1984)



2.2.1 Decision Task Characteristics

Task characteristics influence cognitive processing and therefore decision performance. Many different task characteristics have been identified as having the potential to influence performance. These factors include: task complexity (Campbell, 1988; Wood, 1986), task content (Cats-Baril and Huber, 1987), the degree of problem structure (Sanders and Courtney, 1985), and the number of available decision alternatives (Jarvenpaa, 1989).

Campbell (1988) characterizes task complexity along three different dimensions: 1) complexity as a psychological experience, 2) complexity as a task-person interaction, and 3) complexity as a function of objective characteristics. Complexity as a psychological experience can be assessed by measuring characteristics such as challenge, stimulation, or arousal (Taylor, 1981). Complexity as a task-person interaction has been assessed via a measure of difficulty (Huber, 1985), requirements relative to abilities (March and Simon, 1958), and cognitive demands (Campbell and Gingrich, 1986). Finally, task complexity as a function of objective characteristics have been assessed via multiple alternatives/multiple attributes (Payne, 1976), information interrelationships (Steinmann, 1976), and information load (Schroder, Driver, and Struefert, 1967). Campbell indicates that objective dimensions of tasks are directly related to overall task complexity as defined by four complexity attributes: 1) the presence of multiple decision-making paths; 2) the presence of multiple desired outcomes; 3) the presence of conflicting interdependence among paths to multiple outcomes; and 4) the presence of uncertainty among paths and outcomes. Campbell identified sixteen types of tasks based on the degree to which a task incorporates each complexity attribute and by the total number of attributes inherent in the task.

Campbell defined simple tasks as those that do not have any complexity attributes. Of the sixteen task types Campbell identified, decision tasks are a type of complex task that has optimal solutions. He also indicates there are differences in complexity across decision tasks based on the presence or absence of conflicting interdependence among the outcomes and by either the presence or absence of uncertainty.

The inherent complexity of a task has also been defined across two other dimensions: 1) information processing and information characteristics used in completing the task (Wood, 1986) and 2) the information processing sub-tasks used to complete the task (Einhorn and Hogarth, 1981). Wood identified three attributes that determine the inherent complexity of any task: 1) component complexity, 2) coordinative complexity, and 3) dynamic complexity. Component complexity is the number of information cues and distinct processing acts that must be performed to complete the task. It increases as the number of cues and acts increases. Coordinative complexity is a measure of the interdependency between processing acts performed in completing a task. It increases as the contingent relationship between acts increases. Dynamic complexity is a measure of the form of the relationship between inputs and final solution. Dynamic complexity increases when the relationship between inputs and the solution changes over time or when the relationship is difficult to identify.

Einhorn and Hogarth (1981) define decision-making tasks as consisting of three interrelated processing sub-tasks: 1) information acquisition, 2) information evaluation, and 3) feedback/learning. Information acquisition sub-tasks involve a search of the external environment and memory to access information to be used in a decision-making task. Information evaluation sub-tasks consist of the strategy selected by a decision maker to manipulate and/or interpret information and complete a decision. Feedback or learning sub-tasks allow decision makers to learn from information acquisition and evaluation processing to improve their overall task performance. Simple tasks consist of predominantly information acquisition sub-tasks, while more complex tasks involve information acquisition and information evaluation (Vessey, 1994). Learning subtasks are an ongoing component of simple and complex decision-making tasks and will not be examined in this research.

Finally, Campbell (1988) indicates that two factors influence performance on complex tasks in addition to the task complexity attributes presented above (see Figure 2-2). First, decision makers establish goals and develop strategies that influence task performance. Prior experience may influence goal and strategy development. Based on the complexity attributes, goals, and strategy development, a strategy is formed to complete the task based on which performance can be measured. Accordingly, the strategy used to make a decision can significantly influence performance. Second, the perceived task complexity a decision maker experiences is based on his/her familiarity with the task, computational ability, etc. Therefore, different decision makers will experience different levels of complexity based on their individual experiences and characteristics.

Research has not been undertaken to fully describe the interaction between specific complexity attributes, decision processing strategy, and decision performance. Therefore, a categorization of task types with varying degrees of task complexity and processing strategies are described which guide the theoretical development of task complexity (see Figure 2-3).[1] In general, a feasibly-solvable (FS) task has low levels of each of the complexity factors. A

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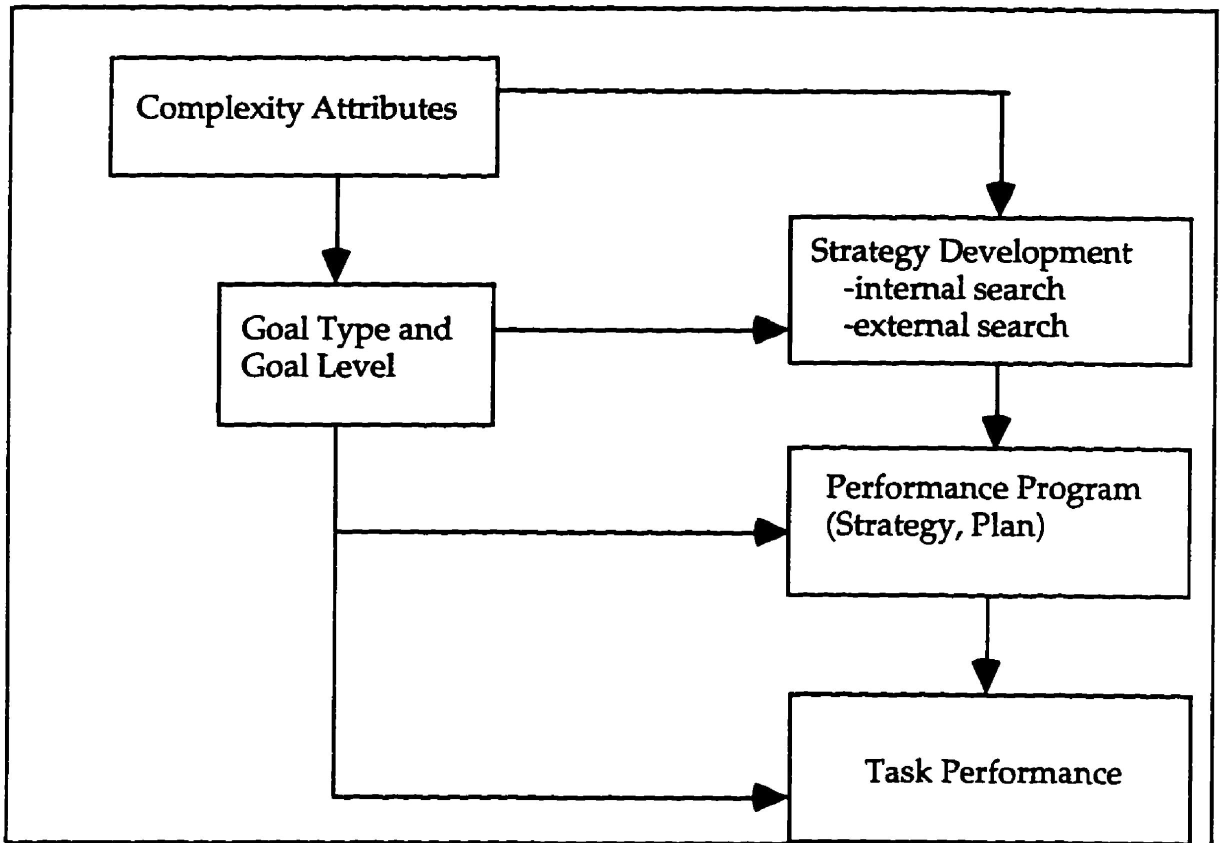
[1] The caterorization of task types based on complexity has received a great deal of conceptual and theoretical attention. However, very little empirical work has been conducted to isolate the attributes and strategies of specific task types.

Figure 2-2

Relationships Between Task Complexity, Goals,

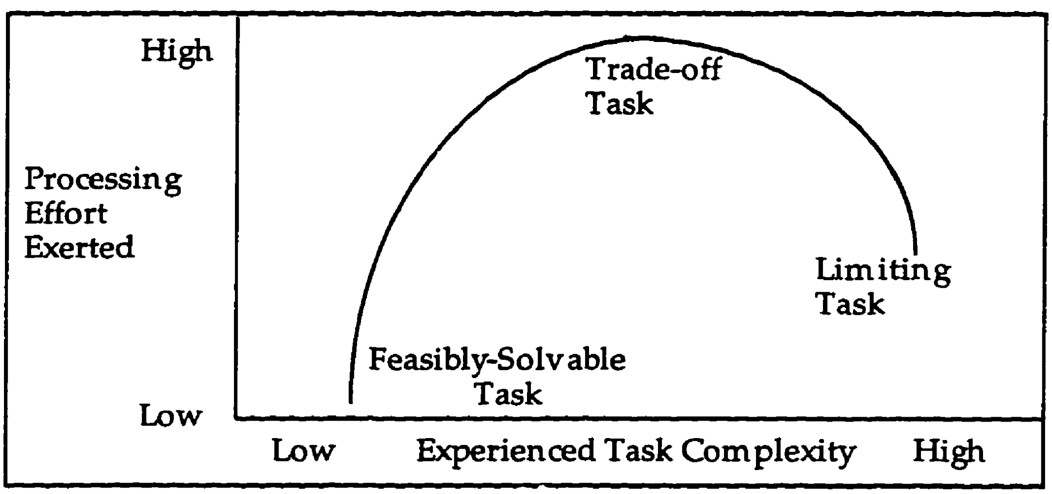
Strategy, and Performance



Campbell (1988)

decision maker would be able to solve this type of complex task type optimally given adequate time and problem-solving knowledge. As complexity increases, a decision maker is likely to expend increased effort to solve a problem. Cost-benefit theory suggests that as the effort required to solve a problem increases, decision makers may change their goal of optimally solving the task. They would most likely change their processing strategy to trade-off accuracy for time (Johnson and Payne, 1985). A trade-off task, therefore, is one that has reached a certain level of complexity and the decision maker may choose to have a less than optimal solution to save effort and therefore, time completing the task. Finally, limiting tasks are at the high end of the inherent task complexity continuum and the effort required to solve such tasks optimally is likely to be beyond the cognitive abilities of the decision maker. Processing effort exerted is likely to be lower on this task type as the decision maker resorts to less effective strategies. Decision makers are typically unable to solve this type of problem without processing assistance, and may cease processing prior to task completion. Hence, decision makers will not complete limiting tasks or will complete them non-optimally by making a best guess estimate.

Figure 2-3
Framework Describing the Processing of Complex Tasks



The discussion of task complexity and different processing strategies, above, focused on unaided decision makers. Computers are being used increasingly to support decision makers, particularly in solving complex problems. Decision support systems (DSSs) perform certain processing operations that would, in an unaided environment, be performed by the decision maker. The use of a DSS, therefore, will reduce the experienced complexity of a specific problem. For example, a task that might be considered to be limiting without a decision aid may fall into the feasibly-solvable task range with the use of a DSS.

2.2.2 Individual Characteristics

The model of decision making presented in Figure 2-1 (DeSanctis, 1984) identifies decision maker characteristics as influencing decision-making performance. Table 1 presents an extensive list of user characteristics that have been examined in prior research (developed from a review of empirical DSS work conducted by Ramamurthy, Premkumar, and King, 1992). These characteristics can be broadly characterized as: 1) personal and demographic; 2) cognitive style and cognitive ability; and 3) personality. Ramamurthy, et al., (1992) found that intelligence, cognitive style, system experience, and domain experience are important user characteristics related to decision accuracy and decision time. Alavi and Joachimsthaler (1992), however, using meta-analysis techniques, found that these user characteristics provide very little explanation of DSS performance.

Given that prior literature reports equivocal support for individual differences, we consider three individual characteristics that appear to be particularly relevant to this research and are described in the following paragraphs: cognitive ability, domain expertise, and gender. In this study, information will be presented using different formats, including both spatial and tabular representations. Spatial orientation measures an individual's ability to perceive spatial patterns in data (Ekstrom et al., 1976). It is important to address because individuals can differ markedly in their spatial abilities. Greater spatial orientation ability implies greater working memory capacity for handling spatial patterns of information. Loy (1991) identified the importance of measuring spatial ability in explaining performance differences on decision tasks.

Table 2-1

User Characteristics Associated with Decision-Making Performance*

User Characteristic Examined	Selected References
Personal and Demographics	
Domain Experience	Benbasat and Schroeder (1977); Taylor and Dunnette (1974);
Domain Expertise	**Ramamurthy, King, and Premkumar (1992); Mackay and Elam (1992)**
System Experience	**Ramamurthy, King, and Premkumar (1992); Mackay and Elam (1992)**
Intelligence	**Loy (1991); Ramamurthy, King, and Premkumar (1992),**
Gender	Silverman (1970); **Ramamurthy, King, and Premkumar (1992)**
Age	Nutt (1986); Taylor,(1975)
Attitude	**Barki and Huff (1985)**; Lucas (1978)
Education	Lucas (1978); Nutt (1986)
Cognitive Style and Cognitive Ability	
Sensing-Intuitive	Hollingsworth (1986); **Ramamurthy, King, and Premkumar (1992)**
Thinking-Feeling	Hollingsworth (1986); **Ramamurthy, King, and Premkumar (1992)**
Field Dependent-Independent	Benbasat and Taylor (1979), **Pracht and Courtney (1988)**
Cognitive Complexity	Driver and Mock (1975); Struefert (1970)
Analytic-Heuristic	Lucas (1975); Mock (1973)
Personality	
Extrovert-Introvert	**Ramamurthy, King, and Premkumar (1992)**; Wynne (1979)
Locus of Control	Nutt (1986); **Parasurman and Igbaria (1990)**
Machiavellianism	Christie and Geis, 1970
Ambiguity	Nutt, 1986
Risk Propensity	Henderson and Nutt, 1980

*Bold References indicate that the research was conducted with the use of an electronically supported DSS

Domain expertise is also an important variable in explaining decision performance. Mackay and Elam (1992), for example, found that subjects with both problem domain and decision support tool expertise had the highest decision accuracy and decision time on a complex task. In addition, Ramamurthy, King, and Premkumar (1992) identified domain expertise as an important explanatory variable when examining decision support system effectiveness.

Finally, gender is an important variable in explaining differences in decision performance, especially with regard to spatial ability. Males generally outperform females in visualization and spatial ability. (See McGee, 1979 for an extensive discussion). In addition, Silverman (1989) indicates that when performing tasks, females are more easily distracted than males.

2.3 Information Presentation

This section describes prior literature examining the influence of information presentation on decision making. As indicated in Figure 2-1, information presentation characteristics are a critical input for understanding the processing and outcomes of decision making. Research investigating the influence of different information presentation formats on decision making dates back to the 1920s. At that time, statisticians became interested in comparing the performance of different graphical formats such as bar graphs and pie charts (Croxton and Stein, 1932; Eells, 1926; Von Huhn, 1927). Continued research effort examining the effects of information presentation on individuals can be seen in a range of disciplines including MIS, consumer behavior, and cognitive science.

Differences in information presentation formats affect information recall and decision-making performance (Bettman and Kakkar, 1977; Bettman and Zins, 1979). In addition, pictorial representations are held for a longer period of time in short-term memory, facilitating the use of graphs over tables (Anderson, 1980; Nickerson, 1965). Features of the decision-making task and information formats used to perform the task influence the processing of information, and therefore, affect decision accuracy and time. The effects of information presentation on decision making have been heavily researched in the MIS discipline. The following discussion provides a brief review of the research stream in this area.

The early 1980s brought a proliferation of graphics capabilities via PC-based business applications. Along with this increase in capabilities came an increase in research examining the effects of graphical formats on decision performance (Ives, 1984; DeSanctis, 1984; Benbasat and Dexter, 1985). This research stream has led to the widely-shared belief that the effectiveness of a specific presentation format depends on the task that is being performed (Benbasat and Dexter, 1985; Benbasat, Dexter, and Todd 1986; Coll, Coll and Thakur, 1994; DeSanctis, 1984; Dickson, DeSanctis, and McBride, 1986; Jarvenpaa and Dickson, 1988; Tan and Benbasat, 1990; Vessey, 1991; Vessey and Galletta, 1991). This wealth of empirical evidence indicates that symbolic formats (e.g., tables) result in better performance when completing a symbolic task (e.g., extracting a specific value); spatial formats (e.g., graphs), on the other hand, result in improved performance when completing a spatial task (e.g., examining relationships between variables or deciphering trends) (Vessey, 1991).

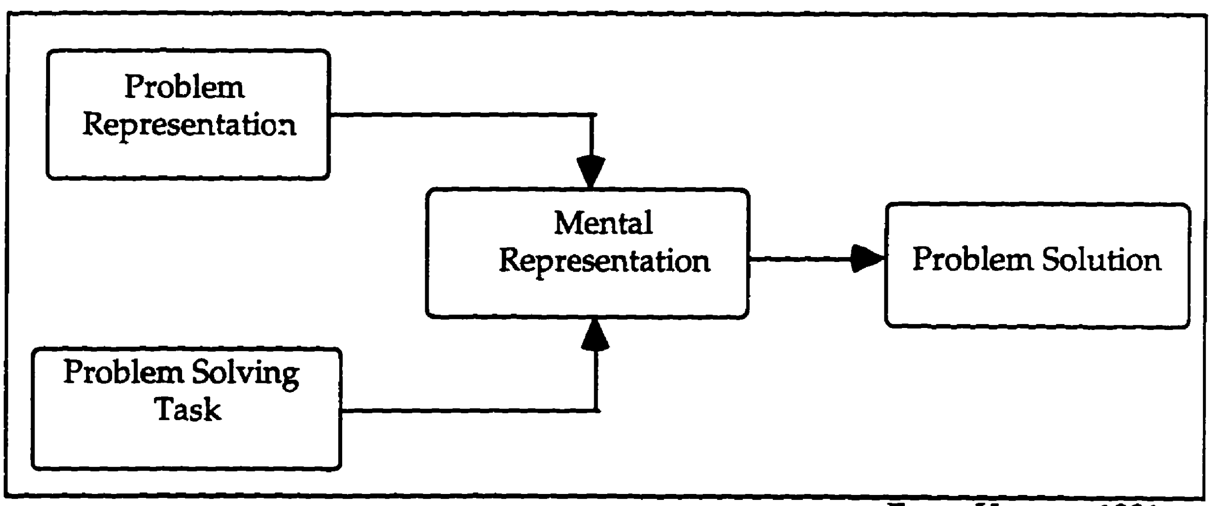
The first section examines Cognitive Fit Theory, which is an identifiable research stream in the Information Systems research discipline. The second section describes information presentation research appearing in the Human Factors literature. Finally, the third section describes the moderating influence of environmental stressors, such as interruptions, on information presentation formats and decision making.

2.3.1 *Cognitive Fit Theory*

Vessey's (1991) Cognitive Fit Theory provides a theoretical grounding for the expected differences in performance across information presentation formats (Figure 2-4). Different presentation formats represent the same information in different ways. When information is presented in the same format as needed to process a specific task (e.g., a spatial representation (graphs) to solve a spatial problem), a match, or cognitive fit occurs. Cognitive fit facilitates decision making as the type of process needed to solve the problem is the same as that used to act on the problem representation. This fit results in the least possible cognitive effort expended to interpret the information. On the other hand, when the information presentation format does not match the task, an individual must exert cognitive effort to transform the information into a usable form. This increased effort will result in decreased performance, specifically, a decrease in decision accuracy and/or time.

Figure 2-4

Problem Solving Model Based on Cognitive Fit



From Vessey, 1991

Both Cognitive Fit Theory (Vessey, 1991) and Tan and Benbasat's (1990) taxonomy for matching information presentation and the decision task have focused on simple tasks. These simple tasks typically involve information acquisition subtasks and can be defined as acquiring a specific data value (a symbolic task) or comparing multiple data values (a spatial task). Vessey and Galletta (1991), Tan and Benbasat (1990) and Vessey (1994) suggest that future research needs to extend current theory by examining more complex tasks.

Complex tasks involve information evaluation sub-tasks in addition to the information acquisition sub-tasks (Einhorn and Hogarth, 1981). Vessey further indicated that these evaluation sub-tasks, like the simple information acquisition sub-tasks, can be either symbolic or spatial in nature. Vessey theorized that Cognitive Fit Theory should apply to the previously defined feasibly-solvable complex tasks when all the sub-tasks (information acquisition and evaluation) are either all symbolic or all spatial. Trade-off tasks are tasks for which decision makers (most commonly) are prepared to save considerable time, and therefore, effort, at the expense of a slight loss in accuracy. When spatial formats support spatial trade-off tasks, trade-off is unnecessary as graphs facilitate fast problem solving; hence cognitive fit also applies. The best format for symbolic trade-off tasks depends on the task performance requirements. When accuracy is required, symbolic trade-off tasks are best supported by symbolic formats. Where accuracy is not essential, symbolic trade-off tasks are best supported by spatial formats, which facilitate substantial time savings with only a slight loss in accuracy.

Limited prior research examines empirically the relationship between information presentation format and task complexity on performance (Addo, 1989; Davis, 1986; Wilson and Addo, 1994). Wilson and Addo (1994) found that the tenets of Cognitive Fit Theory held for simple-symbolic and simple-spatial tasks. However, as complexity increased, there was no significant difference in decision accuracy when using tables and graphs for either type of task. The use of graphs with complex tasks, however, resulted in decreased decision time for both spatial and symbolic tasks, possibly indicating trade-off.

The results of this study suggest that for complex tasks, graphs and tables result in comparable decision accuracy. However, graphical information allows decision makers to work more quickly. These results demonstrate the need to extend and test Cognitive Fit Theory to include complex tasks.

2.3.2 Human Factors Research

Research in the human factors area has also examined issues related to the influence of information presentation on decision making. Findings from this research stream identify similar tenets to Cognitive Fit Theory (Vessey, 1991) (Table 2-2). The principle of "compatibility of proximity" (Boles and Wickens, 1987; Wickens and Andre, 1990) provides an organizing framework for understanding the relationship between information presentation formats and cognitive processing.

Table 2-2

Comparison of MIS and Human Factors Research Examining Information Presentation

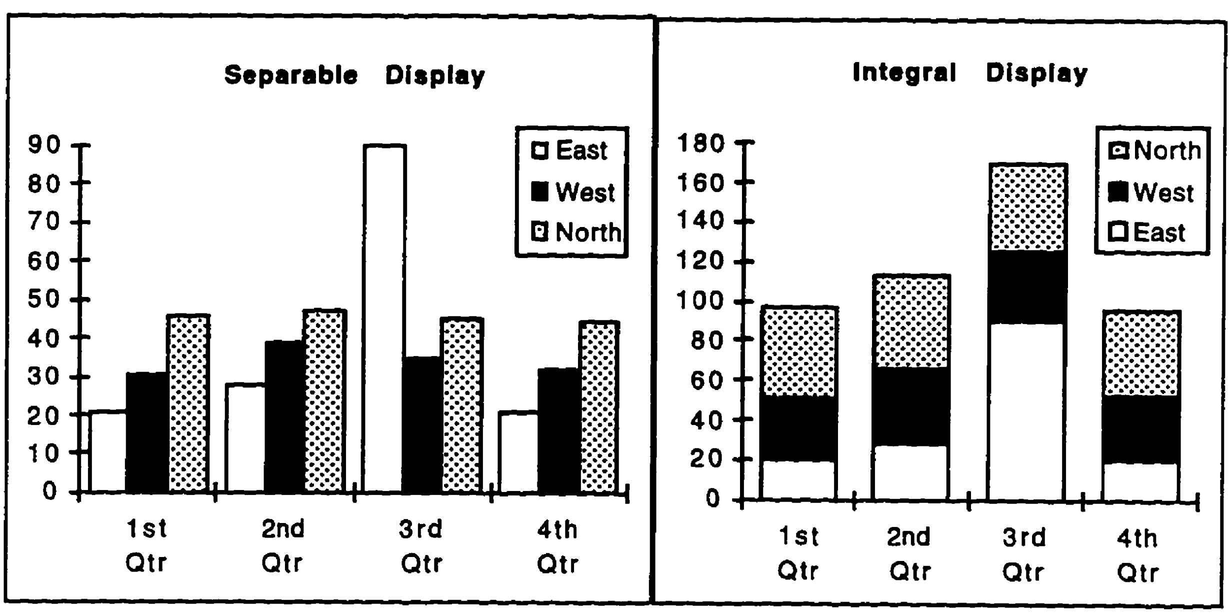
	MIS Research Stream	Human Factors Research Stream
Theoretical Basis	Cognitive Fit Theory * symbolic information for symbolic tasks * spatial information for spatial tasks	Principle of Compatibility of Proximity * separable display for selective information * integral display for divided attention
Information Formats	symbolic (tables) spatial (graphs)	separable {depends on information integral in display}
Task Type	symbolic spatial	selective attention divided attention

Information presentation formats are defined as either separable or integral (Garner, 1974). Separable displays retain their perceptual identity and require independent processing of each element in the display (Bennett and

Flach, 1992). Integral display dimensions are defined "as occurring when a level of one dimension cannot be specified without specifying the level of another dimension" (Garner, 1974) (page 354). An integral display does not directly correspond to a specific type of information format. A given format is considered to be integral based on the information therein (Bennett and Flach, 1992). For example, Figure 2-5 illustrates two bar chart displays, one with separable dimensions and one with integral dimensions. A decision task might request a decision maker to determine the third quarter sales in the North region. This value (approximately 45) can be acquired from the separable display without having to examine other information components (Goettl, Wickens, and Kramer, 1991). On the other hand, an integral display forces a decision maker to look at other information components. To acquire the Northern region's third quarter sales in the integral display, the third quarter sales for the West must also be examined.

Figure 2-5

Examples of Separable and Integral Displays



Information can be used for two different types of tasks; those that require selective attention and those that require divided attention. Selective attention is needed for tasks that require processing a single aspect of the data at the exclusion of all other data. Based on the graphs in Figure 2-5, a selective attention task would be "What is the third quarter sales in the North region?" Divided attention is required to integrate information across multiple dimensions of the data (Bennett and Flach, 1992; Goettl, Wickens and Kramer, 1991; Pomerantz and Pristach, 1989). A divided attention task would be "What is the total third quarter sales across all regions?" These task types are directly comparable to symbolic and spatial tasks in Cognitive Fit Theory.

The proximity compatibility principle states that when information presentation dimensions are grouped together (integral display), selective attention to one dimension is difficult, but dividing attention across dimensions is facilitated. This principle is comparable to Cognitive Fit Theory where spatial formats are best for supporting spatial tasks. On the other hand, selective attention is made easier by separable dimensions, but divided attention is inhibited (Pomerantz and Pritach, 1989). This portion of the principle is also comparable to Cognitive Fit Theory where symbolic formats best support symbolic tasks. The proximity compatibility principle argues that a display format (integral versus separable) should be selected based on the type of processing that is to occur (Andre and Wickens, 1990; Goettl, Wickens, and Kramer, 1991). This principle is very consistent with Cognitive Fit Theory in that it proposes a match between the type information and task processing.

2.3.3 Information Presentation and Environmental Stress

In addition to examining more complex tasks, Cognitive Fit Theory should be extended across different environmental conditions, specifically to conditions with limited time availability (Vessey and Galletta, 1991). Although little empirical work has been performed in this area, existing research may indicate that Cognitive Fit Theory, as it has been empirically validated, does not fully explain existing empirical findings.

Because interruptions are as an important component of knowledge worker environments, it is important to understand the moderating effect interruptions might have on the relationship between information presentation and decision-making performance. The effects of interruptions and information presentation on decision-maker performance has not been examined previously. However, research has been conducted examining the effects of limited time availability and information presentation on decision makers. Both limited time availability and interruptions can induce stress in decision makers (Laird, Laird, and Fruehling, 1983; Kroemer, Kroemer, and Kroemer-Elbert, 1994). Likewise, both interruptions and limited time availability increase the decision maker's drive to respond to the work situation (Baron, 1986). It is likely, then, that the performance effects seen in research studies examining limited time availability might extend to the influence of interruption on decision performance.

Studies examining environmental conditions have focused on limited time availability and increased information load. Coury and Boulette (1992) found that when decision makers have limited time available, they rely on whatever perceptual cues are available in the data. Results suggest that tabular data results in decreased decision accuracy because individuals experience greater difficulty finding and processing information. Graphs and pictorial representations were processed more quickly due to the more readily available perceptual cues and greater information retention. Schwartz and Howell (1985) found that when decision makers perform complex tasks, graphical displays resulted in increased decision accuracy and time when time was limited. Neither information presentation format provided a statistically significant advantage when ample time was available. These findings suggest that individuals using graphs might be able to recover from work interruptions more quickly than those using tables.

2.4 Chapter Summary

Knowledge workers perform a myriad of activities and decision-making tasks are a primary aspect of many jobs. Research in decision making has found that characteristics of the task, the individual, and the information format used in the task all interact to influence cognitive which affects decision accuracy and time. Furthermore, research examining information presentation has determined that specific information formats facilitate performance on specific types of decision-making tasks.

Spatial information presentation formats represent information in such a way as to facilitate retention and provide more conspicuous information cues than tabular data. Therefore, individuals using spatial presentation formats might make decisions more quickly and accurately when interrupted than individuals using symbolic formats, regardless of the type of task being undertaken. A summary of the prior literature is presented in Table 2-3.

Table 2-3
Summary of Prior Literature

Key Concept	Section Summary
Knowledge Workers	* Decision making a primary component of job * Interruptions are a common aspect of knowledge worker environment
Individual Decision Making	* Task complexity is an important characteristic to examine * Individual characteristics of the decision maker are also important
Information Presentation	* Symbolic information facilitates solving symbolic tasks * Spatial information facilitates solving spatial tasks * Spatial information formats facilitate retention and may better support decision makers who experience interruptions for certain tasks

CHAPTER 3
THEORY DEVELOPMENT ON INTERRUPTIONS, RESEARCH MODEL, AND PROPOSITIONS

This section develops a general theory related to the influence of interruptions on individual decision making and presents a general research model and the propositions derived from it. The first section examines the influence of interruptions on cognitive processing and distinguishes between distractions and interruptions. The second section consists of a detailed examination of interruption characteristics and presents a framework for conceptualizing interruptions is presented. The third section presents propositions describing the influence of interruptions and information presentation on performance of intellective decision tasks.

3.1 Effects of Interruptions on Cognitive Processing

This section first defines interruptions and then presents a normative description of the effects of interruptions on cognitive processing. The distinctions between distractions and interruptions are presented and empirical results related to the study of distractions and interruptions are described.

3.1.1 Interruptions

Webster (1995) defines an interrupt as:

> 1: to stop or hinder by breaking in, 2: to break the uniformity or continuity of, 3: to break in upon an action, esp: to break in with questions.

Note that this general definition would be an appropriate description of not only human interruptions, but also a computer-related processing interrupt. Corragio (1990) employed a more specific definition related to human cognitive processing:

> "An interruption is an externally-generated, randomly occurring, discrete event that breaks continuity of cognitive focus on a primary task" (pg. 19)

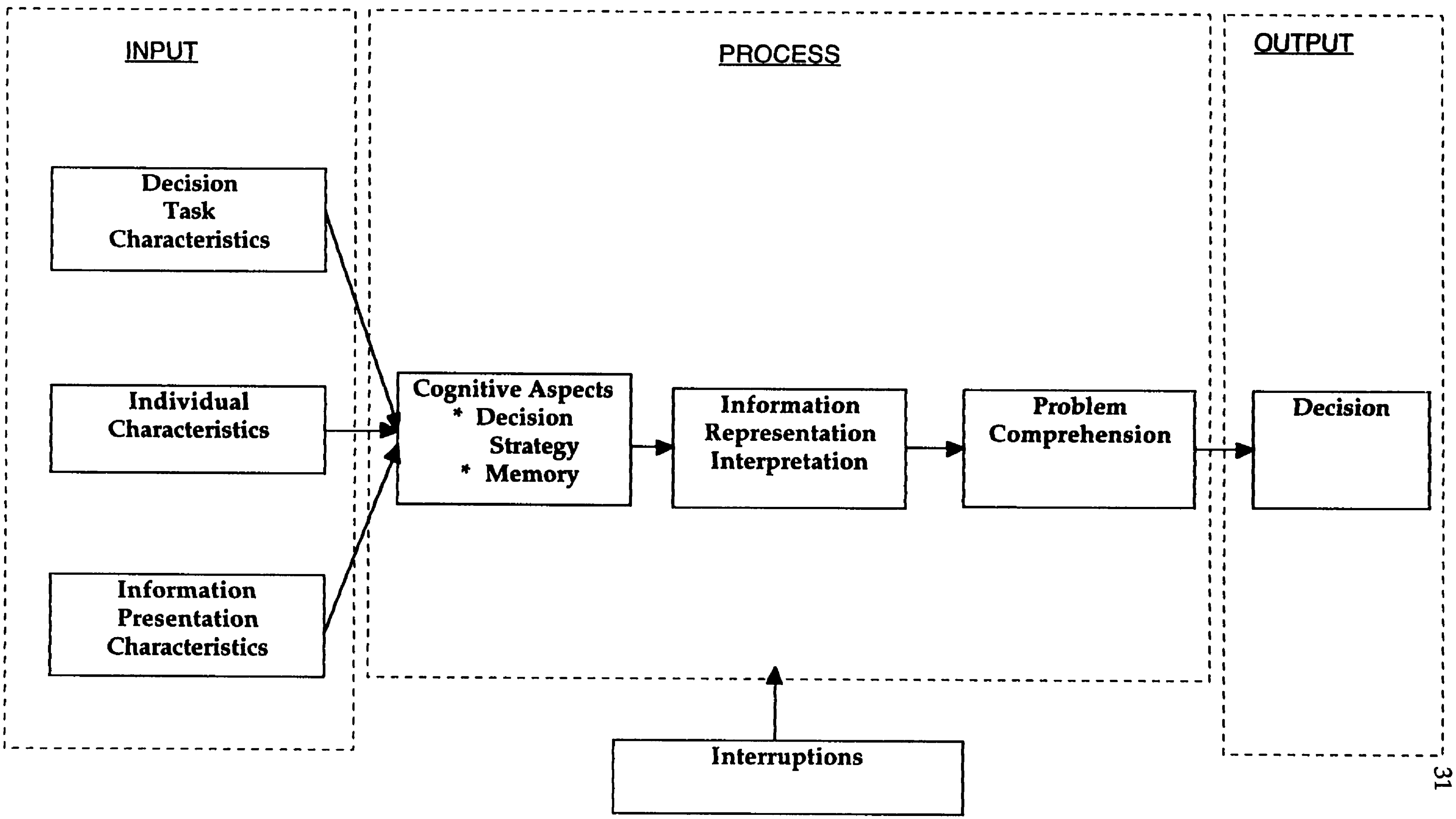
This definition implies that an interruption is created by another person or event and is beyond the control of the individual. The random nature of interruptions implies that individuals will not know if an interruption will occur nor will they have control over the timing of the interruption with respect to other activities on which they may be working. Interruptions are discrete events that have a beginning and an end. Further, interruptions break a decision-maker's attention on a primary task and force the decision maker to turn his or her attention to the interruption event. This criterion distinguishes interruptions from distractions, as distractions could be attended to (or ignored) concurrently with a primary task.

Figure 3-1 depicts the individual decision-making characteristics presented in Chapter 2 and proposes interruptions as a moderating influence on the relationship between these characteristics and decision performance. Interruptions are events distinct from a specific decision-making event and are shown as moderating the influence of the decision task, individual, and information presentation characteristics by influencing the decision process and, ultimately, decision performance.

Interruptions have been found to influence an individual's work-related stress (Kroemer, Kroemer, and Kroemer-Elbert, 1994) and their

FIGURE 3-1

The Influence of Interruptions on Indivdiual Decision Making



processing of a specific task (Kahneman, 1973). Although work stress has direct ramifications for knowledge worker productivity, the focus of this research is on task-specific decision processing. Therefore, the literature presented will be limited to the effects of interruptions on decision processing.

3.1.2 Distractions vs. Interruptions

Few studies examining the influence of interruptions on task performance appear in the literature. Prior research in industrial psychology and human factors has, however, examined the influence of distractions (e.g., plant noise or music) on decision performance. The results from these distraction studies form the basis for building the interruption/performance theory presented in this study.

Distractions are captured by an individual's attention while they are performing another task. Distraction and primary tasks are perceived through different sensory channels and can be "performed" simultaneously (e.g., it is possible to listen to background music while performing a visual reading task). Correspondingly, the distractions operationalized in previous studies did not require any cognitive processing by the individual and were designed only to interfere with the attention-based processing of a task.

Distractions and interruptions share some attributes that suggest the cognitive processes would be similar for these two events. Distractions are a provocative stimulus that, like interruptions, direct attention away from some ongoing activity. Additionally, the pressure to attend to both a primary task and distraction are substantial and roughly equal (Baron, 1986). Distractions result in capacity interference as the cues from both the primary task and distraction creates attentional overload (Cohen, 1980; Groff, Baron, and Moore, 1983). The decision maker chooses which cues to attend to and process to alleviate the overload situation. This choice typically results in a decision to attend to some cues at the expense of others.

On the other hand, interruptions may not be important to the decision maker's priorities, but are typically urgent activities that "require immediate attention" (page 150) and activities that "insist on action" (page 152) (Covey, 1990). Decision makers typically cannot choose to ignore the cues generated by the interruption and therefore must attend to them. Kahneman (1973) indicates that interruptions cause both capacity and structural interference. Structural interference occurs when a decision maker is required (or strongly tempted) to attend to two inputs that require the same physiological mechanisms, (e.g., attending to two different visual signals, one from a computer screen and an unrelated visual signal outside an office door). According to Norman and Bobrow (1975), interruptions are severe attentional distractions that place greater demands on cognitive processing resources than the available capacity can handle. Handling the interruption is likely to result in the loss of the contents of working memory and therefore, decreased decision accuracy and more decision time.

Finally, decision makers are forced to attend to an interruption to some degree (even if it is a conscious decision to ignore a phone call), while a distraction could be completely ignored. Processing an interruption task is likely to get confused with processing a primary task as cues from both tasks are resident in memory at the same time. From this perspective, distractions and interruptions share similar attentional processing characteristics that might influence performance in a similar way. However, interruptions should more severely disrupt task processing and ultimately task performance.

In this research, prior literature describing the influence of distractions on decision making is used to form the basis for examining the influence of interruptions on decision making. It is assumed that because distractions influence decision performance, interruptions would also influence decision performance only in a more severe manner.

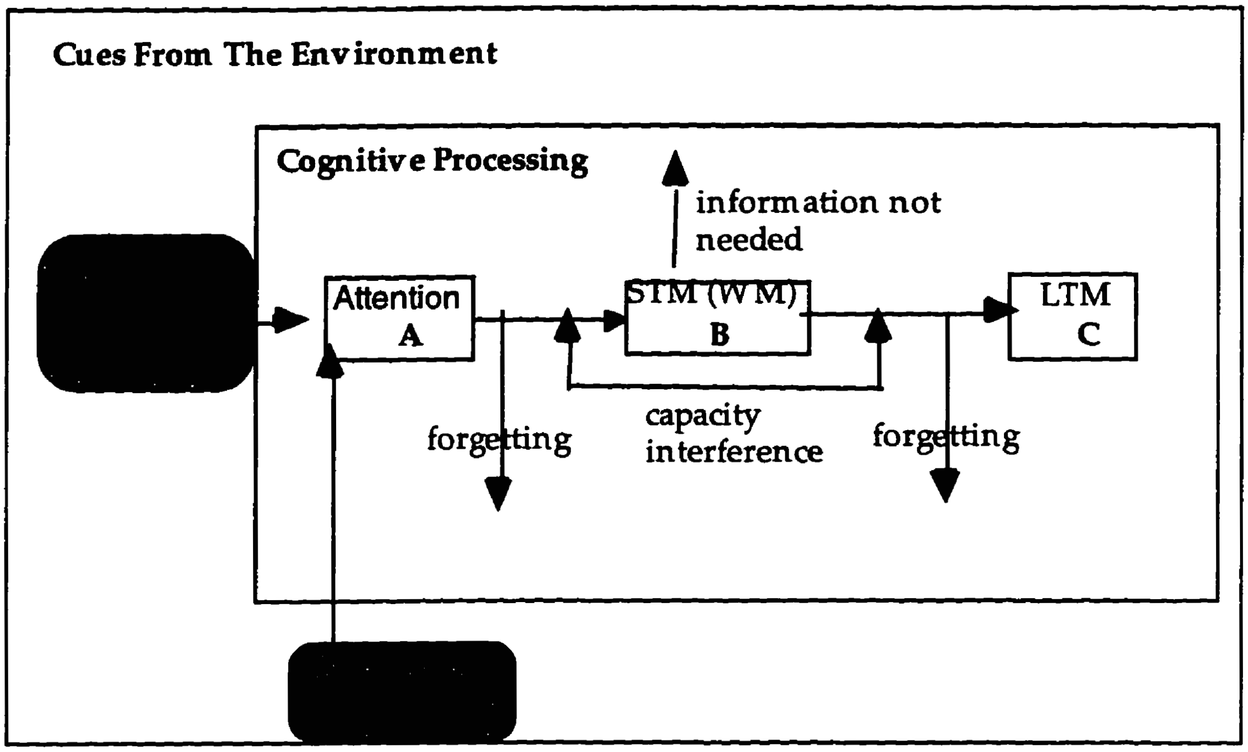
3.1.3 The Effect of Interruptions on Cognitive Processing

Figure 3-2 presents a normative cognitive processing model describing the influence of interruptions on cognitive processing. The model is based on research conducted by Atkinson and Shiffrin (1968) and Kahneman (1973). Cues from the environment are captured through human senses as part of attention (labeled A). When an individual is working on a single task and is not faced with interruptions, the environmental cues consist only of primary task cues. Signals that are needed for task processing enter working memory (WM) inside short-term memory (STM)[2] (labeled B). Some information leaves WM in response to environmental cues that are not necessary for processing, while some other information moves on to long-term memory (LTM) (labeled as C) for more permanent storage (Atkinson and Shiffrin, 1968).

[2]There may be no need to distinguish between WM and STM; some researchers do distinguish between them and others do not.

Figure 3-2

Normative Model of Cognitive Processing with Interruptions



Although competing models differ in the intricacies of how attention operates[3], there is general agreement on the influence of interruptions on cognitive processing. When an interruption occurs, cues from primary and interruption tasks enter WM through A, creating capacity interference between these signals[4]. This interference increases the overall cognitive

[3] For a detailed discussion see Broadbent (1958, 1971), who proposed a bottleneck configuration, and Kahneman (1973), who proposed a capacity model.

[4] Not all incoming signals are competing. For example, individuals can drive a car and listen to a conversation at the same time since different perceptual devices are used. However, structural interference would occur if an individual attempted to drive a car and read a book simultaneously which would require the same perceptual devices.

processing load and forces an individual to focus their attention on one task at the expense of another. In addition, these competing signals may cause an individual to forget some of the information needed for processing so that some signals never enter WM. As the individual completes one task and returns to the other, a recovery period is needed to reprocess information that was forgotten while attending to the interruption, or lost from WM due to capacity interference (Kahneman, 1973). Research conducted by Laird, Laird, and Fruehling (1983) supports this notion by demonstrating that interruptions increase the time to perform primary tasks due to increased backtracking and recovery time.

3.1.4 Prior Empirical Results of Distractions on Decision Performance

This section presents prior empirical results from studies that examining the influence of distractions or interruptions on individual decision-making performance.

Although there has been little research examining the influence of interruptions on decision making, research in cognitive science and industrial psychology has examined the effects of distractions. Distractions have been operationalized in this research as background noise or a 1 to 2 second long attention-grabbing event (Sanders and Baron, 1975; Baron, 1986).

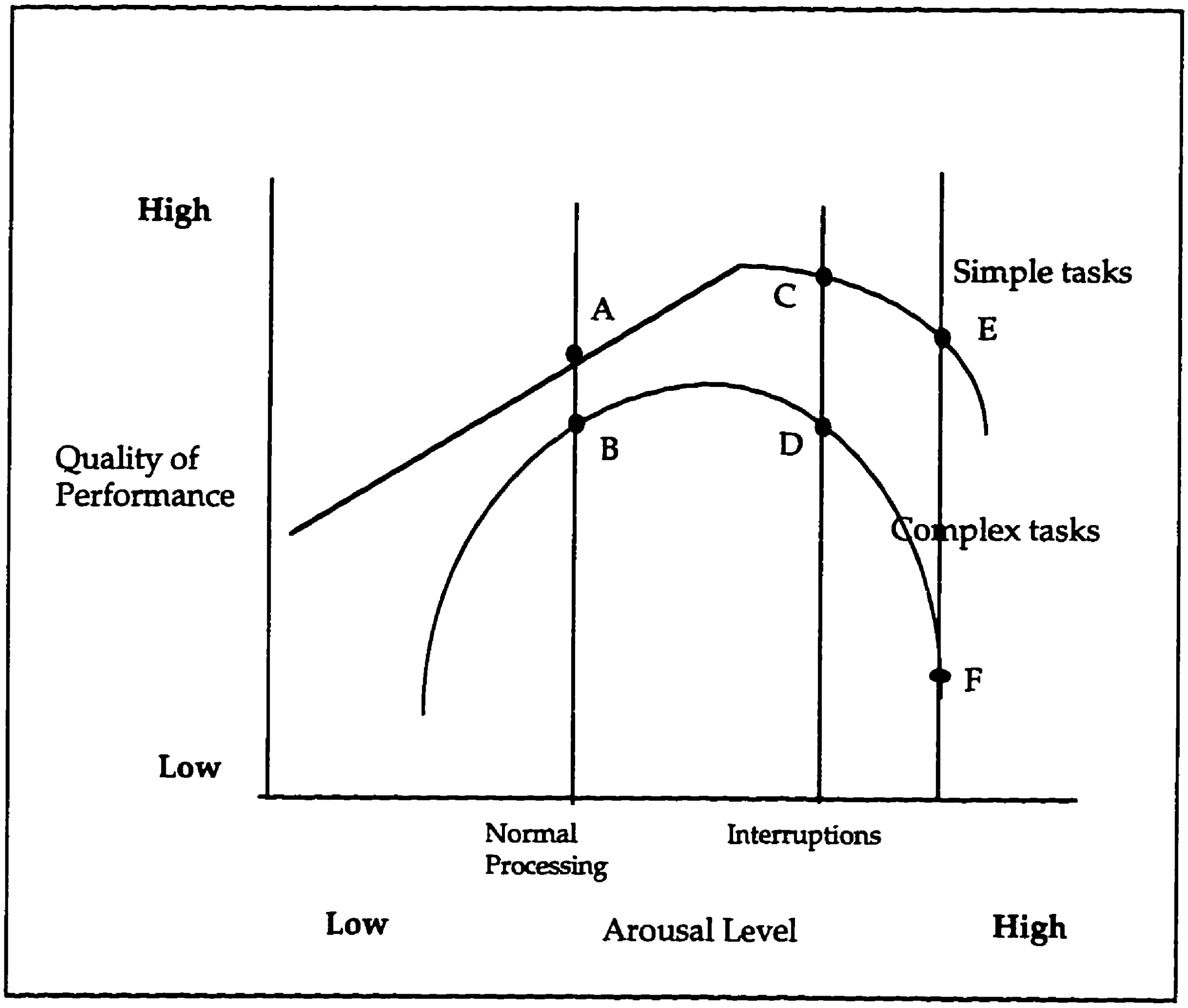
The influence of interruptions on performance depends on the complexity of the task being performed (Zajonc, 1965). The Yerkes-Dodson law (Figure 3-3) was developed to explain the influence of stress or arousal on decision performance. It has been used for the theoretical grounding in explaining the influence of distracting noise on performance (Boggs and Simon, 1968; Hockey, 1969; 1970). The Yerkes-Dodson law purports that the quality of performance on any task is an inverted U-shaped curve based on arousal. Furthermore, the range over which performance improves with increasing arousal varies with task complexity (Yerkes and Dodson, 1908). Increasing arousal improves performance up to a point where the arousal creating events are so intense that performance deteriorates. The level of arousal for optimal performance is higher for simple than for complex tasks.

The Yerkes-Dodson law can also be used to explain task performance when interruptions are present. Low levels of arousal occur when a decision maker is at rest. As he/she begins processing a task, arousal rises to a moderate level (designated as point A for a simple task and point B for a complex task). When an interruption occurs, the extra load of attempting to attend to and process multiple inputs elevates arousal (Baron, 1986; Kahneman, 1973) (designated as point C for a simple task and point D for a complex task). The increased attentional demand generated by the interruption creates attentional overload (Cohen, 1980; Groff, Baron, and Moore, 1983), which decreases the number of information cues a decision maker attends to.

A task can be described by the number of cues that must be processed. A simple task has fewer cues than a complex task. When arousal is low (A and B), both relevant and irrelevant cues are examined uncritically. As arousal increases (C and D), attention is narrowed and irrelevant cues are more likely to be dismissed. The performance of simple tasks is facilitated by interruptions as decision makers are more motivated, only need to examine a few information cues, and therefore, are able to complete tasks more quickly with no loss in accuracy (Baron, 1986, Keele, 1967). As the arousal level increases even further (E), the range of cues under examination diminishes and relevant cues are ignored. At this point, performance deteriorates.

Figure 3-3

The Yerkes-Dodson Law



A similar explanation can be used for complex tasks. However, the optimal arousal level and point of performance deterioration occur at lower arousal levels. At increasing levels of arousal (D), attentional overload occurs, as in the case of simple tasks. However, the range of cues to be examined to complete a complex task is greater than for a simple task. The decision maker therefore ignores some cues, certain of which may be relevant to completing the task. Therefore, task performance deteriorates. As with the simple tasks, as the arousal level increases further (F), attentional overload is further exacerbated and performance deteriorates more severely. In addition to reducing the number of cues attended to, increased arousal may encourage decision makers to use heuristics or to take shortcuts, resulting in lower decision accuracy (Baron, 1986).

The phenomena described by the Yerkes-Dodson law has been formalized as Distraction/Conflict Theory. Distraction/Conflict Theory states that interruptions facilitate the performance of simple tasks while inhibiting the performance of complex tasks (Sanders and Keele, 1967; Baron, 1986).

Past empirical studies support the notion that interruptions impair performance of complex decision-making tasks. Interruptions decrease the accuracy of recall (Schuh, 1978), increase the perceived duration of time required to solve a problem (Schiffman and Griest-Bousquet, 1992), increase frustration, and lead to inconsistent performance (Baron, Baron, and Miller, 1973; Wright, 1974) on complex tasks. Finally, Cellier and Eyrolle (1992) found that interruptions increased the processing time and decreased the accuracy on the interruption task as well as the primary task.

In addition to task complexity, interruptions have also been identified as moderating the influence of individual characteristics on performance (Birnberg and Shields, 1984). Individuals who have task domain experience exhibit higher decision accuracy and less decision time than novices when interrupted (Birnberg and Shields, 1984).[5] Personality type (Peterson, 1994), interruption screening ability (Oldham, Kulik and Stepina, 1991), capacity to handle role overload (Sutton and Rafeli, 1987), and the ease with which a

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[5]Experienced individuals also perform better than inexperienced individuals on many tasks when interruptions do not occur due to increased chunking of information (Miller, 1957, Simon and Chase, 1973).

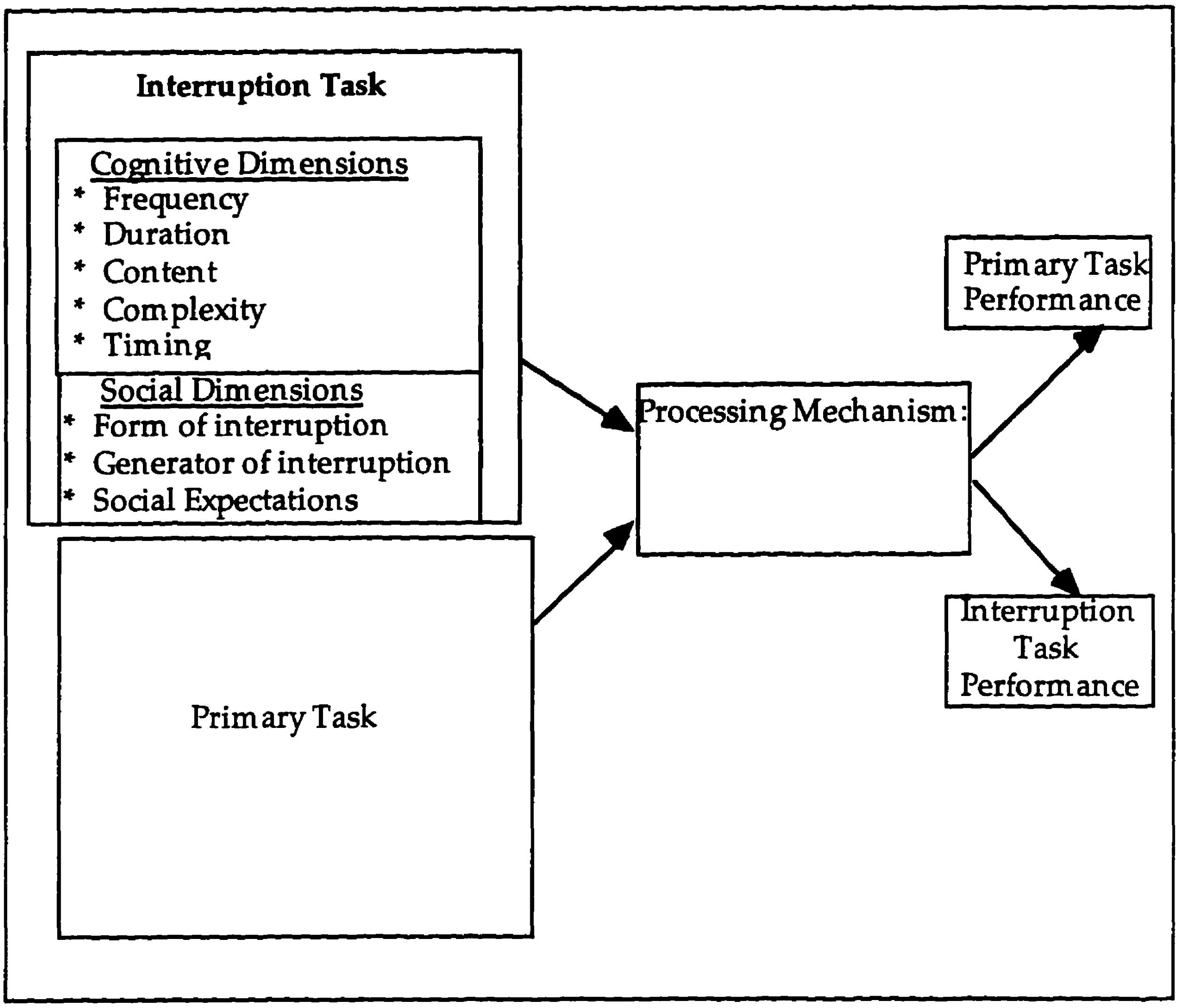
person can be interrupted (Kirmeyer, 1988) also moderate the effects of interruption on performance.

3.2 Characteristics of Interruptions

Given that there has been little or no formalization of interruptions, this section presents specific salient characteristics and examines their influence on decision-maker performance. Moray (1993) states that "as far as I have been able to discover, there is no systematic body of research on what physical or psychological characteristics make it an interrupt" (page 120). In response to this lack of research, Figure 3-4 presents a proposed framework for identifying the important dimensions of an interruption and their influence on performance. These dimensions are subdivided into two categories describing: 1) dimensions that primarily influence cognitive processing, which include frequency, duration, content, and timing of the interruption; and 2) social dimensions which affect how the knowledge worker responds to the interruption including the form of the interruption, the person or object generating the interruption, and social expectations that exist based on organizational culture. Each of these dimensions is elaborated on later in this section. In addition to interruption dimensions, the way in which decision makers attend to the primary and interruption tasks influences the manner in which these tasks are processed. These processing mechanisms are believed to influence performance on both primary and interruption tasks (Kirmeyer, 1988).

Figure 3-4

Interruption Characteristics and Processing Mechanisms



3.2.1 Prior Empirical Results of Interruptions on Decision Performance

There is little existing research examining the phenomena of interruptions. Corragio's (1990) unpublished doctoral dissertation represents the only known study to date that has directly manipulated dimensions of interruptions to better understand the effects on performance. Corragio examined the influence of interruption frequency and duration on both simple and complex tasks. He defined interruption frequency as the number of interruptions that occur during a specific task which was operationalized as 2 interruptions per task at low frequency levels and six interruptions per task at high levels. Interruption duration referred to the overall length of time consumed in responding to the interruption. Corragio controlled the length of the interruption and operationalized low and high duration levels as 30 seconds and 90 seconds, respectively. Subjects completed a multiple choice operations management exam. Simple tasks consisted of a single question while complex tasks consisted of 2 or 3 multiple choice questions grouped together to form one "complex question" without intermediate steps to check for correct solutions.

Corragio found that interruptions do influence task performance and that the influence is moderated by the complexity of task performed. Specifically, he found that long interruptions improved task accuracy and time for simple tasks. On the other hand, short interruptions inhibited task performance for complex tasks. As the duration of the interruption increased, accuracy on complex tasks improved for short duration interruptions. With regard to interruption frequency, Corragio found no consistent effect for either simple or complex tasks.

Corragio identified two potential problems with the experimental manipulation that might explain the findings. First, interruptions were operationalized as trivia questions and were perceived as fun by many of the subjects. Many students indicated that they looked forward to receiving an interruption because it was more enjoyable than the primary task. Second, many subjects completed the interruption task prior to the 30 or 90 second allotted time. He reported that many subjects, particularly those performing the long interruptions, would complete the interruption task in a few seconds and then work on the primary task "on paper" until the problem reappeared on the screen as the "interruption" ended. Further, some subjects "missed" interruptions because they were busy working out calculations on paper and did not notice the interruption task on their PC screen. These factors may explain why performance on complex tasks appeared to improve with long interruptions.

3.2.2 Frequency

Many jobs in the service industry may be subject to frequent interruptions, as is the case, for example, of customer service representatives addressing the needs of multiple customers. As the frequency of interruption increases, there would be more opportunity for capacity interference between the primary and interruption tasks as well as for forgetting primary task cues. Although interruption frequency did not exhibit any significant effects on decision accuracy in the Corragio study, Woodhead (1965) and Eschenbrenner (1971) found that decision accuracy decreased as the frequency of a distraction increased.

3.2.3 Duration

Interruption duration is also a well-defined characteristic of interruptions. Some interruptions are very short requiring less than one minute, while other interruptions are very time consuming. The longer the duration of the interruption, the more likely a decision maker is to forget components of the primary task they have been working on prior to the interruption. Therefore, it is expected that longer interruptions would more strongly inhibit task performance.

3.2.4 Content

Another important characteristic of interruption is the content of the interruption. Research has demonstrated that an interruption that has similar cognitive processing requirements as the primary task is more likely to cause task interference, and therefore, to lead to decreased accuracy (Kinsbourne, 1981, 1982, and Navon, 1984; Paschler, 1986). Processing similar types of information results in the use of similar cognitive processes (Kinsbourne, 1982) or similar information processing requirements (Cellier and Eyrolle, 1992). Processing similar tasks might, therefore, lead to an inappropriate allocation of resources when switching from the primary to the interruption task (Norman, 1981). This misallocation of resources might disrupt the normal processing mechanisms used to complete the primary task and inhibit both primary and interruption task performance.

3.2.5 *Complexity*

Trumbo, Noble, and Swink (1967) examined the effect on performance of inherent difficulty of a primary and interruption task. Their findings suggest that the a priori difficulty of the interruption task did not predict the amount of interference between the two tasks. Therefore, the complexity characteristic may not influence the performance on a primary task. However, additional examination with a variety of interruption tasks is needed.

3.2.6 *Timing*

A fourth characteristic of interruptions involves the timing of the interruption with respect to the primary task. Interruptions that occur toward the beginning or end of a primary task, when involvement is lower, are likely to have a lesser effect than interruptions that occur in the middle of processing (Schuh, 1978). Mid-process interruptions should cause greater capacity interference and forgetting, which result in decreased performance (Corragio, 1990). This notion is supported by Woodhead (1965) who found that decision makers had a greater number of calculation errors when an interruption occurred during memorization (mid-process interruption) than during a calculation process (near completion of the task).

3.2.7 Form of the Interruption

A fifth interruption characteristic concerns the form of the interruption. Interruptions can occur, for example, as e-mail messages, telephone calls, or the request of information from colleagues entering an office. Media Richness Theory (Daft and Lengel, 1984) suggests that the media used to send messages vary in their ability to support users in communicating and processing messages. A medium that facilitates immediate feedback across a variety of channels is very rich (e.g., face-to-face communication). It is more difficult for an individual to terminate or redirect a conversation if it is provided over a rich medium (Rice, 1987). Therefore, richer media are more likely to generate more severe interruptions. For example, a face-to face interruption cannot be ignored easily and is likely to create capacity interference and forgetting. Lean media (e.g., e-mail messages or a memo) might pose a less severe, or insignificant interruption as a decision maker could possibly complete his or her task before attending to the interruption.

3.2.8 Generator of the Interruption

A sixth interruption characteristic involves the generator of the interruption. Interruptions can be generated by various individuals (e.g., bosses, subordinates, family, customers) or by machines (e.g., e-mail message beep, system error messages). Expectancy Theory (Vroom, 1964) suggests that an individual's behavior is a conscious choice selected from a number of different alternatives (e.g., perform the interruption immediately, disregard the interruption). Individuals evaluate the alternatives with the goal of selecting the alternative that will maximize positive outcomes and minimize negative outcomes. In this light, the role of the person generating the interruption may influence the manner in which a decision maker attends to an interruption. An individual may expect a positive outcome by responding to a boss's interruption or a negative outcome by not responding to the interruption. On the other hand, there may be very little to be gained by responding to a social colleague's interruption and the interruption might be ignored or quickly dismissed.

Robbins and DeNisi (1994) found that positive interpersonal affect between a decision maker and an individual creating an interruption positively influenced work performance ratings of the "interrupter". Likewise, Bond and Titus (1983), found that the familiarity with the individual creating the interruption positively influenced work performance ratings of the "interrupter".

3.2.9 Social Expectation

The social expectation dimension of interruptions is grounded in the research literature on organizational culture. According to Schein (1992), organizational culture involves assumptions that are shared by group members and are deeply embedded within the organization. Schriber and Gutek (1987) indicate that organizational culture is embedded in the way in which individuals within an organization approach their work. Specifically, they examined time dimensions associated with work including the autonomy of time use, the awareness of time use, and the allocation of time. They suggest organizations and groups within the same organization place different emphases on time that are associated with differences in underlying culture. The underlying culture of an organization or group might establish a climate for expectations associated with responding to interruptions. One culture might establish an expectation that time is a scarce resource and workers should not be interrupted. Alternatively, a culture emphasizing interdependency and interpersonal relations might establish the expectation that workers make time for others as needed.

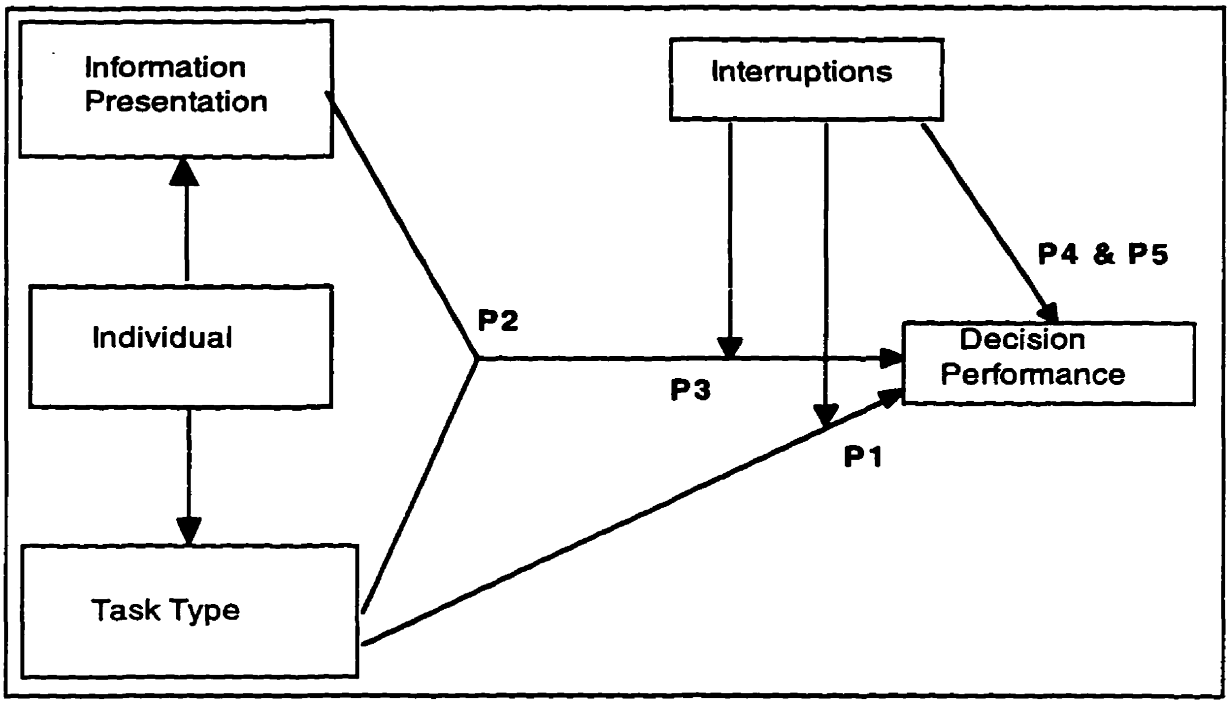
3.2.10 Interruption Processing Mechanisms

Finally, an interruption might be characterized by the way in which it is processed. Kirmeyer (1988) discusses three types of interruption processing mechanisms implemented by police dispatchers: sequential, preemptive, and simultaneous processing. Sequential processing occurs when the first task is completed prior to beginning the interruption task. Preemption occurs when the primary task is left incomplete while attention is immediately given to the interruption task. Third, simultaneous processing occurs when a decision maker attends to both primary and interruption tasks at the same time. The selection of a processing strategy is influenced by the primary task being performed and specific dimensions of the interruption.

3.3 General Research Model

Figure 3-5 presents an integrated model of the decision making, information presentation, and attention literature discussed in Chapter 2. Characteristics of the individual, task, and information presentation format affect each other and task performance (decision accuracy and decision time). Past theory and research supports the conclusion that interruptions moderate the relationship between these characteristics and ultimately influence decision performance. Since the focus of this research is on the influence of interruptions the decision outcomes, the cognitive processing component that was evident in previous figures (e.g., Figure 2-1 and 2-4) has been removed from the General Research Model. Although interruptions clearly have a significant influence on cognitive processing, the internal cognitive processes are not captured in this dissertation. Therefore, the cognitive processing component has not been illustrated in the General Research Model.

Figure 3-5
General Research Model and Propositions



As depicted in the General Research Model, the work environment, specifically interruptions, may influence task performance. Interruptions have both cognitive and social characteristics that influence how a decision maker responds to the interruption and the primary task. As we have seen, cognitive dimensions include frequency, duration, content, and timing. The degree to which each one of these dimensions is present influences the processing of information cues necessary to address both the primary task and the interruption. Social characteristics (including the form of the interruption, the generator of the interruption, and social expectations) also influence the processing of cues and task performance, but may not operate in the same way. An urgent interruption generated by a superior might moderate the cognitive dimensions of interruptions in a different way than a social interruption that takes place via the phone. There are many dimensions to interruptions and many more interactions and relationships between these dimensions that might influence performance in a predictable manner. This study consisted of an exploratory examination of interruptions as they have received limited prior investigation. This study examined the general influence of interruptions on simple and complex tasks. In addition, two cognitive dimensions (frequency and content) were selected for additional study. These dimensions were selected based on prior literature, which enabled the development of theory describing the expected influence on performance.

3.4 Propositions

The following five propositions present the expected influence of interruptions and information presentation format on decision-making performance. These propositions are somewhat simplistic given the dearth of existing research in this area. As the interrelationships between the dimensions of interruptions are better understood, more complex propositions can be developed. As illustrated in Section 2, interruptions and distractions share many characteristics that influence performance. The Yerkes-Dodson law states that at increased levels of arousal (e.g., as generated by interruptions) performance on simple tasks is facilitated, while performance on complex tasks is impaired. Further, Corragio (1990) reported that interruptions have a positive influence on simple memory recall tasks and that short interruptions inhibit performance on complex tasks. Thus, this leads to Proposition 1:

> *Proposition 1: Interruptions significantly moderate the relationship between task type and decision-making performance.*

Cognitive Fit Theory (Vessey, 1991) states that decision-making performance is facilitated when there is a match between the type of information presentation format and task processing. To date, empirical research examining this issue has focused on simple tasks of information acquisition. Vessey (1994) indicates that complex tasks consist of information acquisition and evaluation sub-tasks (Einhorn and Hogarth, 1981) that can often be identified as primarily symbolic or spatial in nature. Further, Wood (1986) suggests that complex tasks have a greater number of information cues, processing acts, greater interdependency between processing acts, and that the relationship between inputs and outputs changes over time. Tasks that require symbolic information acquisition and evaluation and meet Wood's complexity criteria are referred to as complex-symbolic. Likewise, tasks that require spatial information acquisition and evaluation sub-tasks and meet Wood's complexity criteria are referred to as complex-spatial tasks. Finally, the degree of complexity experienced by a decision maker influences the strategy used to process the task. Complex tasks that can be solved without an undue amount of time have been previously described in Chapter 3 as feasibly-solvable. According to Cognitive Fit Theory, a match between the information presentation format and feasibly-solvable task types should result in the use of similar processes for data acquisition and data processing; hence increased performance. Thus, this leads to Proposition 2:

> *Proposition 2: A match between information presentation format and task type significantly increases performance for simple and feasibly-solvable complex-spatial and complex-symbolic tasks.*

Testing Proposition 2 provides the first ex ante test of Cognitive Fit Theory on feasibly-solvable tasks. Although, this proposition is not directly derived from the Research Questions presented in Chapter 1, it establishes a performance baseline from which to compare the influence of interruptions on task type and information presentation format.

Aspects of the work environment may alter the way in which decision makers process information (Cellier and Eyrolle, 1992; Wright, 1974). When a decision maker has limited time or is distracted, he or she relies on information that is easy to find and conspicuous (Berlyne, 1970). Further, information that is presented graphically is often retained longer in working memory and might be easier to recall than information presented in tabular form (Anderson, 1980). Thus, Proposition 3 suggests:

> *Proposition 3: Interruptions will moderate the decision-making performance relationship between task type and information presentation format.*

We have seen that different dimensions of interruptions may affect decision performance. The dimensions examined in this research were: 1) frequency of interruption and 2) content of the interruption.

First, interruptions force decision makers to stop processing on a primary task to attend to an interruption. Once the interruption has been processed, the decision maker must undergo a recovery period upon returning to the primary task. This recovery period involves remembering where in the task they were when interrupted and re-acquiring information they may have forgotten. Each recovery period increases the likelihood that the decision maker will forget necessary information or confuse information between the primary and interruption task (Kahneman, 1973). In this light, we state Proposition 4:

Proposition 4: As the number of interruptions increases decision performance on the primary task significantly decreases.

Second, the content of the interruption might also influence processing during the primary task recovery period and affect decision-making performance. Decision makers are more likely to confuse data that is similar in both the decision-making and the interruption task (Kinsbourne, 1981; Paschler, 1986). As confusion increases, the likelihood of making errors increases. Thus, this leads to Proposition 5:

Proposition 5: Decision-making performance is significantly inhibited when the information content of the interruption and decision-making task are similar.

3.5 Chapter Summary

This chapter presented prior literature on interruptions and developed a framework consisting of interruption characteristics to direct future research. Interruptions influence the way in which information is processed. Furthermore, interruptions may moderate the relationship between specific decision characteristics as cognitive processing occurs. A general, individual decision-making research model was presented showing the influence of interruptions. Propositions derived from this model were then stated.

CHAPTER 4

RESEARCH METHODOLOGY AND HYPOTHESES

This chapter presents the hypotheses and describes the research method used to test these hypotheses. This chapter also describes how the variables were operationalized and measured, and the procedures used to conduct the study.

4.1 Research Method

Research conducted in the MIS field relies on a breadth of research methods ranging from hermeneutic case studies to laboratory experiments. The selection of a research method must, however, be congruent with the objectives of the researcher.

The primary goal of this research is to test theory. An important aspect of such research is to rule out any threat to internal validity. Campbell and Stanley (1966) provide a detailed description of possible threats to internal validity, including differences in historical events that occur between treatments or bias in sample selection. A controlled laboratory experiment is a research method that enables theory testing while simultaneously allowing the researcher to control for threats to internal validity (Jenkins, 1984). The selection of a controlled laboratory experiment limits the generalizabilty of the study. Berkowitz and Donnerstein (1982) suggest, however, that the purpose of any single laboratory experiment is to examine causal relationships in a controlled environment and not to produce directly generalizable results. Issues related to external validity are considered in the design of this study whenever possible without compromising internal validity.

4.2 General Descriptions and Definitions of Variables

A variety of factors are examined in this research based on the propositions presented in Chapter 3. This section describes each of those factors.

Proposition 1 indicates that interruptions influence performance on both simple and complex tasks. Interruptions were defined as tasks requiring attention and processing while subjects are processing a primary task. Simple tasks are those that 1) have relatively few information cues and 2) primarily involve information acquisition. Complex tasks, on the other hand, 1) have more information cues, 2) contain interdependencies between information cues, and 3) require both information acquisition and evaluation processes.

Proposition 2 indicates that the match between information presentation format and task type affects performance. Information presentation format and task types have been defined previously as being symbolic or spatial in nature (Vessey, 1991). Those definitions were applied in this research study. Symbolic formats (tabular) focus on the presentation of specific values while spatial formats (graphical) present the relationships between variables more clearly. Similarly, symbolic tasks require the extraction of a single value while spatial tasks involve the examination of relationships within the data.

Proposition 3 proposes that interruptions will moderate the relationship between task type and information presentation format. These variables are described above.

Proposition 4 suggests that interruption frequency will influence decision performance. Interruption frequency is defined as the number of interruptions that occur during a task. Proposition 5 proposes that the content of the interruption influences decision performance. Interruption content was defined as similarity in information content between the primary and interruption task.

All propositions require an objective measure of decision performance. Two measures were used in this research: decision accuracy and decision time. Decision accuracy is a measure of the percent deviation from optimal achieved on a specific task. Decision time is defined as the time required to complete a specific task.

4.3 Detailed Model and Hypotheses

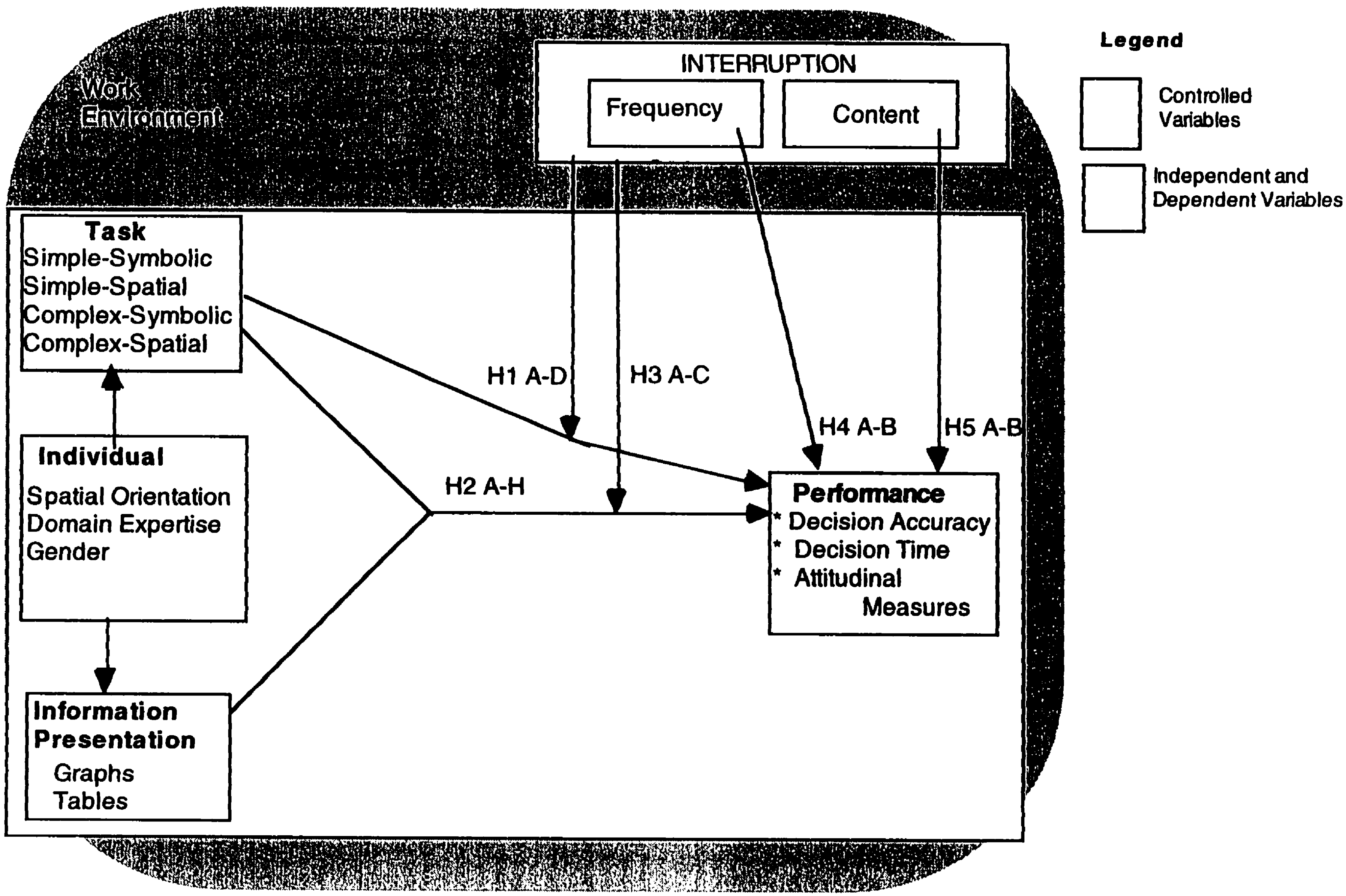
Figure 4-1 illustrates the specific relationships under investigation as well as the hypothesized influence of interruptions and information presentation on task performance. This model will be described in detail together with the hypotheses developed from the previous propositions.

4.3.1 Task Type and Work Environment

Proposition 1 suggests that interruptions moderate the relationship between task type and decision performance. Tasks can be categorized based on the degree of complexity inherent in the task. Specifically, simple and complex tasks can be defined by the processing requirements and number of information cues used to perform the tasks. Simple tasks consist of information acquisition and limited information evaluation (Vessey, 1991). Complex tasks consist of information acquisition and more extensive information evaluation (Einhorn and Hogarth, 1981) and can be characterized as requiring more information cues, greater processing requirements, greater

Figure 4-1

Research Model: Factors to be Examined and Hypotheses



interdependency between subtasks, and a changing relationship between inputs and solution (Wood, 1986).

Simple tasks require few information cues to be retained in working memory or to recover if those cues are lost during an interruption. Simple tasks are performed more quickly and accurately with interruptions because interruptions induce individuals to accelerate their performance to make up for time lost. Hence, interruptions, are likely to facilitate the completion of simple tasks (Baron, 1986; Corragio, 1990; Janis and Mann, 1977).

Complex tasks, however, are negatively affected by interruptions (Baron, 1986). An interruption is likely to require the individual to reprocess some information cues, which increases the likelihood of confusion when retrieving and processing information. Interruptions during complex tasks should result in lower decision accuracy and increased decision time. Proposition 1 suggest that interruptions influence performance. The testable hypotheses are as follows:

H1A: Decision makers perform simple tasks more accurately with interruptions than without interruptions.

H1A1: Decision makers perform simple-symbolic tasks more accurately with interruptions than without interruptions.

H1A2: Decision makers perform simple-spatial tasks more accurately with interruptions than without interruptions.

H1B: Decision makers perform simple tasks more quickly with interruptions than without interruptions.

H1B1: Decision makers perform simple-symbolic tasks more quickly with interruptions than without interruptions.

H1B2: Decision makers perform simple-spatial tasks more quickly with interruptions than without interruptions.

H1C: Decision makers perform complex tasks less accurately with interruptions than without interruptions.

H1C1: Decision makers perform complex-symbolic tasks less accurately with interruptions than without interruptions.

H1C2: Decision makers perform complex-spatial tasks less accurately with interruptions than without interruptions.

H1D: Decision makers perform complex tasks less quickly with interruptions than without interruptions.

H1D1: Decision makers perform complex-symbolic tasks less quickly with interruptions than without interruptions.

H1D2: Decision makers perform complex-spatial tasks less quickly with interruptions than without interruptions.

4.3.2 Task Type and Information Presentation Format

Prior MIS and human factors research have independently determined that the form of information presentation is most effective when the there is a "fit" between the task type and the information presentation format. Tasks that are defined as complex vary in complexity across dimensions described by Wood (1986) and Campbell (1988). This research examines one type of complex task, designated as feasibly-solvable. Feasibly-solvable complex tasks are those that can be solved optimally by a decision maker, given sufficient time, without needing to trade-off accuracy for effort exerted. Specifically, Cognitive Fit Theory indicates that simple and feasibly-solvable symbolic tasks are performed most accurately and quickly when using symbolic (e.g., table) information. Likewise, simple and feasibly-solvable spatial tasks are performed most accurately and quickly when using information presented in a spatial (e.g., graphical).

The interaction between simple tasks and information presentation format has been examined empirically. However, the interaction between complex tasks and information presentation format has received limited investigation. Complex tasks (Vessey, 1994) consist of information acquisition and evaluation sub-tasks. The primary activities that occur during these subtasks should define whether a complex task is more spatial or more symbolic in orientation. The tenets of Cognitive Fit Theory should extend to the sub-tasks within the complex task as long as the majority of the sub-tasks require similar processing and the complex task is in the optimal range of the complex task continuum. Therefore, feasibly-solvable complex tasks that are more symbolic in nature are performed most effectively when using symbolic information and feasibly-solvable complex tasks more spatial in nature are performed most effectively when using spatial information.

Proposition 2 addresses performance effects on both simple and complex tasks. The hypotheses related to the simple tasks are as follows:

H2A: A simple-symbolic task is performed more accurately with tables than with graphs.

H2B: A simple-symbolic task is performed more quickly with tables than with graphs.

H2C: A simple-spatial task is performed more accurately with graphs than with tables.

H2D: A simple-spatial task is performed more quickly with graphs than with tables.

Similar hypotheses have previously been tested in Vessey and Galletta (1991). Therefore, H2A-D provide a further test of Cognitive Fit Theory. In addition, the test of these hypotheses provides a manipulation check for the internal consistency of this study. Proposition 2 also addresses the extension of Cognitive Fit Theory to include complex tasks, which results in the following testable hypotheses:

> **H2E: A feasibly-solvable complex-symbolic task is performed more accurately with tables than with graphs.**
>
> **H2F: A feasibly-solvable complex-symbolic task is performed more quickly with tables than with graphs.**
>
> **H2G: A feasibly-solvable complex-spatial task is performed more accurately with graphs than with tables.**
>
> **H2H: A feasibly-solvable complex-spatial task is performed more quickly with graphs than with tables.**

4.3.3 *Task Type, Information Presentation Format, and Work Environment*

Graphical representation of information results in superior performance over tabular data when used to solve complex problems under time pressure (Coury and Boulette, 1992; and Schwartz and Howell, 1985). The perceptual cues in the graphical representation have been suggested as the reason for this superior performance (Bennett and Flach, 1992). Research focusing on human perception and attention also indicates that conspicuous information, such as that appearing in graphical formats, should enhance performance when there is environmental stress (Berlyne, 1970; Rabbit; 1964).

Simple tasks require the subject to acquire one or two specific information cues. When there are no interruptions, information presented in a symbolic format should result in increased performance on symbolic tasks. However, when interrupted, decision makers with tabular formats may not have developed an internal representation that permits them to retain the information acquired. In this case, their performance will be impaired to a greater extent than for decision makers who have graphical formats, in which case the perceptual cues allow decision makers to recover from interruptions more quickly. Decision makers using graphical formats may take less time to solve simple-symbolic problems when interrupted than decision makers using symbolic formats. Simple-spatial tasks will be performed in the least amount of time with spatial information as suggested by Cognitive Fit Theory.

The perceptual cues in graphical formats enable these representations to be recalled more easily or be located more quickly during recovery from an interruption. However, graphical formats do not provide the precision required by symbolic tasks. Interruptions are likely to lead to increased errors in acquiring the correct piece of information for a symbolic task. However, this increase in acquisition error is not likely to offset the lack of precision in graphical formats. Therefore, symbolic formats will result in higher solution accuracy for simple-symbolic tasks. Simple-spatial tasks will be performed most accurately when spatial information is used as suggested by Cognitive Fit Theory.

For complex tasks, the information cue and processing requirements are far more extensive than for simple tasks. Proposition 2 indicates that decision makers will solve feasibly-solvable complex-symbolic tasks under non-interrupted conditions more accurately and quickly with symbolic data, because symbolic data provides specific point values that facilitate responding to symbolic tasks. When using spatial data to respond to a symbolic task, a decision maker often has to interpolate from the information provided to obtain an answer.

An increased number of errors are likely to occur in acquiring and manipulating information cues when interrupted during a complex task. In addition, decision makers may require additional time to recover from the interruptions. Decision makers using tabular data are likely to experience more errors than those using graphical data. Tabular data lacks perceptual cues that make it easier to locate and remember specific information. The errors that occur in response to interruptions are likely to exceed the inaccuracy of using spatial data to solve feasibly-solvable complex-symbolic tasks. Therefore, the use of spatial information is expected to result in better performance when completing feasibly-solvable complex-symbolic tasks.

Prior research suggests that when interrupted, decision makers will perform simple-symbolic tasks more quickly with graphs that with tables. The same result is expected for feasibly-solvable complex-symbolic tasks because the perceptual cues inherent in the graphical format should facilitate the interruption recovery process. Spatial data should continue to facilitate the performance of feasibly-solvable complex-spatial tasks as would be expected from Cognitive Fit Theory.

Proposition 3 describes the moderating effect of interruptions on information presentation and task type. Only the relationships that are expected to be contrary to Cognitive Fit Theory are stated, resulting in the following three testable hypotheses:

> **H3A: When interrupted, decision makers will perform simple-symbolic tasks more quickly with graphs than with tables.**
>
> **H3B: When interrupted, decision makers will perform feasibly-solvable complex-symbolic tasks more accurately with graphs than with tables.**
>
> **H3C: When interrupted, decision makers will perform feasibly-solvable complex-symbolic tasks more quickly with graphs than with tables.**

4.3.4 Interruption Frequency

When an interruption occurs, a decision maker must respond to the interruption and then return to his or her primary task. This return is likely to involve a recovery period as the decision maker must remember their "position" in solving the primary task (Kahneman, 1973). The decision maker may need to re-process some information, either acquiring information or performing calculations a second time. In addition, a decision maker may face increased confusion after an interruption. Each recovery period, therefore, presents the decision maker with an opportunity to generate errors that might not occur without interruptions. As the number of interruptions increases, there are an increased number of recovery periods and potential errors. The following hypotheses are based on Proposition 4 which focuses on interruption frequency:

> **H4A: Feasibly-solvable complex tasks are performed less accurately when the frequency of the interruption is high rather than low.**
>
> H4A1: Feasibly-solvable complex-symbolic tasks are performed less accurately when the frequency of the interruption is high rather than low.
>
> H4A2: Feasibly-solvable complex-spatial tasks are performed less accurately when the frequency of the interruption is high rather than low.
>
> **H4B: Feasibly-solvable complex tasks are performed less quickly when the frequency of the interruption is high rather than low.**
>
> H4B1: Feasibly-solvable complex-symbolic tasks are performed less quickly when the frequency of the interruption is high rather than low.

H4B2: Feasibly-solvable complex-spatial tasks are performed less quickly when the frequency of the interruption is high rather than low.

4.3.5 Task/Interruption Content Similarity

Research examining attention and memory indicates that task content affects performance when multiple tasks are processed (Broadbent, 1958, 1971). Kinsbourne (1981) and Paschler (1986) suggest that when task information or task processing is similar, there is greater interference in memory than when tasks are dissimilar. Some of the information cues associated with each task reside in working memory. As the similarity among information cues increases, interference occurs within working memory between the information associated with the primary task and the interruption task. This interference results in performance degradation as resources from working memory are inappropriately allocated among tasks (Norman, 1981). Proposition 5 describes the effect of interruption content on performance and is described as:

H5A: Feasibly-solvable complex tasks are performed less accurately when interruptions have similar information content to the primary task than when the information content is dissimilar.

H5A1: Feasibly-solvable complex-symbolic tasks are performed less accurately when interruptions have similar information content to the primary task than when the information content is dissimilar.

H5A2: Feasibly-solvable complex-spatial tasks are performed less accurately when interruptions have similar information content to the primary task than when the information content is dissimilar.

H5B: Feasibly-solvable complex tasks are performed less quickly when interruptions have similar information content as the primary task than when the information content is dissimilar.

H5B1: Feasibly-solvable complex-symbolic tasks are performed less quickly when interruptions have similar information content as the primary task than when the information content is dissimilar.

H5B2: Feasibly-solvable complex-spatial tasks are performed less quickly when interruptions have similar information content as the primary task than when the information content is dissimilar.

4.3.6 Hypothesis Summary

Table 4-2 presents a synopsis of all hypotheses. The experimental studies used to test each hypothesis are described in the next session.

TABLE 4-2
Hypotheses Synopsis

Task Type	Dependent Variable	Experiment	Hypothesis
Simple Tasks	Accuracy	PRES	H1A: I > NI
	Time	PRES	H1B: I > NI
Simple-Symbolic	Accuracy	PRES	H2A: T > G
	Time	PRES	H2B: T > G
	Time	PRES	H3A: G > T
Simple-Spatial	Accuracy	PRES	H2C: G > T
	Time	PRES	H2D: G > T
Complex Tasks	Accuracy	PRES	H1C: NI > I
	Time	PRES	H1D: NI > I
	Accuracy	ID	H4A: LF > HF
	Time	ID	H4B: LF > HF
	Accuracy	ID	H5A: DC > SC
	Time	ID	H5B: DC > SC
Complex-Symbolic	Accuracy	PRES	H2E: T > G
	Time	PRES	H2F: T > G
	Accuracy	PRES	H3B: G > T
	Time	PRES	H3C: G > T
Complex-Spatial	Accuracy	PRES	H2G: G > T
	Time	PRES	H2H: G > T

PRES = PRESENTATION Experiment, ID = INTERRUPTION DIMENSION Experime
I=Interruption, NI=No-Interruption, G=Graph, T=Table, LF=Low Frequency
HF=High Frequency, DC=Different Content, SC=Similar Content

4.4 General Description of Research Studies

This research study involved two laboratory experiments identified as the PRESENTATION and INTERRUPTION DIMENSION experiments. Each experiment consisted of multiple decision and interruption tasks delivered to subjects by a DSS. The decision tasks were all related to the field of Production and Operations Management and have optimal solutions. The tasks in the INTERRUPTION DIMENSION experiment were the same as those used in the PRESENTATION experiment. The interruption tasks were also related to production management concepts and required the decision maker to acquire information at their disposal. The interruption tasks also have optimal solutions. The PRESENTATION experiment tests the set of hypotheses associated with hypothesis 1, 2, and 3. The INTERRUPTION DIMENSION experiment partially tests the set of hypotheses associated with hypothesis 1 and tests hypotheses 4 and 5. Both experiments use the same dependent and control variables. The subjects participating in the two experiments were drawn from the same population and all data was collected within 5 days to facilitate cross-study comparisons.

4.5 Research Study 1-PRESENTATION

The PRESENTATION experiment used a within-subjects full factorial design as illustrated in Table 4-3. Factors manipulated were: *Work Environment* (2 levels), *Information Presentation Format* (2 levels), and *Task Type* (4 levels). The task type manipulation was within-subjects, while information presentation and work environment were manipulated between subjects. The resulting 2 X 2 X 4 full factorial design involved a total of 4 treatments.

Table 4-3

PRESENTATION Experimental Design

CELL	WORK ENVIRONMENT (between subjects factor)	INFORMATION PRESENTATION FORMAT (between subjects factor)	TASK TYPE (within-subjects factor)
1.	No Interruptions	Tables	Simple-Spatial Simple-Symbolic Complex-Spatial Complex-Symbolic
2.	No Interruptions	Graphs	Simple-Spatial Simple-Symbolic Complex-Spatial Complex-Symbolic
3.	Interruptions	Tables	Simple-Spatial Simple-Symbolic Complex-Spatial Complex-Symbolic
4.	Interruptions	Graphs	Simple-Spatial Simple-Symbolic Complex-Spatial Complex-Symbolic

4.5.1. Independent Variables-PRESENTATION

There were three independent variables in the PRESENTATION experiment: the Work Environment, the Information Presentation Format, and Task Type (see Table 4-4).

4.5.1.1 Work Environment

The Work Environment was manipulated by introducing interruptions into the DSS as subjects were performing primary tasks. A baseline performance measure was required for testing Hypotheses 1A-D, hence the need for a treatment free of interruptions. The interruption level of the Work Environment factor was established based on the results of the first pilot study and tested in the second pilot study (see Appendix L).

Subjects in the no-interruption treatment performed all tasks and interruption activities. Fifty percent of these subjects performed all interruption tasks followed by the four experimental tasks. The remaining fifty percent performed all experimental tasks undisturbed followed by all the interruption tasks. In the interruption treatment, the subjects performed the experimental tasks in concert with the interruption tasks.

4.5.1.2 Information Presentation Format

Two levels of information presentation were manipulated in this research study. These levels were operationalized as tables and bar graphs. A single table or graph was presented on a computer screen. In addition, these presentation formats were constructed to conform to current presentation guidelines as outlined in Hoffer, George, and Valacich (1996). These include formatting of graphs and tables to facilitate use, clarity of format, etc.

4.5.1.3 Task Type

Each subject performed four tasks where the presentation order of the tasks was counterbalanced within cells. The Simple-Symbolic task involved a series of six symbolic questions that were answered with a single information presentation format. The Simple-Spatial task was identical to the Simple-Symbolic task except that a series of six spatial questions were answered. These tasks have been validated and used in prior research (Umanath, 1994; Umanath, Scamell, and Das, 1990). The Complex-Symbolic and Complex-Spatial tasks were constructed to be complex as defined by Wood (1986) and Vessey (1994). A facility location task (Complex-Symbolic) consisted of symbolic subtasks and has been described by Buffa (1980). Finally, an aggregate planning task (Complex-Spatial) consisted of spatial subtasks and has been previously used and validated (Davis and Kotteman, 1994; Remus, 1984, 1987). A detailed description of the tasks is provided in section 4.8, entitled Controlled Variables.

Table 4-4

Independent Variables for PRESENTATION Experiment

Independent Variable	Operationalized Level	Method
Work Environment	No Interruptions	Interruption tasks performed before/after experimental tasks
	Interruptions	Interruption tasks performed during experimental tasks
Information Presentation Format	Symbolic	Tables
	Spatial	Graphs
Task Type	Simple Symbolic	Workload Capacity Task
	Simple Spatial	Workload Capacity Task
	Complex Symbolic	Facility Location Task
	Complex Spatial	Aggregate Planning Task

The hypotheses tested did not require comparisons to be performed between simple and complex task types, across simple tasks, or across complex task types. The task types presented in the hypotheses are independent of one another and are being tested as part of a within-subjects design due to a limitation on available subjects. It was important, however, to ensure that the simple tasks were inherently different from the complex tasks. The complex tasks used in this study were selected based on a theoretical definition of complexity as they contained coordinative and dynamic complexity (Wood, 1986) and had higher component complexity that the simple tasks. These features were operationalized as an increased amount of information, an increased number of computations, and greater interdependency between the data. In addition, results from the second pilot study indicated a significant performance difference between simple and complex tasks. Complex tasks were performed less accurately and took more time to complete that the simple tasks indicating greater overall complexity.

4.6 Research Study 2-INTERRUPTION DIMENSION

A second experiment was conducted to better understand the influence of specific dimensions of interruptions on human decision-making performance. Specifically, the frequency and content of the interruption was manipulated. This experiment also consisted of a within-subjects factorial design as illustrated in Table 4-5. The factors manipulated were Interruption Frequency (2 levels), Interruption Content (2 levels) and Task Type (2 levels). The task manipulation was within-subjects while, the interruption frequency and interruption content was manipulated between subjects. The resulting 2 X 2 X 2 factorial design involved a total of four treatments.

Table 4-5

INTERRUPTION DIMENSION Experimental Design

CELL	INTERRUPTION FREQUENCY (between subjects factor)	INTERRUPTION CONTENT (between subjects factor)	TASK TYPE (within subjects factor)
[illegible]	[illegible]	[illegible]	[illegible]
2.	High	Similar to task	Complex-Symbolic Complex-Spatial
3.	Low	Different from task	Complex-Symbolic Complex-Spatial
4.	High	Different from task	Complex-Symbolic Complex-Spatial

[The type and frequency of the interruption in the highlighted cell (#1) was identical to the INTERRUPTION work environment in the PRESENTATION experiment.]

4.6.1 Independent Variables-INTERRUPTION DIMENSION

There were three independent variables in the INTERRUPTION DIMENSION experiment: Interruption Frequency, Interruption Content, and Task Type (see Table 4-6).

4.6.1.1 Interruption Frequency

Two levels of interruption frequency were manipulated in this study. The levels of the Interruption Frequency factor were established based on results of the two pilot studies (see Appendix L). The low frequency level was set to 4 interruptions per task in order to be identical to the Interruption level of the Work Environment factor in the PRESENTATION experiment. Setting these levels to be identical across experiments permitted data to be pooled from both studies when testing H1. It also provided an internal check across studies to identify any inconsistencies in results.

In the pilot studies, the High level of the Interruption Frequency factor was initially set to 8 interruptions per task. This level was established as it was twice the frequency of the Low Frequency level. Results of Pilot Study 2 indicated that there were no significant differences in decision accuracy or decision time ($p>.6$ and $p>.6$ respectively). The High Frequency level was increased to 12 interruptions per task for the Main study. This increased the difference between the Low and High Frequency levels by 50%.

4.6.1.2 Interruption Content

Two levels of interruption content were manipulated in this research. One level, task/interruption similar content, involved interruption tasks that required the subject to use the same data as used in the primary task. In the task/interruption different treatment, subjects used data that was different from that used in the primary task to complete the interruption tasks. Fifty percent of the interruption tasks were presented with the data in a symbolic format (tables) while the remaining fifty percent were presented with a spatial format (graphs).

4.6.1.3 Task Type

Each subject performed two tasks. The complex-symbolic and complex-spatial tasks were identical to those used in the PRESENTATION experiment. All subjects were given spatial information to complete the complex-spatial task and symbolic information to complete the complex-symbolic task as suggested by Cognitive Fit Theory. Tasks were counterbalanced within cells.

Table 4-6

Independent Variables for INTERRUPTION DIMENSION Experiment

Independent Variable	Operationalized Level	Method
Interruption Frequency	Low High	4 interruptions/task 12 interruptions/task
Interruption Content	Similar Different	The same information used to answer experimental and interruption tasks Different information used to answer experimental and interruption tasks
Task	Complex Symbolic Complex Spatial	Facility Location Task Aggregate Planning Task

4.7 Dependent Variables

The primary dependent variables for both experiments were decision *accuracy* and *decision time* (see Table 4-7). Measures regarding perceptions of the information and decision-maker approach to performing the task were also assessed. The dependent variables were evaluated for each task and not aggregated across tasks. The rest of this section describes the details associated with operationalizing these variables.

Table 4-7

Dependent Variables for Both Experiments

Dependent Variable	Measure
Decision Accuracy	% deviation from optimal
Decision Time	Experimental task time minus interruption task time
Information Quality	4 items from Bailey and Pearson (1983)
Information Usefulness	4 items from Bailey and Pearson (1983)
Information Comprehensiveness	3 items from Bailey and Pearson (1983)
Information Format	3 items from Bailey and Pearson (1983)
Information Reliability	4 items from Bailey and Pearson (1983)
Confidence	3 items from Spurrier, Topi, and Valacich (1994)
Rational Approach	4 items from Spurrier, Topi, and Valacich (1994)
Intuitive Approach	3 items from Spurrier, Topi, and Valacich (1994)
Task Importance	3 items from Spurrier, Topi, and Valacich (1994)
Use of Other Information	5 items from Spurrier, Topi, and Valacich (1994)
Interruption Influence	2 items from Corragio (1990)

4.7.1 Decision Accuracy

The evaluation of accuracy for each task was performed using an electronic worksheet. Decision accuracy was measured as the percentage deviation from optimal for all tasks. Each problem within a task had an optimal solution. The solution provided in the spreadsheet was compared to the optimal solution and an assessment was made. When the solution was non-numeric (Simple-Spatial tasks), a correct answered received 1 point and an incorrect answer received 0 points. When the solution was numeric (Simple-Symbolic, Complex-Symbolic, and Complex-Spatial), a percent deviation from optimal was assessed for each problem and then aggregated.

4.7.2 Decision Time

Decision time was measured in seconds and was equal to the time required for the experimental task minus the time required for the interruption task. The Timer function in Visual Basic was used to capture the start and stop time of each problem within the experimental tasks and each interruption task. The Timer function captures the number of seconds elapsed since midnight as measured by the internal clock of the PC. The program written to collect the decision time data was unobtrusive and masked from the subjects.

4.7.3 Perceptual Measures

A number of secondary dependent variables were measured to capture individuals' perceptions regarding the tasks and information used in the tasks (Appendix A). Two instruments were used to collect these measures: 1) items from the User Information Satisfaction instrument developed by Bailey and Pearson (1983) and 2) items previously used by Spurrier, Topi, and Valacich (1994). In addition, 5 questions were added from the Corragio (1990) study to assess subject attitudes regarding the influence of interruptions. Table 4-8 lists the constructs measured in this study and the original instrument the constructs came from.

Table 4-8

Attitudes and Perceptions to be Measured

Measures of Perceptual Constructs		
Bailey and Pearson (1983)	**Spurrier, Topi, and Valacich (1994)**	**Corragio (1990)**
Information Correctness	Confidence	Interruption Influence
Information Precision	Rational Approach	
Information Amount	Intuitive Approach	
Information Comprehensiveness	Solution Importance	
Information Usefulness	Use of Other Information	
Information Format	Amount of Information	

The constructs from the Bailey and Pearson instrument focus primarily on features of the information (correctness, precision, amount, comprehensiveness, usefulness, and format). Subject satisfaction with these dimensions of information provided additional data from which to compare differences between table and graph treatments. The items from the Spurrier, Topi, and Valacich (1994) instrument were used to assess the subject's perceptions regarding their performance (confidence) and what type of strategy they used to perform each task (rational and intuitive approach). Solution importance was used to subjectively assess the importance of obtaining a correct solution was to a subject. Finally, the Use of Other Information construct examined distinctions between the use of graphs or tables to support solving a task.

Confirmatory factor analysis and reliability analysis were assessed on both the data from Pilot Study 2 (Section 4.11) and the Main Study (Section 5.7). Results from these analyses suggest that the instruments had suitable psychometric properties.

4.8 Experimental Controls

The construction of the two experiments provided controls to eliminate variation for general task features and the task presentation (via a computer-based system). In addition, a number of individual factors were statistically controlled. Each of these are described below and presented in Table 4-9.

4.8.1 Task

All treatments received identical tasks presented electronically via a decision support system constructed by the researcher. All of the tasks are defined as decision (Campbell, 1988) or intellective tasks (McGrath, 1984). These task types have an optimal objective solution. The tasks used to operationalize each of the four experimental tasks are presented in the next sections.

4.8.1.1 Simple Tasks–Symbolic and Spatial

A task used in Umanath (1994) and Umanath, Scamell, and Das (1990) was used for both the symbolic and spatial tasks. This task presented machining center workload and capacity constraints for three machining centers over a six-month period. Subjects were asked six symbolic (simple-symbolic task) and six spatial (simple-spatial task) questions regarding the load on specific machining centers. Examples of the symbolic and spatial questions used in these tasks are presented in Appendix B and C.

4.8.1.2 Complex Task–Symbolic

This task involved making facility location decisions as described in Buffa (1980). Subjects solved this task for six different scenarios. Each scenario provided data on six potential warehouse sites. Subjects were given criteria to determine whether a specific site should be opened. At least one warehouse and as many as five warehouses met the criteria in each of the six scenarios. Examples of the facility location task are presented in Appendix D.

4.8.1.3 Complex Task–Spatial

This task involved an aggregate planning decision making task based on work originated by Holt, Modigliani, Muth, and Simon (HMMS) (1960). This aggregate planning task has been used in previous DSS research (Davis and Kotteman, 1994), including DSS research examining information presentation formats (Remus, 1984; Remus, 1987). The HMMS model is based on both linear and quadratic representation of costs that represent production scheduling for a firm. The original HMMS model was used by production planners to plan the number of workers required and the production volume of a product given a predetermined demand. The cost function for each period is the total of three quadratic cost functions and is automatically calculated by the DSS:

Workforce Level Change Cost =

$$64.3\ (\text{current workforce} - \text{new workforce})^2$$

Worker Overtime/Idle-time Cost =

$$.8\ ((\text{new workforce} * 5.67) - \text{new production})^2$$

Non-optimal Inventory Cost =

$$.02\ (\text{current inventory} + \text{new production} - \text{new demand} - 320)^2$$

Subjects were required to select the required workforce and production levels for a given period of plant operation. Subjects completed the task for eight periods of operation. However, the first two periods were used to bring the system to steady state and were not included as part of the subject's task performance. Subjects had a product demand forecast for the next three planning periods (Moskowitz and Miller, 1975; Remus, 1984), current inventory levels/inventory costs, and the costs of hiring and firing laborers available to them. Examples of the aggregate planning task are presented in Appendix E.

4.8.2 Task Presentation

The decision support system presented the task, interruptions, and questionnaires via a PC to the subjects. This DSS was constructed using Microsoft Excel with a Visual Basic front end. The DSS was designed to be highly usable (Shneiderman, 1987) following common user conventions to navigate and manipulate data. Cells available for data entry were well identified and presented in the same color across experimental and interruption tasks. Users did not have access to the menu or worksheet tabs. Navigation through the DSS was handled by clicking on an "OK" button located in the lower right portion of the screen. The first and only exposure subjects had with the DSS tool was in the experimental session, thus DSS expertise was controlled.

Table 4-9

Controlled Variables for Both Experiments

Controlled Variable	Operationalized Level	Method
Task	Intellective tasks (McGrath)	Optimal solutions
DSS	Visual Basic/Microsoft Excel	Experimental session provided initial use
Subjects	Undergraduate students	P301 students
Domain Expertise	General Specific	Course grade Exam questions related to aggregate planning and facility location
Gender	Male/Female	Self-report
Cognitive Ability	Spatial orientation	Kit of Factor Referenced Cognitive Tests (Ekstrom, et al., 1976)
Interruption Task	Decision accuracy Decision time	# correct Seconds elapsed
Interruption Timing	Mid-process	Interruption occurs X seconds after a task event
Interruption Type	Face-to-face with no social characteristics	PC-based intervention from subject's manager. Does not allow for processing experimental and interruption task simultaneously.

4.8.3 Individual Factors

A number of user characteristics were discussed in section 2.3.2 as directly or indirectly influencing performance. Three individual difference characteristics were explicitly measured and controlled in the statistical analysis: domain expertise, gender, and spatial orientation ability. Domain expertise was measured using two metrics: 1) overall course grade in the introductory Production and Operations Management course and 2) performance on the second P301 exam on multiple choice questions related to aggregate planning and facility location problems. The course grade provided a measure of overall competency with respect to production and operations management concepts while the performance on exam questions provides a direct measure of the skills required to solve the tasks in this study.

Gender was measured through self-report data and spatial orientation ability was measured using the Kit of Factor Referenced Cognitive Tests (Ekstrom, French, Harman, and Dermen, 1976).

4.8.4 Interruptions

In addition to the individual difference characteristics, decision accuracy and decision time in performing the interruption tasks was also examined and statistically controlled. Although no evidence of this was seen in the pilot studies, it was possible for students to click on the OK button of the interruption task without attempting to solve the task. It was important to control for this possible behavior as "skipping" the interruption task would minimize the influence of the interruption.

Interruption tasks were constructed to cognitively engage the subject. These tasks were simple tasks (as defined by Einhorn and Hogarth, 1981) and required the subject to acquire information readily available. Trumbo, Noble and Swink (1967) suggested that the a priori difficulty of the interruption task was not predictive of the extent of interference on the primary task. Therefore, minor differences in difficulty between the interruption tasks should not influence performance on the experimental task (Appendix F).

In treatments which involved interruptions, the timing of the interruption was controlled. The interruption timing was configured to occur in the middle of processing. This mid-process interruption should cause greater capacity interference and forgetting than interruptions occurring towards the beginning or end of a subtask (Corragio, 1990; Schuh, 1978). Each interruption was timed to occur a specific number of seconds into a task. The time interval was 7 seconds after a new simple-symbolic or simple-spatial problem, 10 seconds after a new complex-symbolic problem, and 15 seconds after a new complex-spatial problem. The differences in timing between tasks was established to account for differences in the amount of information necessary for acquisition and question length. Pilot studies were used to insure that the interruption timing occurred mid-process.

The interruptions involved an electronic intervention to simulate face-to-face office interruptions from a superior requiring an immediate response. For each individual, the information presentation format used in the interruption tasks were either tabular (50% of interruptions) or graphical (50% of interruptions). The formats were divided evenly across the interruption tasks to minimize any learning effects related to performance on the experimental task. The subject was requested to click an OK button upon completing the task and was immediately returned to the task that was previously being performed.

4.9 Experimental Procedure

The description of the experimental procedure used in the laboratory experiments is divided into two sections: subject sample and a detailed description of the experimental session.

4.9.1 Sample

Subjects were recruited from P301, an undergraduate production and operations management course. Subjects had a course requirement to enroll in the P301 subject pool via a world wide web interface into the IDEAS database. This interface allowed for the gathering of demographic information across the entire subject pool. 295 subjects were enrolled in P301 during the Spring 1996 semester when data was collected. Students were not given a grade for participating in the experiment, but participation allowed them to earn ten points of credit (1%) toward their final grade.

Subjects were encouraged to work both quickly and accurately by offering cash incentives for the best overall performance as measured by decision accuracy per unit time. Subjects had the opportunity to earn $10 in addition to the course credit points earned for attending the session. Subjects participating in the first experiment (PRESENTATION) could earn $2.50 for each of the 4 tasks performed. Subjects participating in the INTERRUPTION DIMENSION experiment could earn $5.00 for each of the two tasks performed. In both experiments, the actual compensation earned was aggregated over the subject's performance on each of the tasks and compared to the task performance to other subjects in the same treatment. The top 10% of subjects in each treatment would earn either $2.50 or $5.00 for each task. Subjects in each treatment that performed tasks in the top 11-25% received either $1.25 or $2.50 (50% of maximum). Subjects in each treatment that performed tasks in the top 25-50% received $.50 or $1.00 (20% of maximum). Subjects performing in the lower 50% for each task received no compensation. As each of these values was aggregated across either 4 or 2 tasks, the individual compensation ranged from $0 to $10. Over 70% of subjects received compensation and qualitative feedback indicated that the opportunity to earn money encouraged the subjects to accurately and quickly perform the tasks.

Subjects participating in this study had prior experience with aggregate planning and facility location problems. Subjects completed assignments and received course credit towards their grade for their homework on both types of tasks.

4.9.2 Experimental Session

The experimental procedures varied depending on the treatment to which a subject was randomly assigned. Prior to subject arrival to the experimental session, the researcher initiated the Microsoft Excel application and inserted a diskette containing an Excel file for the treatments being conducted. An envelope corresponding to the treatment containing paper materials was placed next to the PC. Two treatments were run simultaneously and were paired based on the similarity of training materials and the approximate session length (see Table 4-10). An experimental script (Appendix G) was used to conduct each of the sessions to insure consistency in instructions across sections.

Table 4-10

Experimental Treatments: Pairings

Experiment	Treatment
PRESENTATION	Interruption/Tables No Interruption /Tables
	Interruption/Graphs No Interruption /Graphs
INTERRUPTION DIMENSION	Low Frequency/Similar Content Low Frequency/Different Content
	High Frequency/Similar Content High Frequency/Different Content

Subjects were asked to read and sign the "Informed Consent Statement" (Appendix H) that described the general purpose of the experiment and a description of the compensation associated with their participation. After completing the consent statement, subjects completed each of two parts of the spatial orientation instrument (Appendix I).

Instructions describing the spatial orientation test provided by the Educational Testing Service were read to the subjects. Subjects spent one minute performing a practice test before performing the first part of the spatial orientation test. Three minutes were allocated to complete each part with a 1 minute break between parts.

Following completion of the instrument, the researcher conducted a short training session to familiarize the subjects with the DSS, the tasks, and the information available to solve the tasks (Appendix J). Training took approximately 20 minutes. The researcher answered any questions that were raised and explained the system that was used to award the compensation dollars in detail.

Subjects then performed each task in the treatment they were assigned to. The order of the tasks were counterbalanced across treatments. Subjects were asked to perform each task as quickly and accurately as possible. After each task, the DSS delivered a post-test instrument to the subject to record their attitudes regarding the task, information, and perceptions of their task performance. Upon completion of the questionnaire, the next task appeared on the PC screen for the subject to perform.

In treatments that involved interruptions, interruption tasks were presented in a random order during the processing of an experimental task to minimize learning effects. The interruption informed the subject that his or her manager requested some information. A new screen that contained information and a specific question or questions to be answered appeared. Subjects performed this task (extracting information, manipulating information, calculating information) and input the task solution into the DSS. In treatments that did not involve interruptions, subjects completed the interruption tasks either before or after the experimental tasks.

A final screen appeared on the PC monitor upon completion of the last questionnaire. Subjects were thanked for their time, informed that they would be notified regarding any compensation earned, and told that they could leave the experimental session. The entire experimental session lasted approximately 2 hours..

4.10 Power Analysis

A power analysis was conducted using the procedures described in Cohen (1975) to determine an acceptable sample size to detect medium size effects. This analysis suggested that at an alpha level of .05, a sample size of 45 subjects per cell in the PRESENTATION experiment and 26 subjects per cell in the INTERRUPTION DIMENSION experiment were required to achieve the minimum desired power level of .80.

4.11 Chapter Summary

Chapter 4 presented the research methodology implemented to test that hypotheses derived from the research model The two laboratory experiments conducted in this study were presented. A description of the independent, dependent, and controlled variables and the experimental procedures used in the experiments were described. The hypotheses tested were presented as were results from the two pilot studies.

Chapter 5 will present the statistical methods that were used to analyze the experimental data and the results of the hypothesis testing.

CHAPTER 5

ANALYTICAL PROCEDURES AND RESULTS

This chapter presents the results of the statistical analyses on the experimental data. The experimental sample and subjects are described first, followed by the statistical methods used to analyze the data. The assumptions related to these statistical techniques and appropriate manipulation checks are then presented. Data analysis is presented in two sections. The first section presents the results of hypothesis testing. The second section reports post hoc analyses conducted to more fully examine relationships under investigation in this study. Results from the post hoc analyses are used to interpret in more depth the findings from hypothesis testing. Chapter 5 concludes with a summary of the primary findings of the studies.

5.1 Descriptive Data About Sample and Subjects

Subjects in these studies were students enrolled in I-Core (the Integrative Core consisting of Introductory Finance, Marketing, and Operations Management) during the second semester of 1995-1996. I-Core is a required component of the Business major and is typically the first set of courses taken upon formal admission to the School of Business. All of the students in the subject pool were enrolled in I-Core for the first time during the Spring of 1996 insuring that students had similar exposure to the course content. In addition, these students were all business majors indicating a fairly homogeneous sample. Finally, over 90% of the students in the subject pool were in their junior year. Therefore, there was very little variation on year in school or subject's age. The only demographic factor captured that varied across the sample was gender. Table 5-1 summarizes sample sizes by treatments including a breakdown on gender.

285 subjects were enrolled in the experimental pool, 257 of whom volunteered to participate in the experiment yielding a participation rate in excess of 90%. Due to computer problems, the data from 19 subjects could not be used, giving a usable sample size of 238 subjects. All subjects were randomly assigned to one of eight treatments across the two experiments.

Table 5-1

Subject Gender by Treatment

Treatment	I/G	I/T	NI/G	NI/T	LF/SC	LF/DC	HF/SC	HF/DC	TOTAL
Male	23	26	17	25	18	21	14	15	159
Female	11	9	17	10	8	5	10	9	79
Total	34	35	34	35	26	26	24	24	238

Key: I=interruptions, NI=no interruptions, G= graphs, T=tables, LF=low frequency, HF=high frequency, SC=similar content, SD=different content

Chi-square tests were conducted on gender to check for possible differences among treatment groups. The chi-square statistic was 9.50 (d.f. = 7) with a p-value of .219, indicating no significant differences.

5.2 Statistical Method

This section presents the analytical techniques used to evaluate the experimental data, control variables, and assumptions underlying the use of the statistical tests. A univariate approach was used to assess the experimental data. Lindman (1992) discusses the trade-off between univariate and multivariate statistical tests. He suggests that if the different dependent variables are regarded as a single underlying trait, multivariate tests should be used. However, if the "interest is primarily in the individual behavioral measures, then univariate tests are more appropriate", (page 330). Therefore, ANOVA, ANCOVA, and post-hoc planned comparisons were used to analyze the data.

5.2.1 Controlled Variables

Table 5-2 presents each of the covariates examined and the measures used. Specific individual characteristics (gender, spatial orientation, domain expertise) were examined as covariates influencing decision accuracy and time together with the independent variables. (See Chapters 2 and 4 for details regarding the need to control these variables). These individual characteristics could not be randomly assigned prior to the experiment and were therefore controlled statistically. The use of ANCOVA is recommended when the covariates under examination are independent of the main and interaction effects (Lindman, 1992). In this study, gender, spatial orientation, and domain expertise should all be independent from the manipulated variables: work environment, information presentation format, task type, interruption frequency, and interruption content. Lindman suggests that in these situations, "the effect of the covariate is to reduce the within-subject error, increasing the power of the test and eliminating most interpretation problems" (1992; page 345). Thus, gender, spatial orientation, and domain expertise control variables were all included as covariates in the ANCOVA model for each hypothesis tested.

In addition to statistically controlling for specific individual characteristics, it is also important to examine individual performance on the interruption tasks. An individual may respond to interruptions in a number of different ways. For example, the interruption tasks could be performed poorly or well, quickly or slowly. It is expected that interruption task performance will be equally distributed across subjects within a treatment. However, it is possible that a specific treatment (e.g., interruption frequency) might encourage subjects to respond to the interruptions in a similar fashion, for example to "blow off" the interruption. It is important therefore, to examine the interruption task decision accuracy and interruption task decision time measures to discern whether there are significant differences between treatments in how subjects addressed the interruptions. Interruption task performance measures need to be statistically controlled if interruption task performance significantly influences experimental task performance.

Linear regression was used to determine if the interruption decision accuracy and decision time variables had significant explanatory power in determining the dependent variables in each treatment. Two types of relationships appear across treatments: 1) better performance on the interruption task performance variables was related to better performance on the experimental task, and 2) lower performance on the interruption task performance variables was related to better performance on the experimental task. In the first case, the positive relationship between interruption and experimental task performance can be explained by subject ability and the interruption variables were not controlled. However, in the second case, it appeared that the subjects might have been quickly clicking on the OK button of the interruption task without making a credible attempt to solve the problem. In this situation, it was necessary to control for the way in which the subject responded to the interruption. To accomplish this, decision accuracy and time variables for the interruption tasks were included with the individual characteristics as covariates in the ANCOVA model. The results of the regression analysis suggested that four hypotheses required controlling interruption task decision accuracy and decision time and these variables were only controlled for these four statistical tests. These results are presented in Section 5.5, Hypothesis Testing and in Appendix M.

Results were recorded as statistically significant if the p-value was less than or equal to .05. Results are recorded as marginally significant if the p-value was less than or equal to .10.

Table 5-2

Covariates and Measures

Covariate	Measure
Gender	Self-report
Domain Expertise	Second P301 exam performance
Spatial Orientation	Average score from two parts of spatial orientation cognitive ability test
Interruption Task Decision Accuracy	Number of interruption problems with correct answers aggregated within each task
Interruption Task Decision Time	Time expended responding to interruption problems aggregated within each task

5.2.2 Assumptions Underlying Statistical Analyses

A number of assumptions underlie the use of ANOVA and ANCOVA and the experimental data must be tested to insure that the assumptions are met. These assumptions are: 1) the population scores are normally distributed; 2) the variance is homogeneous within cells; and 3) all scores are independent of other scores (Lindman, 1992). When sample sizes are equivalent and relatively large, the F-test is generally robust to violations of these assumptions. All of the tests conducted in this study are made between cells with fairly large, equal sample sizes. Unfortunately, what constitutes a "large" sample size is open to interpretation. Therefore, appropriate statistical tests were used to examine the assumptions.

First, Kolmogorov-Smirnov tests were conducted to assess the distribution of the dependent variables in each treatment. None of the tests of normality within each cell were significant for either dependent variable. Therefore, the assumption of normal distributions within treatments was satisfied.

Second, the Levene test was used to assess the homogeneity of variances. The Levene test is computed performing a 1-way ANOVA on the absolute difference of each case from the mean. The Levene test was not significant for either dependent variable in any of the treatments. The assumption of equal variances within each treatment was therefore satisfied.

Third, random assignment of subjects to treatments was used to insure the independence of scores.

In addition to the ANOVA assumptions, Lindman (1992) suggests that the use of ANCOVA requires that all dependent variables and covariates be related in a linear fashion and that the slope of the linear functions should be the same for all treatments in the experiment. Lindman suggests, however, that the implications from violating these assumptions are not understood nor are there adequate tests for examining these assumptions. The covariates in these experiments met the assumption of independence from the dependent variable, and were therefore felt to be appropriate to use in the analysis of variance procedure.

5.3 Manipulation Checks

Manipulation checks are used to assess the adequacy of the experimental manipulations. The majority of the experimental manipulations in this study were distinctions between treatments, and are therefore, examined in Section 5.5, Results of Hypothesis Testing.

The remaining manipulation check that needs to be examined is the distinction between simple and complex tasks. In the first experiment, subjects performed four tasks, two that were considered simple and two that were considered complex. The tasks were selected based on a theoretical definition of task complexity discussed in Chapter 2 and 4. It was expected that there would be significant differences between pairs of simple and complex tasks, and no significant differences between simple-simple and complex-complex pairs of tasks. Decision accuracy could not be compared between tasks as neither the simple tasks nor complex tasks were explicitly designed to be equivalent. T-tests were performed to compare the time required to complete each pair of simple and complex tasks. Table 5-3 presents the results of this analysis. As anticipated, there were significant differences between each of the complex-simple task pairs (including Complex-Spatial and Simple-Symbolic at .051). None of the differences in time required to complete the simple-simple and complex-complex pairs were significant at .05 or better, as expected.

Table 5-3

Manipulation Check Between Simple and Complex Tasks

Task Type and Completion Time Pairs	t	d.f.	p-value
Complex-Symbolic and Simple-Symbolic	10.15	65	.000
Complex-Symbolic and Simple-Spatial	15.700	64	.000
Complex-Spatial and Simple-Symbolic	1.966	65	.051
Complex-Spatial and Simple-Spatial	2.092	64	.040
Complex-Symbolic and Complex-Spatial	1.740	65	.086
Simple-Symbolic and Simple-Spatial	1.293	64	.211

5.4 Hypothesis Testing

This section describes scoring procedures for decision accuracy and decision time scoring and the results testing the hypotheses.

5.4.1 Scoring Procedures for Decision Accuracy and Decision Time

As described in Chapter 4, each of the tasks performed in both experiments had an optimal solution. As none of the hypotheses required comparisons between tasks, it was not essential that each task be scored in an identical fashion. Each of the tasks was scored as either a percentage of the optimal score or a percentage deviation from the optimal score. The tasks were scored electronically using an Excel spreadsheet that compared the value in the appropriate cell to the optimal solution. Table 5-4 presents a synopsis of the scoring procedures.

The simple-symbolic task was scored in the following fashion: each of the six problems that made up the simple-symbolic task was scored as the percent deviation from optimal [Absolute Value ((answer - optimal answer)/optimal answer)]. Each of the problem deviation scores was aggregated to form a total percent deviation from optimal for the simple-symbolic task. Therefore, the lower the score, the more favorable the performance.

Table 5-4

Decision Accuracy and Decision Time Performance Scoring

Task Type	Scoring Method	Score Interpretation
Decision Accuracy		
Simple-Symbolic	% deviation from optimal for each of 6 problem aggregated to form overall task score.	lower is better
Simple-Spatial	1 point for each of 6 correct problems aggregated to form task total divided by 6 (optimal score) giving % of optimal	higher is better
Complex-Symbolic	1 point for each correct open/do not open decision and 1 point for correct order for each of 6 problems aggregated to form task total divided by 53 (optimal solution) giving % of optimal	higher is better
Complex-Spatial	Aggregate the total period cost from Period 3-Period 8 to obtain overall total cost divided by $41,874 giving % optimal	lower is better
All Interruption Tasks	1 point for each correct problem aggregated to form task total divided by the number of interruptions for each task giving % of optimal	higher is better
Decision Time		
All Experimental Tasks	Time to complete problem minus any time taken to respond to interruptions aggregated across all problems in the task	lower is better
All Interruption Tasks	Time to complete problem aggregated across all problems in the task	lower is better

The simple-spatial task was scored as correct or incorrect. The answers to these questions were non-numeric answers such as a month or product. Therefore, each of the six problems was scored as a 0 (incorrect) or 1 (correct). The problem scores were aggregated to form a task score ranging from 0-6.

The aggregated score was divided by 6 to obtain the percentage of optimal task score. Therefore, the higher the score, the more favorable the performance.

The complex-symbolic task was scored using a combination of two methods. For each problem, one point was awarded for each correct decision regarding the opening or non-opening of the six warehouses. Although the number of warehouses to be opened varied across problems, a maximum of 6 points was awarded if the correct warehouses were opened. The problem also required subjects to rank order the facilities they opened beginning with the lowest cost facility. For each correct ranking decision, the subject was awarded one point. The ranking evaluation was based on the facilities the subject decided to open. If the subject only opened 3 warehouse when there should have been 4 opened, but all were in the correct order, the subject was assessed three points. Likewise, if the subject opened 5 warehouses when only 4 should have been opened, a maximum of 4 points were awarded if the warehouses were placed in the correct order. The total possible points for each of the six problems therefore, ranged from 7 to 11 points with a potential task total of 53. The six problem totals were aggregated to form an overall task total and then divided by 53. Therefore, the higher the score, the more favorable the performance.

Finally, the complex-spatial task was scored by aggregating the total costs of Periods 3-8 to obtain an overall total cost for the task. This total was divided by the optimal total cost of $41,874 to obtain the percent deviation from optimal. Because the goal of this task was to minimize the overall total cost, the lower the score, the more favorable the performance.

Decision time for all four tasks was recorded in the same fashion. The experimental application kept track of the time expended for each problem, as well as the time expended for each interruption. Total problem time (within each task) was calculated as the total problem time minus total interruption time, where total interruption time was the time taken up by all the interruptions that occurred during a problem solution. In the treatments without interruptions, the measure of decision time was the total problem time. The total problem time for each problem within a task was aggregated to form the overall task decision time.

5.4.2 Hypothesis Testing Results

The ANCOVA results for the test of each hypothesis are presented in Tables 5-5 and 5-6. Table 5-5 presents the means and standard deviations for the each hypotheses. Table 5-6 presents the experiment number, hypothesis number, experimental manipulation, degrees of freedom, F-statistic, and p-value for the same hypothesis. Each row of the table represents a hypothesis presented in Chapter 4 and more fully described in the following sections. Each row in table 5-6 corresponds to the same row number in Table 5-5.

5.4.2 Task Type and Work Environment (H1)

Hypotheses 1A-1D examined decision accuracy and decision time on simple and complex tasks performed with interruptions. Each hypothesis was tested using the interruption factor as the independent variable. Hypotheses 1A that simple tasks would be performed more accurately with interruptions, are stated as follows:

> H1A1: Decision makers perform simple-symbolic tasks more accurately with interruptions than without interruptions.
>
> H1A2: Decision makers perform simple-spatial tasks more accurately with interruptions than without interruptions.

Table 5-5

Summary of Means and Standard Deviations for each Hypothesis

Row	Exp. #	Hypothesis	Mean 1 (s.d.)	Mean 2 (s.d)
			No Interruption	Interruption
1	1	H1A1	3.30 (1.251)	3.87 (1.254)
2	1	H1A2	.735 (.208)	.793 (.130)
3	1	H1B1	154.43 (51.094)	138.95 (50.428)
4	1	H1B2	57.32 (12.594)	42.62 (13.974)
5	1	H1C1	.756 (.159)	.702 (.148)
6	1	H1C2	11.71 (5.120)	19.36 (6.597)
7	1	H1D1	306.29 (152.940)	366.77 (149.373)
8	1	H1D2	1074.61 (361.528)	1007.11 (340.208)
			Tables	Graphs
9	1	H2A	2.85 (1.627)	4.33 (1.836)
10	1	H2B	158.57 (51.871)	134.80 (44.318)
11	1	H2C	.717 (.183)	.811 (.102)
12	1	H2D	58.11 (31.880)	41.83 (24.314)
13	1	H2E	.753 (.177)	.704 (.122)
14	1	H2F	1225.64 (162.880)	846.19 (132.182)
15	1	H2G	19.19 (11.247)	11.15 (8.684)
16	1	H2H	1673.32 (601.602)	1149.86 (496.840)
			Tables	Graphs
17	1	H3A	147.80 (53.501)	130.09 (50.691)
18	1	H3B	.678 (.166)	.729 (.115)
19	1	H3C	1316.67 (170.736)	1296.88 (130.168)
			Low Frequency	High Frequency
20	2	H4A1	.870 (.113)	.794 (.191)
21	2	H4A2	10.08 (8.674)	11.00 (7.499)
22	2	H4B1	832.80 (163.19)	1437.09 (258.76)
23	2	H4B2	1216.50 (471.96)	2232.29 (827.42)
			Similar Content	Different Content
24	2	H5A1	.85 (.160)	.81 (.150)
25	2	H5A2	10.12 (8.505)	10.91 (8.801)
26	2	H5B1	1110.38 (610.25)	1848.94 (718.59)
27	2	H5B2	1319.57 (747.83)	1824.19 (833.57)

Table 5-6

Summary of F and p-values for each Hypothesis

Row	Exp. #	Hypothesis	Manipulation/D.V.	d.f.	F	p-value
			Work Environment X Task			
1	1	H1A1	Accuracy (Sim-Sym)	1,131	.626	.430
2	1	H1A2	Accuracy (Sim-Spa)	1,131	4.080	.045**
3	1	H1B1	Time (Sim-Sym)	1,132	2.845	.094*
4	1	H1B2	Time (Sim-Spa)	1,132	2.829	.095*
5	1	H1C1	Accuracy (Com-Sym)	1,131	5.261	.023**
6	1	H1C2	Accuracy (Com-Spa)	1,131	3.041	.084*
7	1	H1D1	Time (Com-Sym)	1,131	3.415	.067*
8	1	H1D2	Time (Com-Spa)	1,131	.265	.607
			Information Presentation Format X Task			
9	1	H2A	Accuracy (Sim-Sym)	1,132	4.175	.043**
10	1	H2B	Time (Sim-Sym)	1,131	7.072	.009***
11	1	H2C	Accuracy (Sim-Spa)	1,132	10.654	.001***
12	1	H2D	Time (Sim-Spa)	1,132	11.46	.001***
13	1	H2E	Accuracy (Com-Sym)	1,127	5.618	.019**
14	1	H2F	Time (Com-Sym)	1,127	10.109	.002***
15	1	H2G	Accuracy (Com-Spa)	1,131	2.832	.050**
16	1	H2H	Time (Com-Spa)	1,131	11.092	.001***
			Work Environment X Information Presentation Format X Task			
17	1	H3A	Time (Sim-Sym)	1,66	3.650	.048**
18	1	H3B	Accuracy (Com-Sym)	1,66	.158	.214
19	1	H3C	Time (Com-Sym)	1,66	.208	.650
			Frequency X Task			
20	2	H4A1	Accuracy (Com-Sym)	1,74	4.05	.039**
21	2	H4A2	Accuracy (Com-Spa)	1,74	.053	.819
22	2	H4B1	Time (Com-Sym)	1,74	25.216	.000***
23	2	H4B2	Time (Com-Spa)	1,74	26.129	.000***
			Content X Task			
24	2	H5A1	Accuracy (Com-Sym)	1,74	1.436	.235
25	2	H5A2	Accuracy (Com-Spa)	1,74	.006	.937
26	2	H5B1	Time (Com-Sym)	1,74	11.62	.001***
27	2	H5B2	Time (Com-Spa)	1,74	7.08	.009**

The statistical results from the ANCOVA used to test these hypotheses are presented in Table 5-5: Row 1 and Row 2, respectively. The domain expertise control variable was significant for the test of interruptions on decision accuracy for the simple-symbolic task (see Appendix M). The control variables for the test of interruptions on decision accuracy for the simple-spatial task were not significant. The result of testing the work environment variable on decision accuracy for the simple-symbolic task was not significant ($p = .430$). The interruption treatment resulted in significantly higher decision accuracy ($p = .045$) than the no-interruption treatment when performing the simple-spatial task. Hence, Hypothesis 1A1 is not supported and Hypothesis 1A2 is supported.

Hypotheses 1B that simple tasks are performed more quickly with interruptions, are stated as follows:

> H1B1: Decision makers perform simple-symbolic tasks more quickly with interruptions than without interruptions.
>
> H1B2: Decision makers perform simple-spatial tasks more quickly with interruptions than without interruptions.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 3 and Row 4, respectively. The control variables for the test of interruptions on decision time were non-significant for both the simple-symbolic and simple-spatial tasks both having p-values greater than .05. The difference in the means are marginally significant for both the simple-symbolic ($p =.094$) and simple-spatial task ($p = .095$) and in the direction hypothesized with the interruption treatment resulting in significantly less decision time. Hence, hypotheses 1B1 and 1B2 are marginally supported.

Hypotheses 1C that complex tasks are performed less accurately with interruptions, are stated as follows:

> H1C1: Decision makers perform complex-symbolic tasks less accurately with interruptions than without interruptions.
>
> H1C2: Decision makers perform complex-spatial tasks less accurately with interruptions than without interruptions.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 5 and Row 6, respectively. The domain expertise control variable was significant for the test of interruptions on decision accuracy for the complex-symbolic task (see Appendix M). The control variables for the test of interruptions on decision accuracy were not significant for the complex-spatial task. The difference between the means of the complex-symbolic task was significant at .023, while the differences for the complex-spatial task was marginally significant at .08. The difference between the means for both tests was in the direction hypothesized with the no-interruption treatment having higher decision accuracy than the interruption treatment. Hence, hypothesis 1C1 is supported and hypothesis 1C2 is marginally supported.

Hypotheses 1D that complex tasks are performed less quickly with interruptions, are stated as follows:

> H1D1: Decision makers perform complex-symbolic tasks less quickly with interruptions than without interruptions.
>
> H1D2: Decision makers perform complex-spatial tasks less quickly with interruptions than without interruptions.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 7 and Row 8, respectively. The control variables for the test of interruptions on decision time for the complex-symbolic task were not significant. The linear regression used to assess the significance of the interruption performance measures on the complex-spatial task suggested that interruption decision accuracy and decision time should be included as covariates (see Appendix M). The spatial-interruption decision time control variable was significant for the test of interruptions on decision time for the complex-spatial task (see Appendix M). The p-value for the influence of interruptions on complex-symbolic decision time is marginally significant at .067, however, the p-value for complex-spatial decision time is .607. The decision time for the complex symbolic task is in the direction hypothesized with the no-interruption treatment requiring less time than the interruption treatment. Hence, there is marginal support for hypothesis 1D1 and no support for hypothesis 1D2.

A summary of the results of Hypothesis 1 is presented in Table 5-7.

Table 5-7

Summary of Hypothesis 1

Hypothesis	Dependent Variable	Outcome	Support
H1A1: Simple-Symbolic H1A2: Simple-Spatial	Decision Accuracy	N.S. I > NI**	Not Supported Supported
H1B1: Simple-Symbolic H1B2: Simple-Spatial	Decision Time	I > NI* I > NI*	Marginally Supported Marginally Supported
H1C1: Complex-Symbolic H1C2: Complex-Spatial	Decision Accuracy	NI > I ** NI > I*	Supported Supported
H1D1: Complex-Symbolic H1D2: Complex-Spatial	Decision Time	NI > I * N.S.	Partially Supported Not Supported

* significant < .1 ** significant < .05
I=Interruption treatment NI = No Interruption treatment

5.4.4 Task Type and Information Presentation Format (H2)

Hypotheses 2A-2H examine decision accuracy and decision time on simple and complex tasks using tabular and graphical information presentation formats. Each hypothesis was tested using the information presentation format factor as the independent variable. H2A that simple-symbolic tasks are performed more accurately with tables, is stated as follows:

> H2A: A simple-symbolic task is performed more accurately with tables than with graphs.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 9. The domain expertise control variable was significant for the test of information presentation format on decision accuracy for the simple-symbolic task (see Appendix M). The p-value was significant at .043 and the results were in the direction hypothesized with the tabular treatment resulting in higher decision accuracy than the graphical treatments. Hypothesis 2A is supported.

H2B that simple-symbolic tasks are performed more quickly with tables, is stated as follows:

> H2B: A simple-symbolic task is performed more quickly with tables than with graphs.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 10. The control variables for the test of information presentation format on decision time were not significant for the simple-symbolic task. The p-value for decision time was significant at .009. However, this p-value was not in the direction hypothesized. The graphical treatment resulted in significantly less decision time than in the tabular treatment. Hence, hypothesis 2B is not supported, and is contradicted. This contradiction will be discussed in Chapter 6.

H2C that simple-spatial tasks are performed more accurately with graphs than with tables, is stated as follows:

> H2C: A simple-spatial task is performed more accurately with graphs than with tables.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 11. The spatial orientation control variable was significant for the test of information presentation format on decision accuracy for the simple-spatial task (see Appendix M). The p-value for decision accuracy was significant at .001 in the direction hypothesized. The graphical treatment resulted in significantly higher decision accuracy than the tabular treatment. Hence, hypothesis 2C is supported.

H2D that simple-spatial tasks are performed more quickly with graphs, is stated as follows:

> H2D: A simple-spatial task is performed more quickly with graphs than with tables.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 12. The control variables for the test of information presentation format on decision time were not significant for the simple-spatial task. The p-value is significant at .001 and in the direction hypothesized. Graphical treatments resulted in significantly less decision time than tabular treatments. Hence, hypothesis 2D is supported.

H2E that feasibly-solvable complex-symbolic tasks are performed more accurately with tables, is stated as follows:

> H2E: A feasibly-solvable complex-symbolic task is performed more accurately with tables than with graphs.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 13. The domain expertise control variable was significant for the test of decision accuracy on the complex-symbolic task (see Appendix M). The p-value is significant at .019 and in the direction hypothesized. Tabular treatments resulted in higher decision accuracy than graphical treatments. Hence hypothesis 2E is supported.

H2F that feasibly-solvable complex-symbolic tasks are performed more quickly with tables, is stated as follows:

> H2F: A feasibly-solvable complex-symbolic task is performed more quickly with tables than with graphs.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 14. The control variables for the test of decision time on the complex-symbolic task were not significant. The p-value for decision time was significant at .002. However, this finding was not in the direction hypothesized. The graphical treatment resulted in significantly less decision time as compared to the tabular treatment. Hence, hypothesis 2F is not supported, and is contradicted. This contradiction will be discussed in Chapter 6.

H2G states that feasibly-solvable complex-spatial tasks are performed more accurately with graphs, is stated as follows:

> H2G: A feasibly-solvable complex-spatial task is performed more accurately with graphs than with tables.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 15. The control variables for the test of information presentation format on decision accuracy were not significant for the complex-spatial task. The p-value for decision accuracy was significant at .05 and in the direction hypothesized. The graphical treatment resulted in higher decision accuracy than the tabular treatment. Hence, hypothesis 2G is supported.

H2H that feasibly-solvable complex-spatial tasks are performed more quickly with graphs, is stated as follows:

> H2H: A feasibly-solvable complex-spatial task is performed more quickly with graphs than with tables.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 16. The control variables for information presentation format on decision time were not significant for the complex-spatial task. The p-value for decision time was significant at .001 in the direction hypothesized. The graphical treatment resulted in less decision time than the tabular treatment. Hence, hypothesis 2H is supported.

A summary of the results of Hypothesis 2 are presented in Table 5-8.

Table 5-8

Summary of Hypothesis 2 Testing

Hypothesis	Dependent Variable	Outcome	Support
H2A: Simple-Symbolic	Decision Accuracy	T > G**	Supported
H2B: Simple-Symbolic	Decision Time	G > T***	Contradicted
H2C: Simple-Spatial	Decision Accuracy	G > T***	Supported
H2D: Simple-Spatial	Decision Time	G > T***	Supported
H2E: Complex-Symbolic	Decision Accuracy	T > G**	Supported
H2F: Complex-Symbolic	Decision Time	G > T***	Contradicted
H2G: Complex-Spatial	Decision Accuracy	G > T**	Supported
H2H: Complex-Spatial	Decision Time	G > T***	Supported

5.4.5 Task Type, Information Presentation Format, and Work Environment (H3)

H3A-C examined the moderating influence of interruptions on the relationship between task type and information presentation format. Each hypothesis was tested using the information presentation format factor as the independent variable and only the interruption treatments were examined. H3A that when interrupted, decision time decreases for simple-symbolic tasks when graphs are used, is stated as follows:

> H3A: When interrupted, decision makers perform simple-symbolic tasks more quickly with graphs than with tables.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 17. The control variables for the test of interruptions and information presentation format on decision time were not significant. The p-value for decision time was significant at .048 in the direction hypothesized. The graphical treatment resulted in less decision time than the tabular treatment. Hence, hypothesis 3A is supported.

H3B that when interrupted, complex-symbolic tasks are solved more accurately with graphs, is stated as follows:

> H3B: When interrupted, decision makers perform feasibly-solvable complex-symbolic tasks more accurately with graphs than with tables.

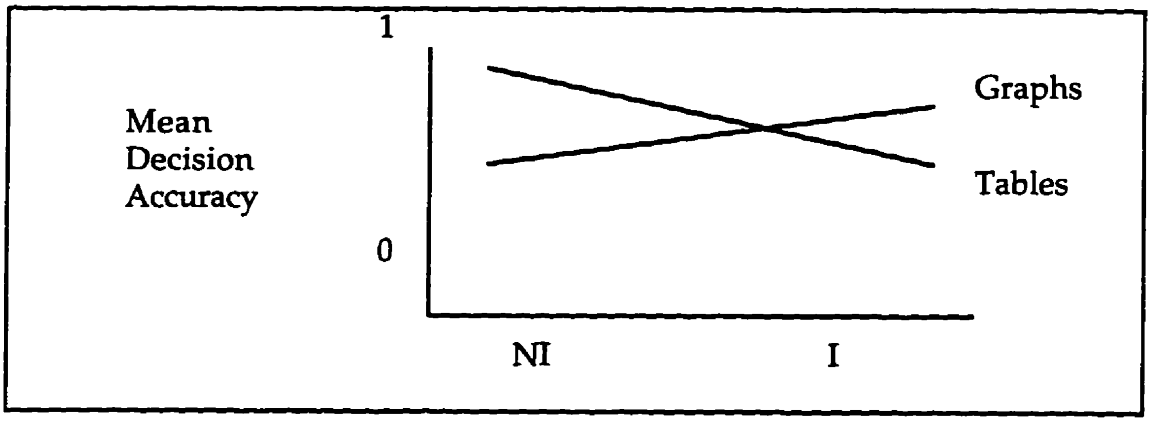
The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 18. The domain expertise control variable was marginally significant for the test of interruptions and information presentation format on decision accuracy and results (see Appendix M). The p-value for decision time was not significant at .214. Although the difference between the means was not significant, the results were in the direction hypothesized. The 2-way interaction between interruption treatment and information presentation format was examined to more clearly understand the influence of these independent variables. The No Interruption/Table treatment resulted in significantly higher decision accuracy than all other treatments. Although the results are not significant, the Interruption/Graph treatment resulted in greater decision accuracy than the No Interruption/Graph treatment as hypothesized (see Appendix M and Figure 5-1). **Hence, hypothesis 3B is not supported.**

H3C that when interrupted, complex-symbolic tasks are performed more quickly with graphs, is stated as follows:

> H3C: When interrupted, decision makers perform feasibly-solvable complex-symbolic tasks more quickly with graphs than with tables.

Figure 5-1

Influence of Interruptions and Information Presentation on Decision Accuracy for Complex-Symbolic Tasks



The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5, Row 19. The control variables for the test of interruptions and information presentation format on decision time was not significant for the complex-symbolic task. The p-value for decision time was not significant at .650. Hence, hypothesis 3C was not supported.

A summary of the results of hypothesis 3 are presented in Table 5-9.

Table 5-9

Summary of Hypothesis 3 Testing

Hypothesis	Dependent Variable	Outcome	Support
H3A: Simple-Symbolic	Decision Time	G > T**	Supported
H3B: Complex-Symbolic	Decision Accuracy	N.S.	Not Supported
H3C: Complex-Symbolic	Decision Accuracy	N.S.	Not Supported

5.4.6 Interruption Frequency (H4)

Hypotheses 4A-B examine the relationship between interruption frequency and decision accuracy and decision time. Each hypothesis was tested using the interruption frequency factor as the independent variable. Hypotheses H4A that decision accuracy would decrease when the frequency of interruptions increase, are stated as follows:

> H4A1: Feasibly-solvable complex-symbolic tasks will be performed less accurately when the frequency of the interruption is high rather than low.
>
> H4A2: Feasibly-solvable complex-spatial tasks will be performed less accurately when the frequency of the interruption is high rather than low.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5: Row 20 and Row 21, respectively. The spatial orientation control variable was significant for the test of interruption frequency on decision accuracy for the complex-spatial task (see Appendix M). The p-value for decision accuracy on the complex-symbolic task was significant at .039 in the direction hypothesized, while the p-value on the complex-spatial task was not significant at .819. The high frequency interruption treatment resulted in significantly lower decision accuracy than the low frequency treatment. Therefore, hypothesis 4A1 was supported and hypothesis 4A2 is not supported.

Hypothesis 4B that decision time would increase when there was an increased frequency of interruptions, are stated as follows:

> H4B1: Feasibly-solvable complex-symbolic tasks will be performed less quickly when the frequency of the interruption is high rather than low.

H4B2: Feasibly-solvable complex-spatial tasks will be performed less quickly when the frequency of the interruption is high rather than low.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5: Row 22 and Row 23, respectively. The linear regression used to assess the significance of the interruption performance measures suggested that interruption decision accuracy and decision time should be included as covariates as presented in Table 5-41 (complex-symbolic tasks) and Table 5-42 (complex-spatial tasks). The gender and interruption task decision accuracy control variables were significant for the test of frequency on decision time on the complex-symbolic task (see Appendix M). The interruption task decision accuracy control variable was significant for the test of frequency on decision time on the complex-spatial task (see Appendix M). Both of the p-values are highly significant at .000 and in the direction hypothesized. Treatments with a high frequency of interruptions performed the task less quickly than treatments with low frequency. Hence, hypothesis 4B1 and 4B2 are supported.

A summary of the results of hypothesis 4 are presented in Table 5-10.

Table 5-10

Summary of Hypothesis 4 Testing

Hypothesis	Dependent Variable	Outcome	Support
H4A1: Complex-Symbolic H4A2: Complex-Spatial	Decision Accuracy	LF > HF** N.S.	Partially Supported
H4B1: Complex-Symbolic H4B2: Complex-Spatial	Decision Time	LF > HF*** LF > HF***	Not Supported

5.4.7 Task/Interruption Content Similarity (H5)

Hypotheses 5A-B examined the relationship between the information content of the interruption with respect to the primary task and decision accuracy and decision time. Each hypothesis was tested using the interruption content factor as the independent variable. Hypotheses 5A that decision accuracy would decrease as the information used in the interruption task was more similar to the primary task, are stated as follows:

> H5A1: Feasibly-solvable complex-symbolic tasks will be performed less accurately when interruptions have similar information content to the primary task than when the information content is dissimilar.
>
> H5A2: Feasibly-solvable complex-spatial tasks will be performed less accurately when interruptions have similar information content to the primary task than when the information content is dissimilar.

The statistical results from the ANCOVA used to test this hypothesis are presented in Tables 5-5: Row 24 and Row 25, respectively. The control variables for the test of interruption content on decision accuracy were not significant for the complex-symbolic task. The domain expertise and spatial orientation control variables were significant or marginally significant for the test of interruption content on decision accuracy for the complex-spatial task (see Appendix M). Neither of the p-values were significant at the .05 level ($p=.235$ for the complex-symbolic task and $p=.937$ for the complex-spatial task) and therefore Hypothesis 5A is not supported.

Hypotheses 5B that decision time would increase as the information used in the interruption task was more similar to the primary task, are stated as follows.

> H5B1: Feasibly-solvable complex-symbolic tasks will be performed less quickly when interruptions have similar information content as the primary task than when the information content is dissimilar.

H5B2: Feasibly-solvable complex-spatial tasks will be performed less quickly when interruptions have similar information content as the primary task than when the information content is dissimilar.

The statistical results from the ANCOVA used to test this hypothesis are presented in Table 5-5: Row 26 and Row 27, respectively. The linear regression used to assess the significance of the interruption performance measures suggested that interruption decision accuracy and decision time should be included as covariates on the complex-symbolic task (see Appendix M). The gender, interruption task decision time, and interruption task decision accuracy control variables were significant for the test of decision time on the complex-symbolic task. The gender control variable was significant for the test of interruption content on decision time for the complex-spatial task (see Appendix M). Both p-values are highly significant at .001 and .009. However, these values are not in the direction hypothesized. Interruption treatments that contained similar information as the primary task resulted in less decision time than interruption treatments that contained different information from the primary task. Hence, hypotheses 5B1 and 5B2 are not supported, and are contradicted.

A summary of the results of hypothesis 5 are presented in Table 5-11.

Table 5-11

Summary of Hypothesis 5 Testing

Hypothesis	Dependent Variable	Outcome	Support
H5A1: Complex-Symbolic H5A2: Complex-Spatial	Decision Accuracy	N.S. N.S.	Not Supported
H5B1: Complex-Symbolic H5B2: Complex-Spatial	Decision Time	SC > DC*** SC > DC***	Contradicted

5.4.8 Summary of Hypothesis Testing

Predictions regarding the direct influence of interruptions on simple and complex tasks were generally supported. There was also general support for the relationships between information presentation format and task type as suggested by Cognitive Fit Theory. The moderating influence of interruptions on the information presentation format/task type relationship was not supported. Finally, general support was found for the influence of interruption frequency, but not for the influence of interruption content on decision accuracy and decision time. A more detailed discussion of these results is contained in Chapter 6.

5.5 Results of Post Hoc Statistical Analyses

In addition to the statistical testing of the hypotheses, post hoc statistical analyses were also performed. This post hoc analysis involved 1) examining the perceptual data collected during the experiment, and 2) a more extensive examination of interruptions as a moderating influence on information presentation format and task type. This section presents the validation of the instruments used in this study and the significant results of the post hoc analysis.

5.5.1 Instrument Validation

Two instruments were used to collect subjects' perceptions of the task and information used in the task. Principal components factor analysis using varimax rotation was used to assess both the Bailey and Pearson (1983) and the modified Spurrier et al. (1994) instruments. A seven-factor solution was expected from the Bailey and Pearson instrument and a six-factor solution was obtained explaining 74.7% of the variance. The items associated with the amount of information and the overall perception of the information loaded together on one factor and was labeled "Overall Information Usefulness". It consists of 3 items from the Amount of Information scale and 3 items from the Information Overall scale.

A seven-factor solution was expected from the Spurrier et al. instrument and a seven-factor solution explaining 62.9% of the variance was obtained. The seven factors were not the same as those seen in Spurrier et al. as the Intuitive Problem-Solving Approach factor did not emerge as a factor and the Use of Other Information factor appeared as two distinct factors.

As in the pilot study, the intuitive problem-solving approach did emerge as a factor. All of the items for this factor loaded with the rational approach items only with negative factor loading values. An attempt was made to force these negative factor loadings into another factor. However, the negative intuitive approach items remained with the positive factor loadings associated with the rational approach. All of the tasks were likely to be solved using a rational strategy, as all of the tasks performed in this experiment had an optimal solution. It is likely that the intuitive and rational items are seen as opposing items measuring a single construct based on the tasks used in this study. Therefore, the rational approach items were used to form a factor labeled as rational approach and the intuitive items were dropped from any subsequent examination.

In the pilot study, the Spurrier et al. factor labeled "Use of Other Information" appeared as two separate factors, "Use of Graphs" and "Use of Tables". That same distinction appeared in the factor analysis of the main study. Spurrier's original Use of Information factor generally examines preferences for graphic and tabular information presentation formats. However, the explicit focus on graphs and tables in this study appears to have created a distinction between the two formats, resulting in two different constructs.

Tables 5-12 and 5-13 present the factor loadings (by questionnaire item number), the factor eigenvalues, and reliabilities associated with each scale on the Bailey and Pearson and Spurrier et al. instruments, respectively.

ANOVA was used to assess whether there were significant differences between the experimental treatments on the perceptual measures from the questionnaires. Only the perceptual measures that are significant are presented in this section. Appendix M provides the complete results of all statistical tests on the perceptual measures.

5.5.2 Summary of Post Hoc Analyses

The purpose of the post-hoc analysis was to tease out perceptions about the task and performing the task that went beyond the objective performance measures. ANOVA was used to test the significance of each perceptual measure across the different treatments examined in the hypotheses and results are presented where the p-value for a specific test is less than .1. Table 5-14 presents the significant results of these tests by task type, while Table 5-15 presents the significant results by hypothesis. The results are presented in this way to facilitate identifying patterns in the data. The interpretation of these results are integrated with the results from the hypothesis testing and are presented in Chapter 6.

Table 5-12

Bailey and Pearson Factor Loadings and Reliabilities from Main Study

Factor Label	Item Number	Factor Loading	Eigenvalue	Cronbach's Alpha
Information Precision	2-A	.722	13.706	.913
	2-B	.764		
	2-C	.770		
	2-D	.740		
Overall Information Usefulness	6-A	.741	3.059	.906
	6-C	.785		
	6-D	.598		
	7-A	.773		
	7-B	.683		
	8-C	.687		
Information Format	5-A	.707	.958	.915
	5-B	.721		
	5-C	.778		
	5-D	.510		
Information Comprehensiveness	4-A	.747	1.178	.927
	4-B	.556		
	4-C	.761		
	4-D	.771		
Information Reliability	3-A	.747	1.127	.828
	3-B	.556		
	3-C	.761		
	3-D	.771		
Information Correctness	1-A	.755	.899	.876
	1-B	.797		
	1-C	.604		
	1-C	.512		

Table 5-13

Spurrier et al. Factor Loadings and Reliabilities from Main Study

Factor Label	Item Number	Factor Loading	Eigenvalue	Cronbach's Alpha
Confidence	9 14 26	.773 .779 .740	4.86	.788
Perception of Interruptions	8 13 19	.687 .817 .727	2.23	.621
Amount of Information	10 24	.830 .798	1.56	.680
Rationale Approach	11 18 22	.529 ..559 .747	1.45	.781
Use of Tables	23 27	.830 .834	1.38	.648
Solution Importance	12 15 29	.677 .779 .633	1.20	.801
Use of Graphs	17 25	.643 .761	1.18	.781

Table 5-14
Summary of Post-Hoc Analyses by Task Type

Dependent Variable	Simple-Symbolic Task	Simple-Spatial Task	Complex-Symbolic Task	Complex-Spatial Task
1) Negative Perception of Interruptions	I > NI*** (H1)	I > NI*** (H1)	I > NI*** (H1) G > T*** (H2) DC > SC* (H5)	DC > SC* (H5)
2) Amount of Information Makes Problem More Difficult		I > NI** (H1)	I > NI* (H1) I/T > NI/T** (H3) I/T > I/G** (H3)	HF > LF* (H4)
3) Confidence	I > NI** (H1) T > G* (H2)	T > G*** (H2)		T > G** (H2) LF > HF*** (H4)
4) Rational Problem Solving Approach	I > NI* (H1)		T > G** (H2)	
5) Number of Interruptions	G > T* (H2) NI/G > I/G*** (H3) NI/G > NI/T*** (H3)	T > G** (H2)	G > T** (H2)	
6) Information Comprehensiveness			T > G** (H2) HF > LF** (H4)	
7) Information Precision			I//G > NI/G* (H3) NI/T > NI/G* (H3) HF > LF** (H4)	NI/T > I/T** (H3) I/T > I/G** (H3)
8) Information Usefulness			I/G > I/T* (H3) HF > LF* (H4)	I/T > I/G* (H3)
9) Information Reliability		NI/T > NI/G* (H3)	HF > LF* (H4)	
10) Information Format			HF > LF*** (H4)	
11) Use of Tables			LF > HF* (H4)	

Table 5-15

Summary of Post-Hoc Analyses by Hypothesis

	Experiment 1			Experiment 2	
Dependent Variable	H1	H2	H3	H4	H5
1) <u>Negative Perception of Interruptions</u>					
-Simple-Symbolic	I>NI***				
-Simple-Spatial	I>NI***				
-Complex-Symbolic	I>NI***	G>T***			DC>SC*
-Complex-Spatial					DC>SC*
2) <u>Amount of Information Makes Problem More Difficult</u>					
-Simple-Spatial	I>NI**				
-Complex-Symbolic	I>NI*		I/T>NI/T**		
			I/T>I/G**		
-Complex-Spatial				HF>LF*	
3) <u>Confidence</u>					
-Simple-Symbolic	I>NI**	T>G**			
-Simple-Spatial		T>G***			
-Complex-Spatial		T>G**		LF>HF***	
4) <u>Rational Problem Solving Approach</u>					
-Simple-Symbolic	I>NI*				
-Complex-Symbolic		T>G**			
5) <u>Number of Interruptions</u>					
-Simple-Symbolic		G>T*	NI/G>I/G***		
			NI/G>NI/T***		
-Simple-Spatial		T>G**			
-Complex-Symbolic		G>T**			
6) <u>Information Comprehensiveness</u>					
-Complex-Symbolic		T>G**		HF>LF**	
7) <u>Information Precision</u>					
-Complex-Symbolic			I/G>NI/G*	HF>LF**	
			NI/T>NI/G*		
-Complex-Spatial			NI/T>I/T**		
			I/T>I/G**		
8) <u>Information Usefulness</u>					
-Complex-Symbolic			I/G>I/T*	HF>LF*	
-Complex-Spatial			I/T>I/G*		
9) <u>Information Reliability</u>					
-Simple-Spatial			NI/T>NI/G*		
-Complex-Symbolic				HF>LF*	
10) <u>Information Format</u>					
-Complex-Symbolic				HF>LF***	
11) <u>Use of Tables</u>					
-Complex-Symbolic				LF>HF*	

* = significant at .1, ** = significant at .05, *** = significant at .01

Key: I=interruptions, NI=no interruptions, G= graphs, T=tables,
LF=low frequency, HF=high frequency, SC=similar content, DC=different content

Post-hoc analysis was also used to examine the moderating influence of interruptions on the information presentation format and task processing relationship. Hypothesis 3 examined three relationships (simple-symbolic/decision time, complex-symbolic/decision accuracy, complex-symbolic/decision time) where interruptions were expected to moderate the relationships indicated by Cognitive Fit Theory. It was suggested that interruptions would not influence the remaining relationships (simple-symbolic/decision accuracy, simple-spatial/decision accuracy, simple-spatial/decision time, complex-spatial/decision accuracy, and complex-spatial/decision time indicated by Cognitive Fit Theory. The results of the hypothesis testing and post hoc results are presented in Table 5-16. The interpretation of these results are integrated with the results from the hypothesis testing and are presented in Chapter 6.

Table 5-16

The Moderating Influence of Interruptions on Task Type and Information Presentation Format

Task Type	Outcome
Decision Accuracy	
Simple-Symbolic Task	N.S. (.213)
Simple-Spatial Task	NI/G > NI/T** I/G > NI/T*** I/T > NI/T** I/G > I/T*
Complex-Symbolic Task (H3B)	N.S. (.214)
Complex-Spatial Task	N.S. (.280)
Decision Time	
Simple-Symbolic Task (H3A)	G > T**
Simple-Spatial Task	I/G > NI/G** I/G > I/T***
Complex-Symbolic Task (H3C)	N.S. (.650)
Complex-Spatial Task	N.S. (.136)

* = significant at .1, ** = significant at .05, *** = significant at .01

5.6 Chapter Summary

The planned statistical analysis examined the influence of interruptions and information presentation formats on decision accuracy and decision time. This analysis showed general support for the influence of interruptions and information presentation on decision-making performance. However, there was no support found for the hypotheses suggesting interruptions moderate the relationship between the information presentation format and task type (Hypotheses 3A-C).

The post-hoc analysis provides additional insight into the influence of interruptions on decision making. In many instances, interruptions appear to change the way in which the information used in the decision-making tasks is perceived. Chapter 6 discusses and interprets the results from both the planned and post-hoc analyses.

CHAPTER 6
DISCUSSION OF RESULTS

The broad problem area addressed by this research was to better understand the influence of interruptions on individual decision making. The decision-making model including interruptions described how interruptions were expected to influence decision performance, either directly or indirectly through decision task and information task characteristics. Four research questions were addressed in this research: 1) What is the effect of interruptions on certain types of tasks?; 2) When a decision maker is interrupted, do different information presentation formats facilitate decision-making performance on certain types of tasks?; 3) Does the frequency of interruptions affect decision-making performance on certain types of tasks?; and 4) Does the content of the interruption affect decision-making performance on certain types of tasks?

Propositions from the developed model posited that: 1) interruptions would influence both simple and complex tasks; 2) relationships suggested by Cognitive Fit Theory would exist for simple and complex tasks, and interruptions would, for some tasks, moderate this relationship; 3) interruption frequency and content characteristics would influence decision performance; and 4) interruption content would influence decision time.

Hypotheses applicable to each of the propositions were derived from the research model and were tested using 2 laboratory experiments. The next section interprets the results presented in Chapter 5. It is followed by a discussion of the implications of the findings for both theory and practice in the final section.

This chapter is structured as follows: 1) Section 6.1.1 presents the findings from this research study at a highly detailed level; 2) a summary level presentation of these findings is presented in Section 6.2; and 3) Section 6.3 discusses the implications of these research findings from both a theoretical and practical perspective.

6.1 Interpretation of Research Results

The purpose of this section is to integrate and discuss the findings presented in Chapter 5. This chapter is structured to focus on three key outcomes of this research: 1) the influence of interruptions on task performance, 2) the moderating influence of interruptions on information presentation format and task type, and 3) the effect of specific interruption dimensions on decision performance.

6.1.1 Influence of Interruptions on Task Performance

Hypotheses 1A-D examined the influence of interruptions on decision accuracy and decision time. The Yerkes-Dodson law was used as the basis for these hypotheses. Both simple and complex tasks were examined because interruptions were expected to influence the task types differently. The results of the statistical analyses provide partial support for the hypotheses that interruptions facilitate simple tasks and inhibit complex tasks.

6.1.1.1 Simple Tasks

There was partial support for interruptions facilitating decision accuracy on simple tasks. Decision accuracy on simple-spatial tasks was significantly higher with interruptions than without interruptions. There was no difference in decision accuracy between the interruption and noninterruption treatments on simple-symbolic tasks. With respect to decision speed, the statistical analyses provided marginal support for the hypotheses (p-values less than .1): subjects required less decision time when interrupted for both simple-symbolic and simple-spatial tasks. Figures 6-1 and 6-2 illustrate the relationship between interruptions and decision performance across simple task types.

Figure 6-1

The Influence of Interruptions on Decision Accuracy Across Simple Task Types

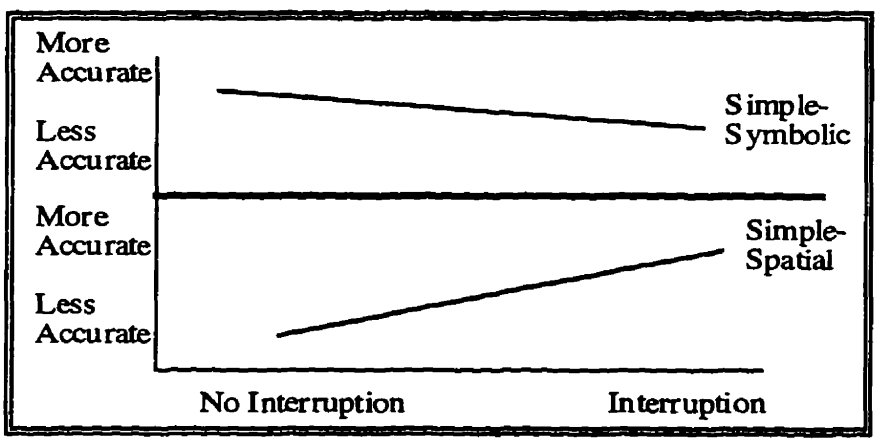
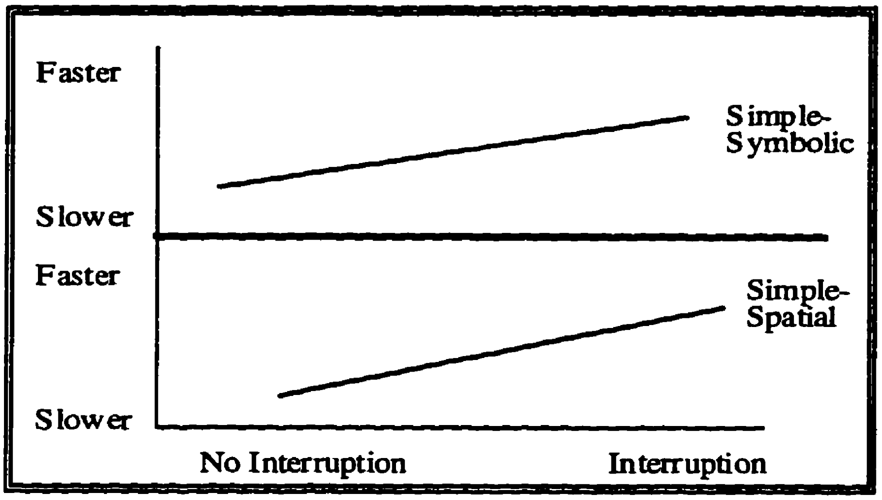


Figure 6-2

The Influence of Interruptions on Decision Time Across Simple Task Types



Interruptions may not have significantly influenced decision accuracy on the simple-symbolic task for two reasons. First, the simple-symbolic task consisted of several problems that required a varying amount of computational effort. It is possible that some of the problems requiring more computational effort might not be simple enough to be positively influenced by interruptions. When all the problems are aggregated together, the potentially positive interruption interference on the very simple tasks might be diluted by the influence of interruptions on the "less simple" simple-symbolic tasks. Second, it is possible that the strong influence of domain expertise, with greater domain expertise resulting in higher decision accuracy, may have masked any significant relationship with interruptions.

Although decision accuracy did not differ significantly for the interruption and no-interruption treatments for simple-symbolic tasks, interruptions did seem to influence perceptions of the task and problem-solving strategy. Interestingly, subjects in the interruption treatment perceived that interruptions negatively influenced performance; yet had higher confidence in their solutions than did subjects in the no-interruption treatment. In addition, subjects in the interruption treatment were more likely to report using a rational problem-solving approach than subjects in the no-interruption treatment. It is possible that interruptions changed their problem-solving strategy for this task. Subjects might have perceived the interruptions as negative influences, and therefore felt it necessary to follow a well-defined strategy to solve these problems. Following this rational strategy might have resulted in greater confidence in their solutions over subjects in the no-interruption treatment. Of course, there were no real differences in decision accuracy between the two groups. It does appear, however, that interruptions may influence the strategy used and perceptions about the success of solving the problem.

Subjects in the interruption treatment perceived that simple-spatial tasks were more difficult to solve due to the overall amount of information presented in the problem. As with the simple-symbolic tasks, it appears that interruptions can influence perceptions regarding the information used in the task in addition to the influence on decision accuracy.

6.1.1.2 Complex Tasks

Decision accuracy was significantly inhibited by interruptions for complex-symbolic tasks and marginally inhibited for complex-spatial tasks. Additionally, subjects who were interrupted during the complex-symbolic task required significantly more time to complete the task (greater decision time) than subjects who were not interrupted. There was no difference in the time required to complete the complex-spatial tasks with and without interruptions. Figures 6-3 and 6-4 illustrate the relationship between interruptions and decision performance across complex task types.

Figure 6-3

The Influence of Interruptions on Decision Accuracy Across Complex Task Types

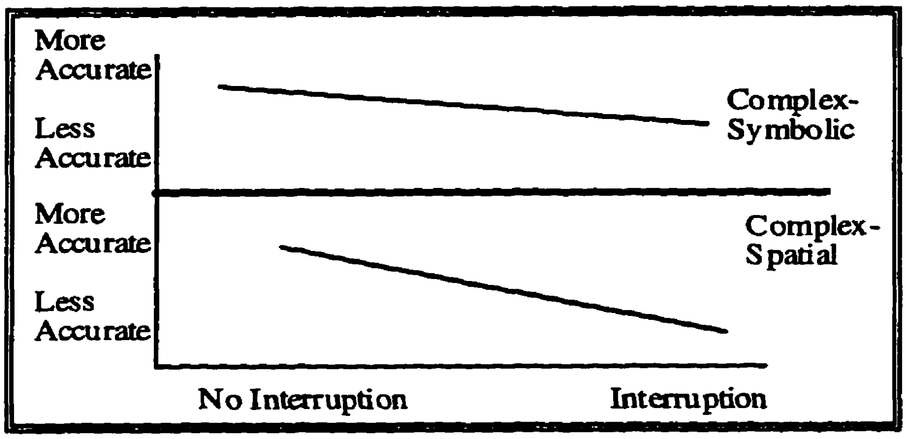
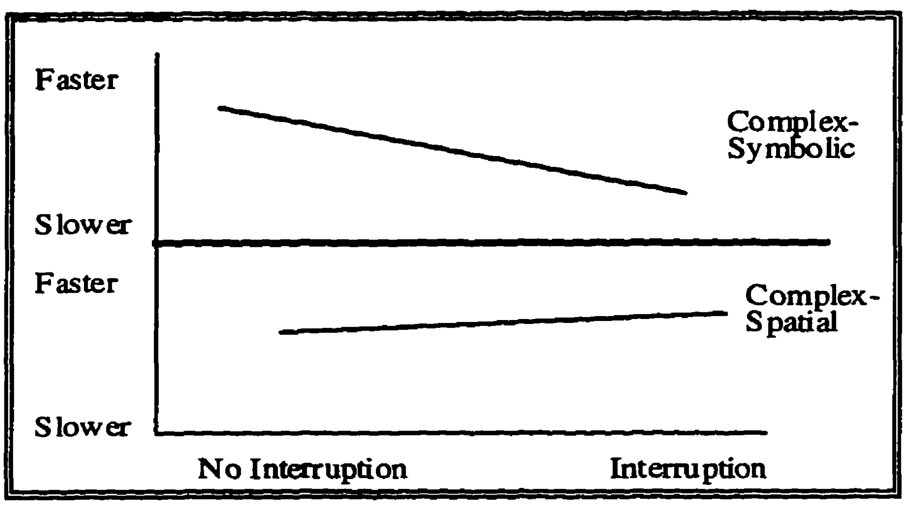


Figure 6-4

The Influence of Interruptions on Decision Time Across Complex Task Types



The significance of the interruption performance control variables might explain the lack of significant findings on decision time for the complex-spatial task. The Beta values for the interruption decision time and decision accuracy control variables suggest that decision time on the complex-spatial task increased when subjects performed the interruptions more quickly and less accurately. Therefore, it appears that subjects completing the complex-spatial task did not "faithfully" perform the interruption tasks. It appears that these subjects may have traded-off lower decision accuracy for less decision time. This possibility might explain why no significant interruption effect was seen for the complex-spatial task.

The complex-spatial task was the only task for which interruptions were not perceived as having a negative influence. The complex-spatial task took more time to complete than any of the other tasks and subjects may have felt the interruptions were less intrusive given the overall time required to complete the task. In addition, interruption accuracy and time significantly influenced decision time for complex-spatial tasks, suggesting the interruptions were not faithfully performed. The combination of these factors might explain why interruptions did not significantly influence decision performance and negative perceptions regarding interruptions.

Subjects in the interruption treatment perceived that the complex-symbolic tasks were more difficult due to the overall amount of information presented in the problem. Consistent with the findings on the perception of interruptions on simple tasks, it appears that interruptions also influence the perceived difficulty and the actual performance on the complex task.

Finally, as with the simple-symbolic task, the domain expertise control variable exerted a significant influence on decision accuracy for the complex-symbolic task. These results suggest that domain expertise influences decision accuracy on symbolic task types. The same effect is not seen on spatial tasks.

6.1.1.3 Summary

These results generally support the Yerkes-Dodson Law and Distraction-Conflict Theory (Yerkes and Dodson, 1908; Baron, 1986).

Generally, interruptions facilitate decision-making accuracy and time on simple tasks and impair decision accuracy and time on complex tasks. Interestingly, subjects in the interruption treatment perceived that interruptions negatively influenced performance in all but the complex-spatial task. This negative perception about the influence of interruptions was apparent from the perceptual measures even though subjects performing the simple tasks had higher decision accuracy with interruptions. This finding suggests that even in the situations where interruptions might improve or not influence decision accuracy, subjects perceive interruptions to be negative.

6.1.2 Moderating Influence of Interruptions on Information Presentation Format and Task Type

This section first describes the influence of information presentation on decision accuracy and time. The specific hypotheses were developed from Cognitive Fit Theory (Vessey, 1991). Simple and complex tasks were examined. The moderating influence of interruptions on the information presentation format and task type is also presented.

6.1.2.1 Interpretation

The results of the statistical analyses suggest there is general support for the relationships suggested by Cognitive Fit Theory. Past research has demonstrated the fit between type of task and information presentation format for simple tasks. These results, which extend Cognitive Fit Theory to feasibly-solvable complex tasks, are consistent with previous findings except for the decision time findings on symbolic tasks which indicated less decision time when using graphical presentation formats. In addition, there was little support for the hypotheses suggesting that interruptions moderate the relationships predicted by Cognitive Fit Theory. However, there are indications that interruptions do change some of the relationships between information presentation format and task type as described in Section 6.1.2.3.

6.1.2.2 Cognitive Fit Relationships

Simple-Symbolic Tasks. Decision accuracy was significantly higher when simple-symbolic tasks were addressed using tables (a symbolic format) than with graphs as predicted by Hypothesis 2A. Counter to Hypothesis 2B, there was not a "fit" relationship between decision time and information presentation format. Subjects using graphs (spatial format) required significantly less decision time than subjects using tables. An explanation for the non-significant decision time finding might involve the specific nature of the simple-symbolic problems. Some of these problems required computations and involved simple information evaluation processes. It is possible that subjects using the graphical format believed they had no chance of obtaining an optimal solution and could only perform a best guess estimate for these computations resulting in decreased decision accuracy and less decision time. At the same time, subjects in the tabular treatment took the necessary time required to perform the computations, slowing decision time, but resulting in higher decision accuracy.

With respect to the perceptual data, subjects preferred to have fewer, longer interruptions in the tabular treatment than in the graphical treatment. This result might suggest that subjects had more difficulty or took more time recovering from interruptions in the tabular treatment as they had to re-perform computations. Alternatively, subjects in the graphical treatment should have been able to recover from the interruptions without having to perform computations and could more easily recover from the interruptions.

Not surprisingly, subjects in the tabular treatment had greater confidence in their solutions over subjects using graphical data. Tabular data facilitated performance of this task as the purpose was to find specific data values. Subjects using tabular data felt they had answered the questions adequately, while subjects in the graphical treatment felt they were giving their best estimate.

As with the interruption/simple-symbolic task relationship, domain expertise was a significant control variable influencing decision accuracy with greater domain expertise resulting in higher decision accuracy.

Simple-Spatial Tasks. The hypotheses that simple-spatial tasks would be best supported by graphical information presentation formats for both decision accuracy and decision quality were supported.

With respect to the perceptual data, subjects in the graphical treatment preferred to have fewer, longer interruptions than subjects in the tabular treatment. This result is the opposite of that found for the simple-symbolic task where subjects in the graphical treatment preferred more interruptions. Taken together, these results might suggest that subjects consciously or subconsciously identify a "fit" between the task type and information presentation format. When a match occurs between task and format, subjects prefer to have fewer interruptions in order to process the task. On the other hand, when the information does not match the task, additional processing is necessary to manipulate information into the appropriate form to respond to the question (as indicated by Cognitive Fit Theory). In this situation, the additional processing necessary to address the interruptions may not be perceived as adding any significant processing overhead beyond that which is performed to manipulate the information. Therefore, subjects who experience a mismatch between task and information format may not care as strongly about the number of interruptions as they are already performing additional task processing.

Although the graphical treatment resulted in higher decision accuracy and time, subjects in the tabular treatment were more confident in their solutions than those in the graphical treatment. Generally, subjects may feel more confidence in determining the correctness of a problem when they have numeric information that allows them to unequivocally determine the correct answer. The use of graphical information often requires an estimate or comparison between bar charts that may appear to have similar values and subjects must rely on perceptual processes to determine an answer as opposed to determining the solution computationally. However, it also appears that subjects may be over confident in their ability to manipulate tabular information. Subjects made mistakes using the tabular data resulting in lower decision accuracy even though they believed that their decision accuracy would improve with tabular data.

Complex-Symbolic Tasks. Hypothesis 2E and 2F suggested that complex-symbolic tasks would be solved more accurately and quickly using tabular data. The findings suggest that higher decision accuracy occurs when tabular formats are used to solve complex-symbolic tasks. Similar to the simple-symbolic task, there was a significant relationship between decision time and information presentation format. However, this relationship was not in the direction hypothesized and subjects using graphical data required significantly less decision time than those using tabular data.

As with the simple-symbolic tasks, the complex-symbolic tasks required computations on the available information to accurately solve the problems. Subjects in the graphical treatment could only perform best guess estimates, which took less time to perform than the computations of the tabular group. Therefore, use of graphical formats resulted in faster, yet less accurate decisions.

With respect to perceptual data, subjects using tabular data preferred fewer, longer interruptions than subjects using graphical data. As with the simple-symbolic task, this finding is consistent with subjects not wanting frequent interruptions when having to perform and likely re-perform computations on data. Not surprisingly, the mean preferred number of interruptions is lowest for complex symbolic-tasks than for any of the other task types. This result might suggest that as the number and frequency of the computations increases, fewer interruptions are desired.

In addition to the significant difference in the number of desired interruptions between information presentation treatments, there was also a significant difference between treatments with regard to the perceptions of interruptions. Subjects using graphs perceived interruptions as significantly inhibiting their performance compared to subjects using tables. Subjects using graphs were expected to be less bothered by the interruptions; so this finding is surprising. It is possible that general frustration with solving the complex-symbolic problems with graphical data was exacerbated by interruptions and the combination resulted in the perception regarding interruptions.

Similar to the simple-symbolic task, subjects in the tabular treatment were more likely to use a rational approach for solving these problems. Subjects using graphs would have had to rely on "intuitive" guesses or estimation. Therefore, the fact that subjects had to estimate answers might explain the significant difference on this perceptual measure.

Similarly, subjects using tabular data believed their information to be significantly more comprehensive than those using graphs. Although the two treatments had the same information, subjects using the graphical format would have to estimate their solutions resulting in a possible feeling of incomplete or inadequate information. This finding supports the general suggestion of Cognitive Fit Theory that fit between information presentation format and task results in minimal cognitive effort while lack of fit results in information being manipulated to solve the problem, and hence the perceptions of increased effort.

Finally, consistent with the previous findings on both simple and complex symbolic tasks, domain expertise was a significant covariate influencing decision accuracy, with greater domain expertise resulting in higher decision accuracy. It appears that greater domain expertise strongly influences performance on symbolic tasks as opposed to spatial tasks. This may be a spurious relationship where the underlying influence is related to mathematical problem solving ability.

Complex-Spatial Tasks. Hypotheses 2G and 2H suggested that graphical information presentation formats would result in higher decision accuracy and less decision time on complex-spatial tasks. The results of the statistical analyses support these hypotheses.

Similar to the simple-spatial tasks, subjects using tabular formats had greater confidence in their solutions than those using graphical formats, even though graphical formats resulted in higher decision accuracy. It would appear that the use of tables gives subjects a feeling of confidence in their ability to successfully achieve a solution, even though the resulting outcome is not consistent with this confidence.

Summary. The performance relationships between information presentation format and task type were supported for all tasks except for decision time on both simple and complex symbolic tasks. In both instances, decision-making was faster with graphs, counter to expectations. Generally, it takes less time to perceptually compare bar charts than to perform computations on tabular data. Therefore, subjects using graphical data performed these tasks more quickly, but less accurately.

Subjects tended to have greater confidence in their solutions when tabular data was used, even when graphs facilitated decision accuracy (simple-spatial and complex-spatial tasks). This increased confidence is likely to come from the increased precision that can be gained when using tabular data. The apparent comfort with tabular data can also be seen with the perception that tabular data provides greater information comprehensiveness and facilitates using a rationale problem-solving approach.

There appears to be a relationship between the desired number of interruptions, the information presentation format, and task type. For simple-symbolic, simple-spatial, and complex-symbolic tasks, subjects prefer to have fewer, longer interruptions when using the information presentation format that matches the task type according to Cognitive Fit Theory. It may be that when fit exists, subjects are able to quickly understand how to solve the problem and an increased number of interruptions interferes with their ability to process the task. On the other hand, when there is a task type/information presentation format mismatch, subjects have to manipulate the data to successfully solve the problem. In this case, an increased number of interruptions does not interrupt the processing as severely as when information does not have to be manipulated.

6.1.2.3 Moderating Influence of Interruptions

This section discusses the influence of information presentation format and interruptions on decision accuracy and decision time. Three hypotheses were presented (simple-symbolic tasks and decision time; complex-symbolic tasks and decision accuracy and decision time) in Chapter 4 where interruptions were believed to moderate the relationship between information presentation format and decision accuracy or decision time. The remaining five task/performance relationships (simple-symbolic tasks on decision accuracy; simple-spatial tasks on decision accuracy and decision time; and complex-spatial tasks on decision accuracy and decision time) were also examined and all of the results are presented below.

Simple-Symbolic Tasks. Interruptions were not expected to moderate the relationship between information presentation format and decision accuracy on simple-symbolic tasks. There was a significant positive relationship between the use of tables and decision accuracy without interruptions. However, there was no significant effect for information presentation format when interruptions occurred, resulting in comparable decision accuracy for both tables and graphs. Therefore, interruptions did change the relationship between information presentation format and task type. It is possible that interruptions more strongly disrupt subjects using tabular data due to information overload and increased computation errors related to manipulating tabular data.

It was hypothesized that subjects using graphical formats would require less decision time on simple-symbolic tasks with interruptions (H3A). The results of the statistical analysis support this hypothesis. As presented in Section 6.1.2, there was also a significant relationship between graphical formats and decision time without interruptions. Therefore, it cannot be suggested that interruptions moderate the relationship between information presentation format and decision time for simple-symbolic task since the relationship is the same with or without interruptions. However, both of these results are counter to the prediction of Cognitive Fit Theory. Figures 6-5 and 6-6 illustrate the performance relationships between interruptions and information presentation format on simple-symbolic tasks.

Figure 6-5
The Influence of Interruptions and Information Presentation Format on Decision Accuracy For Simple-Symbolic Tasks

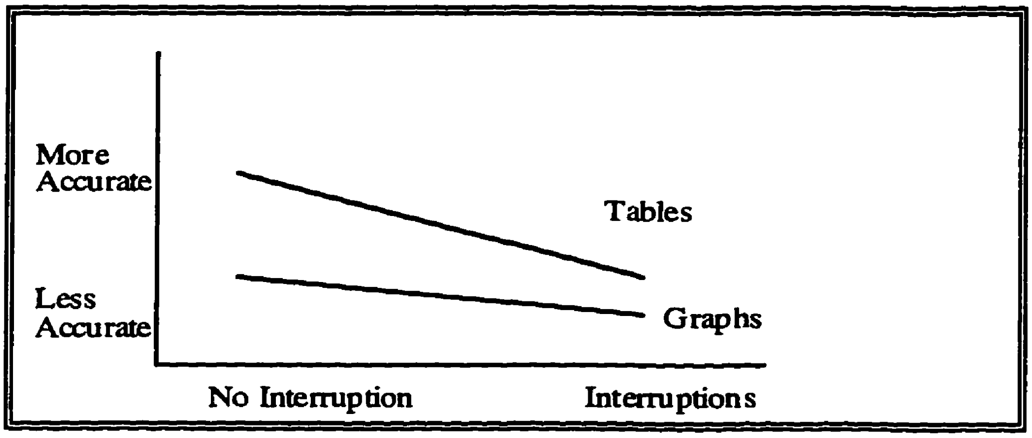
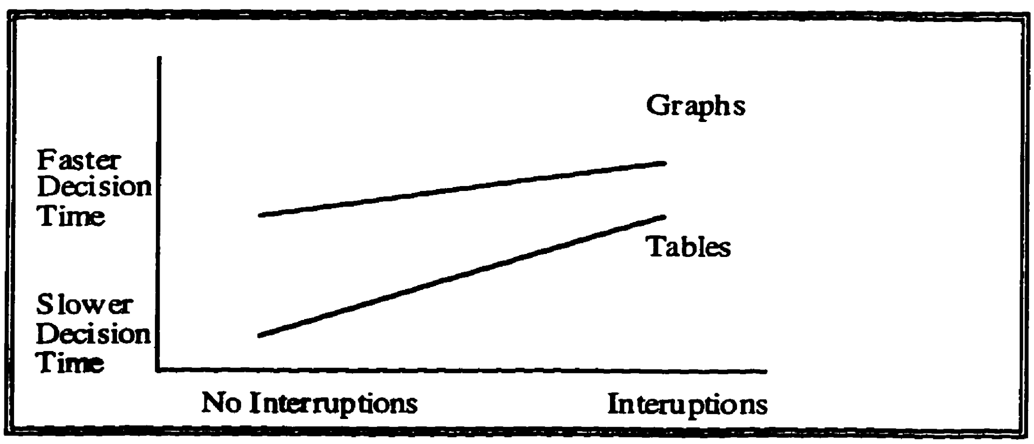


Figure 6-6
The Influence of Interruptions and Information Presentation Format on Decision Time For Simple-Symbolic Tasks



The only significant perceptual measures for the simple-symbolic tasks were perceptions regarding the influence of interruptions and the number of interruptions on performance. Subjects using tabular data believed that interruptions significantly impaired performance compared to those who did not have interruptions. This finding would be consistent with interruptions impairing performance with tables more so than graphs as seen in the results of the statistical testing.

With respect to the number of interruptions desired, there was a significant difference between the interruption and no-interruption treatments for subjects using graphical data. Subjects using graphs who experienced interruptions preferred to have fewer, longer duration interruptions than those who did not experience interruptions. Interestingly, there was a significant difference across different information presentation format treatments for subjects who did not experience interruptions. Subjects using tabular data indicated that they would prefer fewer, longer interruptions than those using graphical data. The relationships observed in the perceptual data are congruent with the findings of the objective performance measures. With interruptions, tables no longer facilitate decision accuracy and in fact, are perceived as inhibiting the success performance of the task.

Simple-Spatial Tasks. Interruptions were not expected to moderate the relationship between information presentation format and both decision accuracy and decision time for simple-spatial tasks. The results of the data analyses indicate significant relationships between information presentation format and both decision accuracy and decision time when interruptions occur. Consistent with Cognitive Fit Theory, the use of graphs result in increased decision accuracy and less decision time when interruptions occur. These significant relationships also exist when interruptions do not occur. Therefore, interruptions do not moderate the relationships predicted by Cognitive Fit Theory for simple-spatial tasks. Figures 6-7 and 6-8 illustrate the performance relationships between interruptions and information presentation format across simple task types.

Figure 6-7
The Influence of Interruptions and Information Presentation Format on Decision Accuracy For Simple-Spatial Tasks

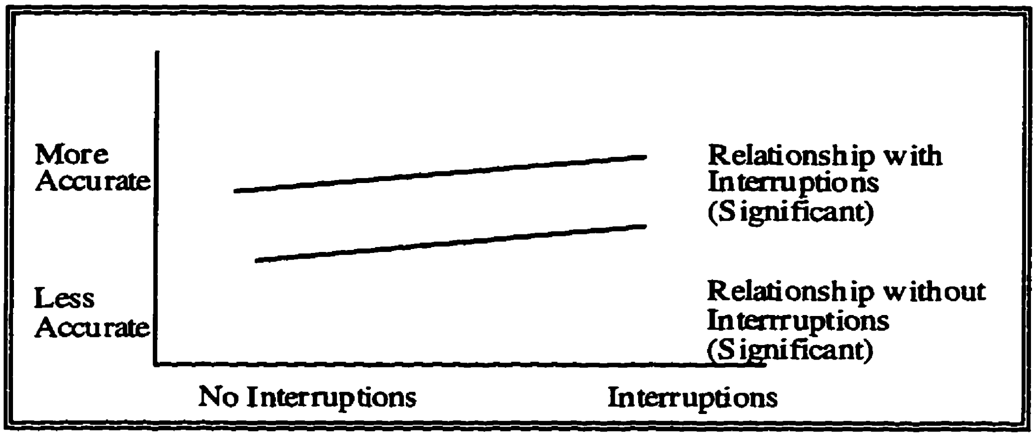
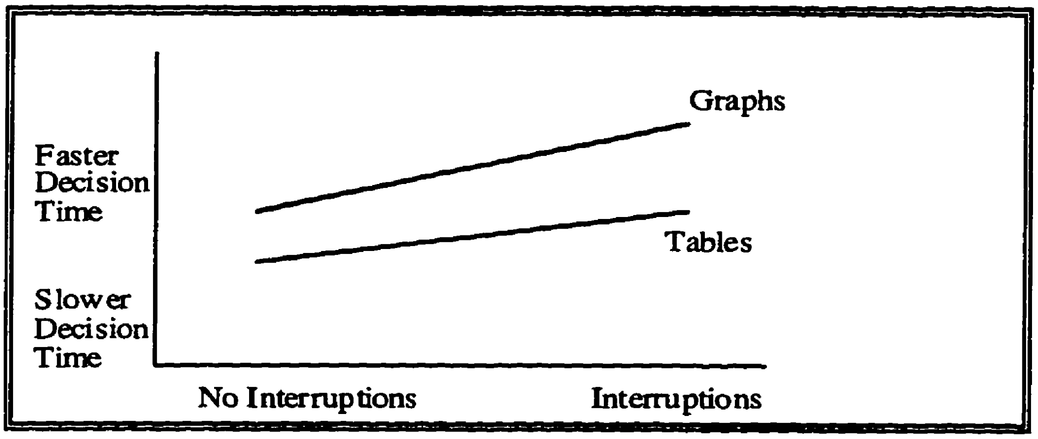


Figure 6-8
The Influence of Interruptions and Information Presentation Format on Decision Time For Simple-Spatial Tasks



Complex-Symbolic Tasks. Interruptions were hypothesized to moderate the relationship between information presentation format and decision accuracy for complex-symbolic tasks. The results of the statistical analyses indicate that the relationship is not significant. The difference between the means is in the direction hypothesized with subjects using graphs having increased decision accuracy over those using tables. Upon examination of the post-hoc planned comparison, subjects in the no-interruption/table treatment had significantly higher decision accuracy than all other treatments. Subjects in the interruption/graph treatment demonstrated the next highest decision accuracy, while there was virtually no difference in decision accuracy between the no-interruption/graph and the interruption/table treatments at the low end of decision accuracy (See Figure 6-9).

Interruptions were also hypothesized to moderate the relationship between information presentation format and decision time for complex-symbolic tasks. There is no significant information presentation format effect. This result is particularly interesting as the use of the graphical format resulted in significantly faster decisions without interruptions. It was hypothesized that with interruptions, graphs would result in less decision time. However, based on the post-hoc planned comparison, it appears that when interrupted, subjects using tables perform the task somewhat more quickly than those without interruptions, while those using graphs perform the task somewhat more slowly than those without interruptions. Figures 6-9 and 6-10 illustrate the performance relationships between interruptions and information presentation format across simple task types.

Figure 6-9
The Influence of Interruptions and Information Presentation Format on Decision Accuracy For Complex-Symbolic Tasks

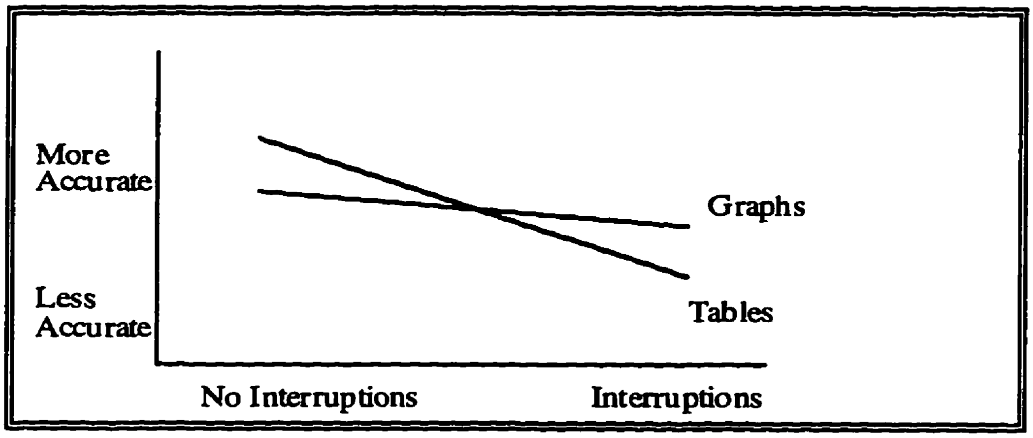
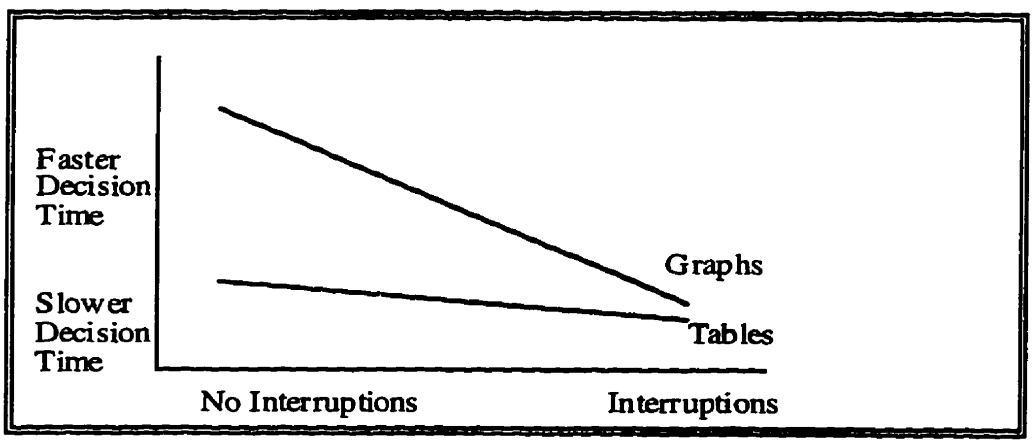


Figure 6-10
The Influence of Interruptions and Information Presentation Format on Decision Time For Complex-Symbolic Tasks



Interruptions, therefore, do influence the relationship between information presentation format and complex-symbolic tasks. Tabular formats no longer provide a significant improvement in decision accuracy and graphs no longer facilitate decision time when interruptions occur.

However, neither information presentation format clearly improves decision-making performance.

The perceptual measures suggest a number of significant relationships associated with interruptions and information presentation format on complex-symbolic tasks. Subjects using tables perceive the information to be significantly more precise than those using graphs in the no-interruption treatment. However, there are no significant differences between the information presentation format treatments when interruptions occur. This finding might suggest that concerns regarding the quality of the information are diminished when subjects must spend time and effort attending to interruptions.

Conversely, subjects using graphs in the interruption treatment found the information in the graphs to be significantly more useful than those subjects using tables. This supports the general notion behind H3 suggesting that perceptual cues inherent in graphical formats allow subjects to recover more quickly and with less effort from interruptions and would therefore improve performance. Although the performance measures were not significant, this result might indicate that the process of interruption recovery was facilitated.

Similarly, subjects using tables perceived that the amount of information used to make a decision made the task significantly more difficult than those using graphs in the interruption treatment. There was also a significant difference between subjects in the no interruption/table treatment and those in the interruption/table treatment. Subjects in the interruption/table treatment believed the task was more difficult to perform due to the amount of information. As with the information usefulness measure, these findings might suggest that interruptions do affect the processing of information in such a way that interruption recovery was facilitated using graphs.

Finally, subjects in the interruption/graph treatment perceived the information format to be more useful than those in the interruption/table treatment. This finding is consistent with the other perceptual measures suggesting that interruptions influence individual's perceptions regarding various aspects of the information. In this case, subjects experiencing interruptions perceived graphs to be more useful even though tabular formats resulted in better performance.

Complex-Spatial Tasks. Interruptions were not expected to moderate the relationship between information presentation format and complex-spatial tasks on both decision accuracy and decision time. The results of the statistical analyses suggest there are no significant differences between the use of tabular and graphical formats when interruptions occur, while significant differences do exist when interruptions do not occur. Similar to the results of the simple-symbolic tasks, this is counter to what was expected. Without interruptions, there was a significant relationship between information presentation format and performance with graphs resulting in significantly higher decision accuracy and less decision time. With interruptions, graphs no longer result in superior performance. The post-hoc planned comparison suggests that subjects in the no interruption/graph treatment exhibit the highest decision accuracy, followed by the interruption/graph and no-interruption/table treatments which have similar decision accuracy performance. Finally, the interruption/table treatment exhibits the lowest decision accuracy.

As expected, the post-hoc planned comparisons for decision time suggest that graphs do facilitate faster decision making than tables with or without interruptions. The decision time for both the interruption/graph and no-interruption/graph treatment is significantly less than either the interruption/table or no-interruption/table treatments. Figures 6-11 and 6-12 illustrate the performance relationships between interruptions and information presentation format across simple task types.

Figure 6-11
The Influence of Interruptions and Information Presentation Format on Decision Accuracy For Complex-Spatial Tasks

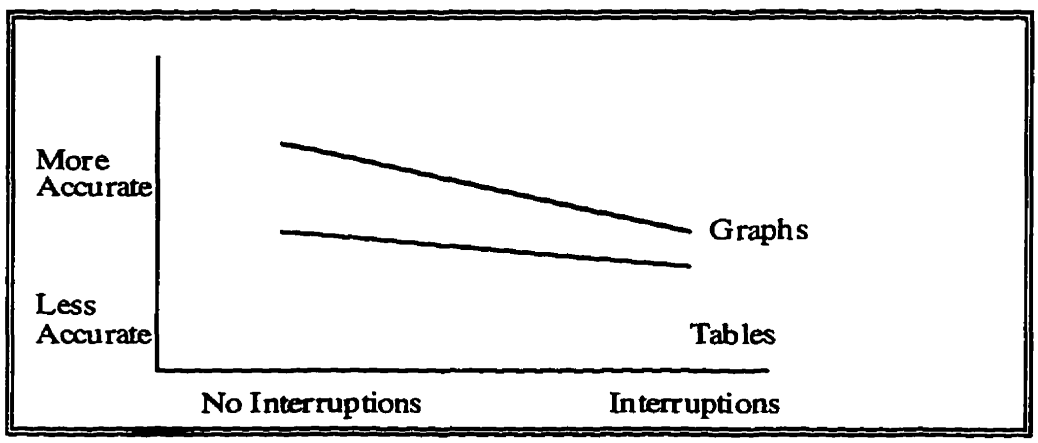
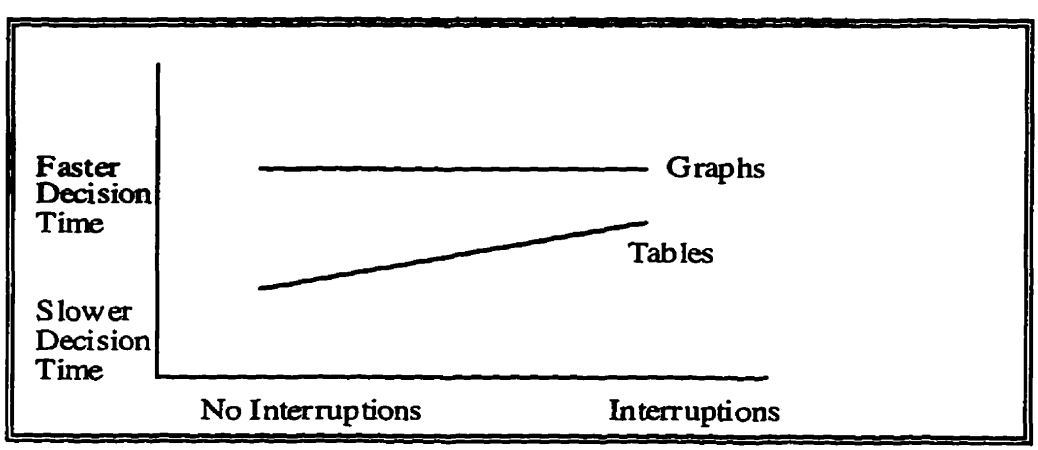


Figure 6-12
The Influence of Interruptions and Information Presentation Format on Decision Time For Complex-Spatial Tasks



The perceptual measures indicate that perceptions regarding information precision and information formats are important to consider. Interruptions appear to influence subject's perception regarding the precision of the information. Subjects using graphs perceive the information to be significantly more precise with interruptions than without. In addition, subjects in the no-interruption treatment perceived the tabular data to be more precise than those using graphs.

Results examining information formats indicate that subjects perceive the data in tables to be more useful than the data in graphs when interruptions occur. This is interesting as it is counter to the perception that graphs contain more precise information that tables with interruptions. It is also counter to the suggestion of fit between task and information presentation format suggested by Cognitive Fit Theory. As presented in Section 6.3.3, graphical formats were perceived as more useful when experiencing interruptions for the complex-symbolic tasks, also contrary to the task/format predictions of Cognitive Fit Theory. Taken together, these results might suggest that interruptions add to the general confusion of cognitive processing and make it difficult for subjects to distinguish the most useful way to present information in supporting the decision-making process.

6.1.2.4 Summary.

Although the hypotheses were not supported (H3A was supported but the findings were the same without interruptions and therefore, suggesting no moderating relationship), it appears that interruptions do influence the information presentation format/task type relationship. Without interruptions, there were significant relationships between information presentation format and task type for decision accuracy and decision time.

With interruptions, three of the four symbolic task/decision performance relationships are no longer significant. The only significant symbolic relationship involves less decision time when using graphs on simple-symbolic tasks. Likewise, the use of graphs result in higher, though not statistically significant, decision accuracy on complex-symbolic tasks. Therefore, there is some evidence that the use of graphical formats facilitates or results in equivalent decision making over the use of tables for symbolic and spatial tasks with interruptions.

It also appears that interruptions influence the perceptions regarding information for symbolic tasks. Tables are perceived as impairing performance on simple-symbolic tasks when interruptions occur. For complex-symbolic tasks, graphs are perceived as containing more information than tables and the amount of information contained in the tables was perceived as making the task more difficult with interruptions. The perceptual measures suggest that interruptions negatively influence the use of tables when solving complex-symbolic tasks.

6.1.3 Influence of Interruption Dimensions

This section describes the influence of interruption frequency and interruption content on decision accuracy and decision time. It was hypothesized that an increased frequency of interruptions would result in decreased decision accuracy and less decision time. Likewise, it was hypothesized that information content that was similar between the experimental and interruption task would result in decreased decision accuracy and less decision time.

6.1.3.1 Interruption Frequency

Results from the statistical analyses indicate partial support for this hypothesis. When performing the complex-symbolic task, increased frequency of interruptions significantly impaired decision accuracy. However, there was no significant relationship between interruption frequency and decision accuracy for the complex-spatial task. It was also hypothesized that an increased frequency of interruptions would result in less decision time. The results of the statistical analyses were highly significant for both task types. In both cases, decision time was significantly impaired with an increased frequency of interruptions. Figures 6-13 and 6-14 illustrate the performance relationships between interruptions and information presentation format across simple task types.

Figure 6-13
The Influence of Interruption Frequency on Decision Accuracy for Complex Tasks

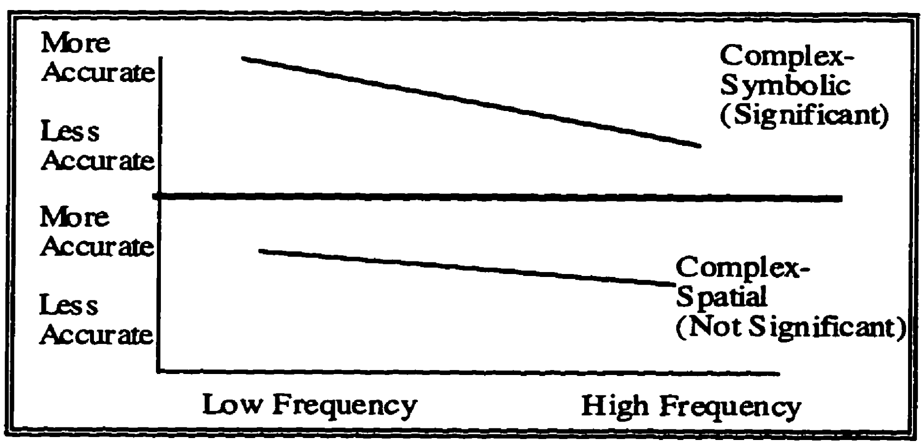
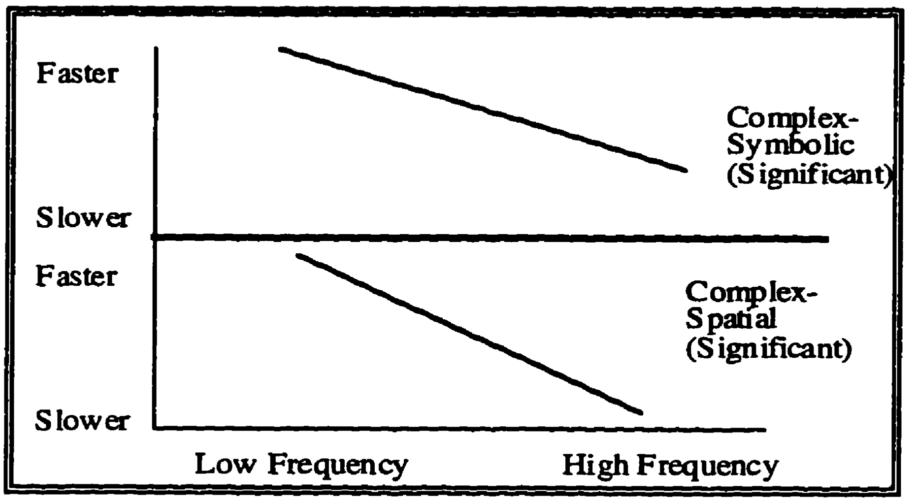


Figure 6-14

The Influence of Interruption Frequency on Decision Time for Complex Tasks



There was a significant relationship between the covariates and decision time for both complex-symbolic and complex-spatial tasks. Specific to the complex-symbolic task, gender and interruption decision quality were significantly related to decision time. Women were able to perform the task significantly faster than men. In addition, those subjects who had worse performance on the interruption task had better performance on the complex-symbolic task. Again, this is another instance of a possible "unfaithful" response to the interruptions and it is important to control for this. However, even with the unfaithful response to interruptions, the high frequency interruption treatment resulted in significantly lower decision accuracy.

A similar result was seen for the complex-spatial tasks where interruption decision accuracy was a highly significant covariate. Similar to the complex-symbolic task, subjects who performed worse on the interruption tasks performed the complex-spatial task more quickly. As this finding is consistent across both tasks, it is likely that subjects got frustrated with the frequent interruptions and responded by not attempting to obtain the best solution on the interruption tasks.

The perceptual measures suggest a significant relationship between interruption frequency, complex-symbolic tasks, and many aspects of the information. Subjects experiencing frequent interruptions were significantly more likely to perceive the information presented during the task as being more useful, more comprehensive, more precise, more reliable, and the format of the information as more useful. Subjects in the high frequency treatment also were less likely to prefer the use of tables (consistent with the format being used as useful). Additionally, subjects experiencing more frequent interruptions were significantly more likely to perceive the amount of information making the task more difficult and were less confident in their solutions when performing the complex-spatial task.

It appears that a high frequency of interruptions makes subjects more aware of attributes associated with information used in performing the task for complex-symbolic task. It also appears that when there are a higher frequency of interruptions, subjects get frustrated and do not make a "best effort" attempt to process the interruption. Finally, an increased frequency of interruptions influences the perceptions subjects have regarding the information used to process the some tasks (in this case, the complex-symbolic task). Information was perceived as more useful, comprehensive, precise, reliable, and a more useful format when there were frequent interruptions. It is possible that the increased stress of attending to the interruptions causes subjects to appreciate the information at their disposal to perform the task, improving their perceptions of the information at hand.

6.1.3.2 Interruption Content

There was no support for the hypotheses examining the relationship between interruption content and performance. The results of the statistical analyses indicate that the influence of interruption content on decision accuracy is not significant for either the complex-symbolic and complex-spatial tasks. The results of the statistical analyses also indicate a significant relationship between interruption content and decision time for both complex-symbolic and complex-spatial tasks. Counter to predictions, subjects experiencing interruptions that had different information content from the task took significantly longer to complete than those experiencing interruptions with similar content. It was hypothesized that interruptions with similar content to the primary task would result in less decision time due to individuals getting confused about how the information was being used across tasks. It appears that having similar information facilitated decision time as individuals had a better understanding of the information at hand and were able to process it more quickly. Figures 6-15 and 6-16 illustrate the performance relationships between interruptions and information presentation format across simple task types.

Figure 6-15

The Influence of Interruption Content on Decision Accuracy for Complex Tasks

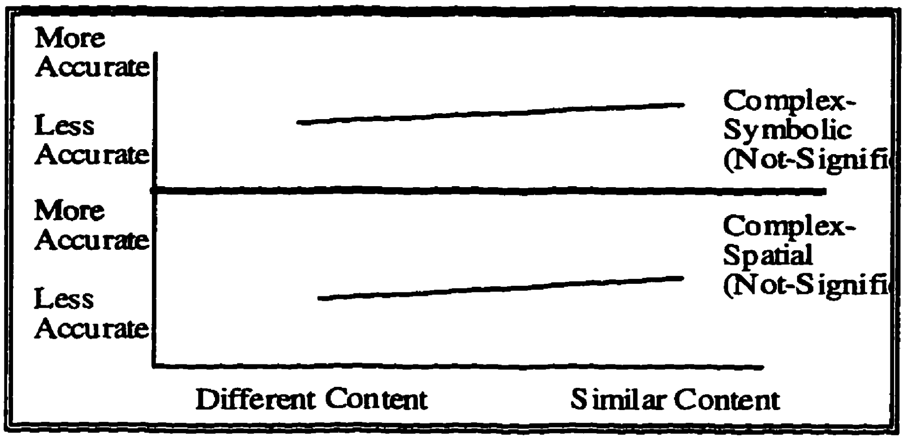
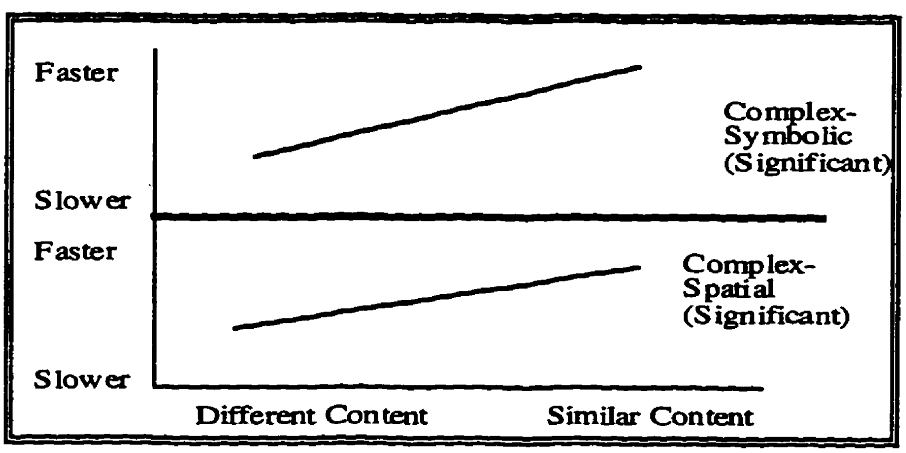


Figure 6-16

The Influence of Interruption Content on Decision Time for Complex Tasks



There were also significant control variables for both task types. When performing complex-symbolic tasks, gender, interruption decision time, and interruption decision quality all significantly influenced decision time. The interruption-related control variables indicate that subjects did not faithfully perform the interruptions as those who performed interruptions more quickly and less accurately performed the primary task more quickly. Gender significantly influenced decision time for both complex-symbolic and complex-spatial task types with women performing the tasks more quickly than men.

The perceptual data indicates a marginally significant relationship between the perception of interruptions and interruption content for both task types. Consistent with the performance findings, subjects experiencing interruptions that contained information that was different from the primary task perceived the interruptions to more significantly impair performance on the task.

6.2 Overall Conclusions from the Research Study

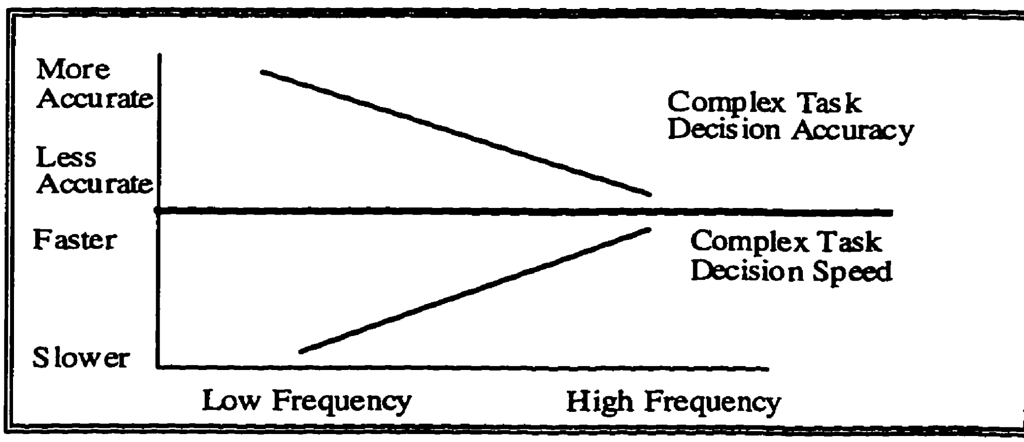
The overall conclusions from this research study are presented in two sections: the influence of interruptions on decision making and the influence of information presentation and interruptions on decision making.

6.2.1 The Influence of Interruptions on Individual Decision Making

This research has supported the influence of interruptions on individual decision making. There was some support for the notion that interruptions enhance decision accuracy and decision time on simple tasks. However, perceptual measures collected in the study suggested that interruptions were perceived as having a negative influence on performance. There was also support for interruptions impairing decision performance on complex tasks. The complex tasks examined in this study are comparable to activities that many knowledge workers perform as an everyday aspect of their jobs. Therefore, the negative influence of interruptions on complex task performance suggests that the work environment of the decision maker should be included in subsequent examinations of decision making performance.

When examining specific dimensions of interruptions, this research also found support for the influence of interruption frequency on decision performance, particularly decision time. The most interesting result may be the way in which interruptions were handled when the frequency of interruptions increased. Figures 6-17 illustrates the influence of interruptions on performance of the interruption tasks.

Figure 6-17
The Influence of Interruption Frequency on Interruption Task Performance



In these situations, subjects quickly processed the interruption task apparently without making a sincere attempt to accurately solve the problem. Subjects had been told that the performance on all tasks determined who was compensated and how much they were compensated, indicating that they "blew off " the interruption tasks even though they were important in judging their overall performance. There may be other interruption characteristics (e.g., generator of the interruption) that would influence decision makers to attend more closely to the interruption task. However, these results suggest that the increased frequency of interruptions induces decision-maker frustration resulting in a decision to process the interruption as quickly as possible in order to return to the primary task. This has direct ramifications for the quality and accuracy of information obtained from a knowledge worker who was interrupted from a task to provide the information.

Finally, the results suggest that significant differences in decision time exist when comparing interruptions with similar and different content from the primary task. Interruptions containing information different from the primary task took more time to recover from and less decision time on the primary task.

6.2.2 The Influence of Information Presentation and Interruptions on Individual Decision Making

The results from this research found that Cognitive Fit Theory can be extended to certain types of complex tasks as suggested by Vessey (1994). The only exceptions to the relationships predicted by Cognitive Fit Theory were decision time for both the simple-symbolic and complex-symbolic tasks. The number of computations required to solve both of these tasks might explain the faster decision time as those decision makers using graphs could not perform the calculations and therefore, provided their best estimate.

There was some evidence that interruptions moderate the relationship between the task type and information presentation format. Spatial and symbolic tasks are performed more quickly with graphs. Although the differences were not significant, graphs provided higher decision accuracy than tables on complex-symbolic tasks. The perceptual data supports the notion that graphs are the preferred information presentation format when interruptions occur. It appears interruptions negatively influence the perceptions about the use of tables.

6.3 Implications of the Research Results

The results of these two experiments have important implications for both theory and practice.

6.3.1 Theory

Previous research examining individual decision making has paid limited attention to characteristics of the work environment. This research study has demonstrated the importance of taking one aspect of the work environment, interruptions, into consideration when studying decision-making performance.

The results of this research suggest that interruptions generally influence the decision accuracy and decision time performance on intellective tasks. Specific characteristics of interruptions, namely interruption frequency and interruption content, also influence decision performance. Therefore, it is possible to examine each characteristic of interruption independently and interacting with other characteristics to better understand the influence of interruptions on decision performance.

A second outcome of this study is to extend our theoretical understanding of the influence of information presentation formats across different environmental contexts. First, Cognitive Fit Theory was used to examine the influence of information presentation formats on specific types of complex tasks. This is the first known empirical effort to extend Cognitive Fit Theory beyond the simple-symbolic and spatial tasks previously examined. Results of the study suggest that there are matches between information presentation format and task type for simple and complex tasks.

The influence of information presentation format and interruptions was also examined. Interruptions do appear to moderate the relationship between information presentation format and task type for some tasks. This suggests that interruptions change the way information is perceived, used, and processed. A better understanding of how interruptions influence the use of information will allow us to better understand how to positively influence decision-making performance.

6.3.2 Practice

Practitioner books and articles have identified the management of time in the workplace as critical. This research demonstrates that workplace interruptions influence performance on knowledge worker decision tasks. The complex tasks examined in this study might be consistent with the types of tasks performed by knowledge workers in business organizations. Interruptions impaired the performance on these types of tasks and may provide motivation for better managing the knowledge worker work environment.

Managers and knowledge workers need to be made aware of the negative influence of interruptions on task performance. This may allow knowledge workers to better manage their worktime, performing tasks that are more complex during the times of day when interruptions are less likely to occur. Additionally, managers may be able to influence when interruptions occur by establishing "interruption-free" time at certain periods of the workday.

Influencing the workday in an attempt to manage away interruptions may not adequately solve the problem. The requests for information that create an interruption are often essential to be answered for another knowledge worker to complete his/her task. Similarly, some knowledge worker jobs, such as a sales representative or a customer agent, are filled with interruptions that must be handled expediently.

Is it possible, then, to design features into systems to better support knowledge workers who are interrupted? Information presentation formats were examined in this research and the results of this study do not provide a clear cut answer. Interruptions did change the way information contained in the information presentation formats was used and perceived. However, neither graphs nor tables provided an unequivocally superior presentation format with interruptions. The results do suggest that system design features may play a role in helping knowledge workers recover from the inevitable interruption. System designers and human factors researchers may want to investigate a range of possible interface features to enable knowledge workers to recover from interruptions. These features might include system backtracking features, the use of color or other features to highlight previously used information, etc.

6.4 Chapter Summary

This chapter has interpreted the results of the statistical analyses presented in Chapter 5. This interpretation consisted of the objective performance measures, which were of primary interest in this study as well as perceptual measures to elaborate on apparent relationships in the data. Interruptions were found to influence decision accuracy and decision quality. There was also some support for the two interruption characteristics examined, frequency and content, to influence decision accuracy and time. Relationships predicted by Cognitive Fit Theory regarding task type and information presentation format were identified for both simple and complex tasks. Interruptions did influence the relationship between task type and information presentation format, with graphs generally leading to better performance than tables on both the objective and perceptual measures.

CHAPTER 7

LIMITATIONS AND FUTURE DIRECTIONS

This chapter discusses the strengths and important limitations of interpreting the research results. It reports the lessons learned from this research particularly with regard to the capture of additional data on interruptions and the use of within-subject tasks. The chapter concludes with directions for future research.

7.1 Strengths and Limitations

When conducting any research study, the findings should be examined in light of both the strengths and limitations of conducting the study.

7.1.1 Strengths

The use of the two controlled laboratory experiments is believed to be a strength of this research. This research method imposed some limitations for generalizing the results (described in the next section). However, it allowed for the isolation of specific interruption and information presentation effects. Every effort was made to control for intervening influences which threaten the experimental manipulation or provide an alternative explanation of the results. Possible influential factors that were controlled in this study included the use of a single source for research subjects, a single technology, a common physical environment, structured instrumentation, previously-validated tasks, transparent collection of decision time data, scripted experimental instructions, and a single researcher conducting the experimental sessions.

The operationalization of the interruptions is also believed to be a strength of this research. The only known prior study that manipulated interruptions (Corragio, 1990) was identified as having possible problems in this area. In the studies conducted for this research, decision makers could not ignore interruptions nor could they continue working on the primary task when interruptions occurred. Furthermore, the use of Visual Basic as a front end to the decision-task environment allowed for unobtrusive capturing of all objective performance measures, particularly those related to decision time.

7.1.2 Limitations

The increased control afforded by laboratory experiments must be traded-off against inherent limitations of the approach, primarily that of generalizability. Limitations included in this research involve the use of student subjects, the generalizability of the tasks, and the operationalization of the interruptions.

The use of university subjects as a population from which to generalize results to the business community has been long debated (Gordan et al., 1986, 1987; Greenberg, 1987). The primary issue arising from this debate that is relevant to this research is the purpose of the study. This dissertation sought to understand the influence of interruptions and information presentation on knowledge worker performance. The students who participated in this study were one year away from graduation and will soon be considered knowledge workers. In addition, participation in this study occurred after the course material relevant to the tasks (aggregate planning and facility location) had been covered in class, assignments had been performed, and exams had been taken. Therefore, all subjects who participated had a nominal level of domain expertise associated with the types of tasks being performed. Based on the decision accuracy performance, student subjects proved to be adequate decision makers to investigate these research questions. Prior to generalizing the results to other populations, the reader should consider possible differences between the decision-making abilities of business students and the target population.

The motivation of student subjects is also likely to be different from the motivation of a knowledge worker in a business setting. Course credit and financial incentives were used to induce the subjects to perform to the best of their abilities. Seventy-two percent of the subjects received some form of financial compensation suggesting that all participants responded to this incentive in a similar fashion.

The four tasks involved responding to general production management questions as well as a complex aggregate planning and facility location task. The generalizability of these findings may be limited to comparable tasks. However, the aggregate planning and facility location tasks involve perceiving, interpreting, and calculating information within a production context. The information processing required by this task is comparable to tasks across a range of environments. Therefore, generalizability of the tasks should extend beyond production and operations management.

Although the operationalizations of the interruptions were considered a strength due to the tight controls used, the interruptions used in this study were devoid of social characteristics. The operationalization used for the interruption mimicked a face-to-face interruption as subjects were forced to attend to the interruption and not the primary task. However, the interruption could not convey social characteristics such as the status of the interrupter. Likewise, there was no social context to influence how subjects processed the interruption, nor were the interruptions intended to examine alternative forms of interruption (e.g., telephone call). Therefore, the highly-controlled type of interruptions in this study should be taken into account prior to generalizing these results to all work environments and interruptions.

Likewise, prior research suggests that the detrimental impact of an interruption depends on the timing of the interruption with respect to the activities the individual is currently performing. If the interruption occurs in the middle of processing information, its influence is likely to be greater than if the individual has just completed a task or sub-task. Each interruption was timed to occur a specific number of seconds after processing of the primary task was initiated. The timing is unlikely to occur at the same point in processing for each individual because subjects would process the primary task at different times. These timing differences may moderate the effect of the interruption on performance.

Individual differences have significant explanatory power in decision performance. Three user characteristics (gender, domain expertise, and spatial orientation) were measured and statistically controlled in this study. It is assumed that any other individual differences that might influence decision performance were equally distributed across treatments through the use of random assignment.

A final limitation of this research is the "one-time" nature of the experimental session. It is possible that experience, both in processing similar tasks and in processing interruptions, would lessen the effects of the interruptions seen in these results.

7.2 Lessons Learned

In the process of conducting any research project, the investigator gains new insights regarding certain components of the research process. This section reports additional insights into capturing perceptions regarding interruptions and the use of within-subject tasks.

7.2.1 Perceptions of Interruptions

The primary objective of this research was to measure the influence of interruptions using objective performance measures. Other perceptual measures, including user perceptions of the interruptions, provided additional data about the decision-making process. It was observed that interruptions affected subjects very differently from an emotional perspective. Some subjects, upon receiving an interruption, would throw themselves back in their chairs and appear to be both angry and frustrated. Other subjects did not outwardly react to the interruption and completed the task with no outward displays of frustration.

It would be interesting to better understand what personality or other individual factors influence some people to react so strongly while others seemed unfazed by the interruptions. Similarly, further interpretation of the objective performance measures would be possible if those subjects who reacted so strongly could be identified.

The use of process tracing and/or videotaping sessions might allow for a more in-depth examination of the emotional state of the subjects. Physiological measurement (via the use of a heart monitor) could further be used to better detect the influence of interruptions on the participant's emotional state.

7.2.2 Within-Subject Tasks

One objective of this study was to examine the influence of interruptions and information presentation on specific types of simple and complex tasks. Another objective was to examine the influence of interruptions and characteristics of interruptions on simple and complex tasks. The simple tasks were fairly comparable in the amount of time required to process the information and the nature of the task.

The complex tasks were designed to be significantly different from the simple tasks, but little attempt was made to make the two complex tasks comparable. The inability to compare the complex tasks directly leaves us with somewhat equivocal findings for some of the hypotheses. Interruptions seemed to more strongly influence the complex-symbolic task than the complex-spatial task. It is difficult to discern the specific reason for this difference. The complex-spatial task required more time, was considered to be more difficult, and required the subjects to become more involved to successfully complete the task. We do not know which, if any, of these factors might explain the differences in findings between the two complex task types. Tasks used for future investigation of this type might make stronger use of the complexity metrics described by Wood (1986) and Campbell (1988) to define more equivalent tasks.

7.3 Future Research Directions

The results of this research suggest that interruptions influence decision-making performance. The findings from these studies provide an initial understanding of the relationship between interruptions and intellective task types. Additional research effort should examine a broader range of tasks including creative and judgment tasks.

A framework of interruption characteristics was presented in Chapter 3 to guide future research examining interruptions. Two of those characteristics, frequency and content, were examined in this research study. However, to fully understand the influence of interruptions each of the interruption characteristics presented in Chapter 3 should be examined individually and together with other characteristics to isolate the features of interruptions that most strongly affect decision performance.

The social characteristics of interruptions were fully controlled for in this research. However, interruptions happen in the social environment of the workplace, and their influence on performance are likely to be strongly moderated by these social characteristics. Research conducted in a field setting using some of the techniques used by Kirmeyer (1991) could prove to be fruitful for more thoroughly understanding interruptions in the workplace.

As discussed in the previous section, certain individual characteristics appear to be particularly important in examining interruptions. Kirmeyer (1991) controlled for personality type and found that it had a significant influence on how interruptions were perceived. Future research should include a stronger focus on the emotional reaction to interruptions, perhaps using process tracing methods to capture the rich data more fully.

This research examined specific types of complex tasks (defined as feasibly-solvable) as a first effort to examine empirically the influence of information presentation on complex tasks. There was general support for the influence of tables on feasibly-solvable complex-symbolic tasks and for graphs on feasibly-solvable complex-spatial tasks. Future research should examine other task types (trade-off and limiting tasks) as well as other information presentation formats.

Finally, information presentation formats were examined in this research as a possible design factor to manipulate when building systems designed for knowledge workers who face interruptions in their work environment. A well-developed research stream has been developed investigating information presentation formats allowing for theory to be developed investigating this feature. However, there are many other features that could be examined including the use of a backtracking or zoom in/zoom out capability. Backtracking features would show subjects the most recent activities they had performed to facilitate the backtracking component of the interruption recovery process. Likewise, zoom in/zoom out features would allow subjects to focus only on the information being examined to solve a specific problem to lessen the information load when performing calculations or identifying trends.

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Appendix

Appendix A
Post-Test Questionnaire

We are interested in how you approached this task. This questionnaire is composed of 32 statements. Please indicate in the space provided the degree to which each statement applies to you. Indicate your choice by clicking on the bar associated with each scale and moving it to the appropriate position on the scale. Click on OK when you have answered all the questions on the page. There are no right or wrong answers. Many of the statements are similar to other statements. Do not be concerned about this.

1 Rate the ease of difficulty you had when performing this task.

convenient — **inconvenient**

1 2 3 4 5 6 7

good — **bad**

1 2 3 4 5 6 7

easy — **difficult**

1 2 3 4 5 6 7

efficient — **inefficient**

1 2 3 4 5 6 7

2 Rate the correctness of the information.

accurate — **inaccurate**

1 2 3 4 5 6 7

high — **low**

1 2 3 4 5 6 7

consistent — **inconsistent**

1 2 3 4 5 6 7

sufficient — **insufficient**

1 2 3 4 5 6 7

3 Rate the precision of the information.

sufficient — **insufficient**

1 2 3 4 5 6 7

consistent — **inconsistent**

1 2 3 4 5 6 7

high — **low**

1 2 3 4 5 6 7

superior — **inferior**

1 2 3 4 5 6 7

4 Rate the reliability of the information.

consistent — **inconsistent**

1 2 3 4 5 6 7

high — **low**

1 2 3 4 5 6 7

superior — **inferior**

1 2 3 4 5 6 7

sufficient — insufficient

1 2 3 4 5 6 7

5 Rate the comprehensiveness of the information.

complete — incomplete

1 2 3 4 5 6 7

consistent — inconsistent

1 2 3 4 5 6 7

sufficient — insufficient

1 2 3 4 5 6 7

adequate — inadequate

1 2 3 4 5 6 7

6 Rate the format of the information.

good — bad

1 2 3 4 5 6 7

simple — complex

1 2 3 4 5 6 7

readable **unreadable**

1 2 3 4 5 6 7

useful **useless**

1 2 3 4 5 6 7

7 Rate the amount of information.

concise **redundant**

1 2 3 4 5 6 7

sufficient **insufficient**

1 2 3 4 5 6 7

necessary **unnecessary**

1 2 3 4 5 6 7

reasonable **unreasoanble**

1 2 3 4 5 6 7

8 Overall, rate the information.

useful **useless**

1 2 3 4 5 6 7

relevant **irrelevant**

1 2 3 4 5 6 7

clear **hazy**

1 2 3 4 5 6 7

good **bad**

1 2 3 4 5 6 7

9 How do you think you would have performed on this task if you had not been interrupted?

Much Higher **About th e same** **Much Lower**

1 2 3 4 5 6 7

10 I am confident that my solution is the best possible one.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

11 The amount of information made this task difficult.

stronly disagree **strongly agree**

1 2 3 4 5 6 7

12 I used an organized plan to solve the problem.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

13 Answering the questions correctly was important to me.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

14 How did the interruptions affect your ability to concentrate on the task?

Really hurt **Didn't aff ect me** **Really helped**

1 2 3 4 5 6 7

15 There are better answers to this task than the ones I reached.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

16 I couldn't care less what the right answers were.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

17 I answered questions based upon overall impressions.

Really hurt **Didn't aff ect me** **Really helped**

1 2 3 4 5 6 7

18 I would prefer to use information displayed in bar charts in order to successfully perform this task.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

19 My answers were based on a logical process of making choices.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

20 When an interruption arrived, what was your intial reaction?

Really pleased **Indiff erent** **Really displeased**

1 2 3 4 5 6 7

21 My answers were based on intuition.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

22 Information displayed in graphs would increase the time required to obtain an answer.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

23 I would characterize my approach to completing this task as being systematic.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

Information displayed in tables would increase the accuracy of my answers.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

25 The amount of information made answering the question confusing.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

26 Information displayed in tables would increase the time required to obtain an answer.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

27 I am sure that the quality of my answers were outstanding.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

28 I would prefer to use information displayed in tables in order to successfully perform this task.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

29 I was unable to use a rational strategy in arriving at my answers.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

30 It is personally significant for me to achieve the best possible solution.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

31 Information displayed in tables would increase the time required to obtain an answer.

strongly disagree **strongly agree**

1 2 3 4 5 6 7

32 Suppose you had to respond to interruptions as you did in this task. Which of the following interruption scenarios would your prefer?

A. 1 interruption with 12 questions
B. 2 interruptions with 6 questions in each
C. 3 interruptions with 4 questions in each
D. 4 interruptions with 3 questions in each
E. 6 interruptions with 2 questions in each

Appendix B
Simple-Symbolic Experimental Task

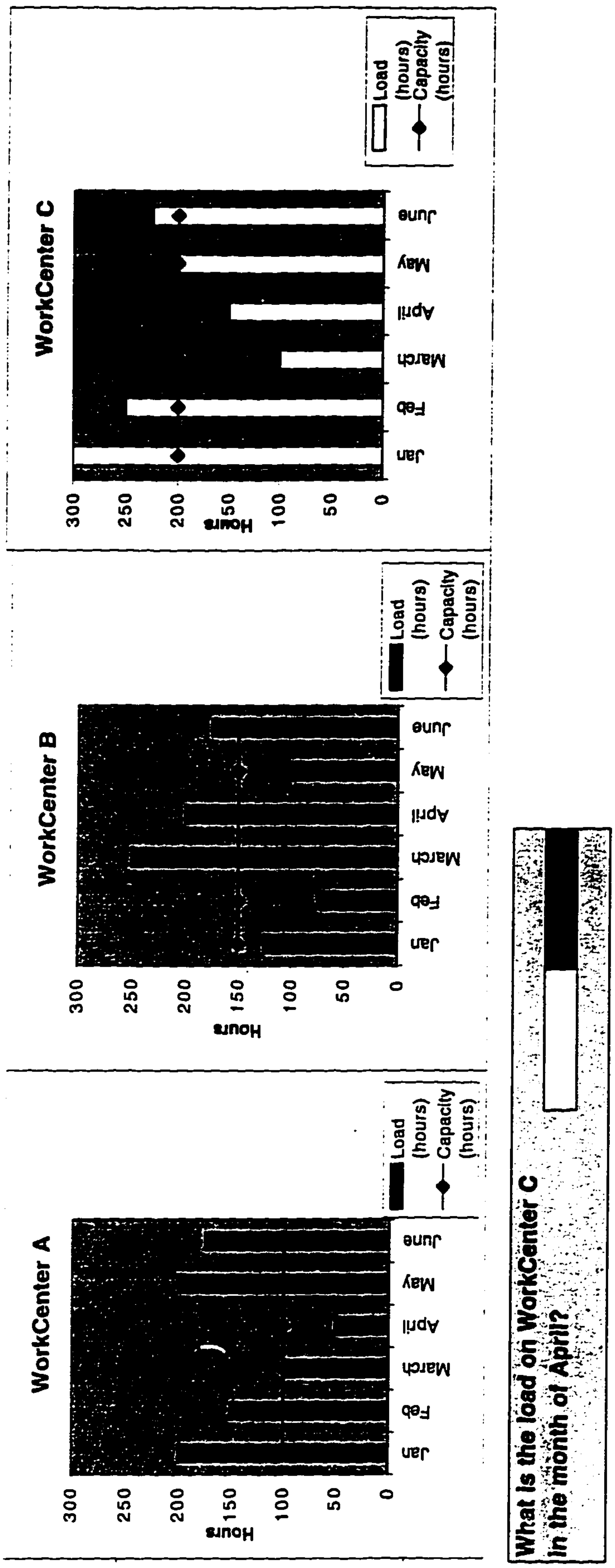
Simple Symbolic Task

Work Center Load Profiles

	Jan	Feb	March	April	May	June
Work Center A						
Capacity (hour	100	100	100	100	100	100
Load (hours)	200	150	100	50	200	175
Work Center B						
Capacity (hour	150	150	150	150	150	150
Load (hours)	125	75	250	200	100	175
Work Center C						
Capacity (hour	200	200	200	200	200	200
Load (hours)	300	250	100	150	200	225

What is the load on WorkCenter C in the month of April?

SYM1


WorkCenter A
WorkCenter B
WorkCenter C
Hours
300
250
200
150
100
50
0
Jan
Feb
March
April
May
June
Load (hours)
Capacity (hours)
What is the load on WorkCenter C
in the month of April?

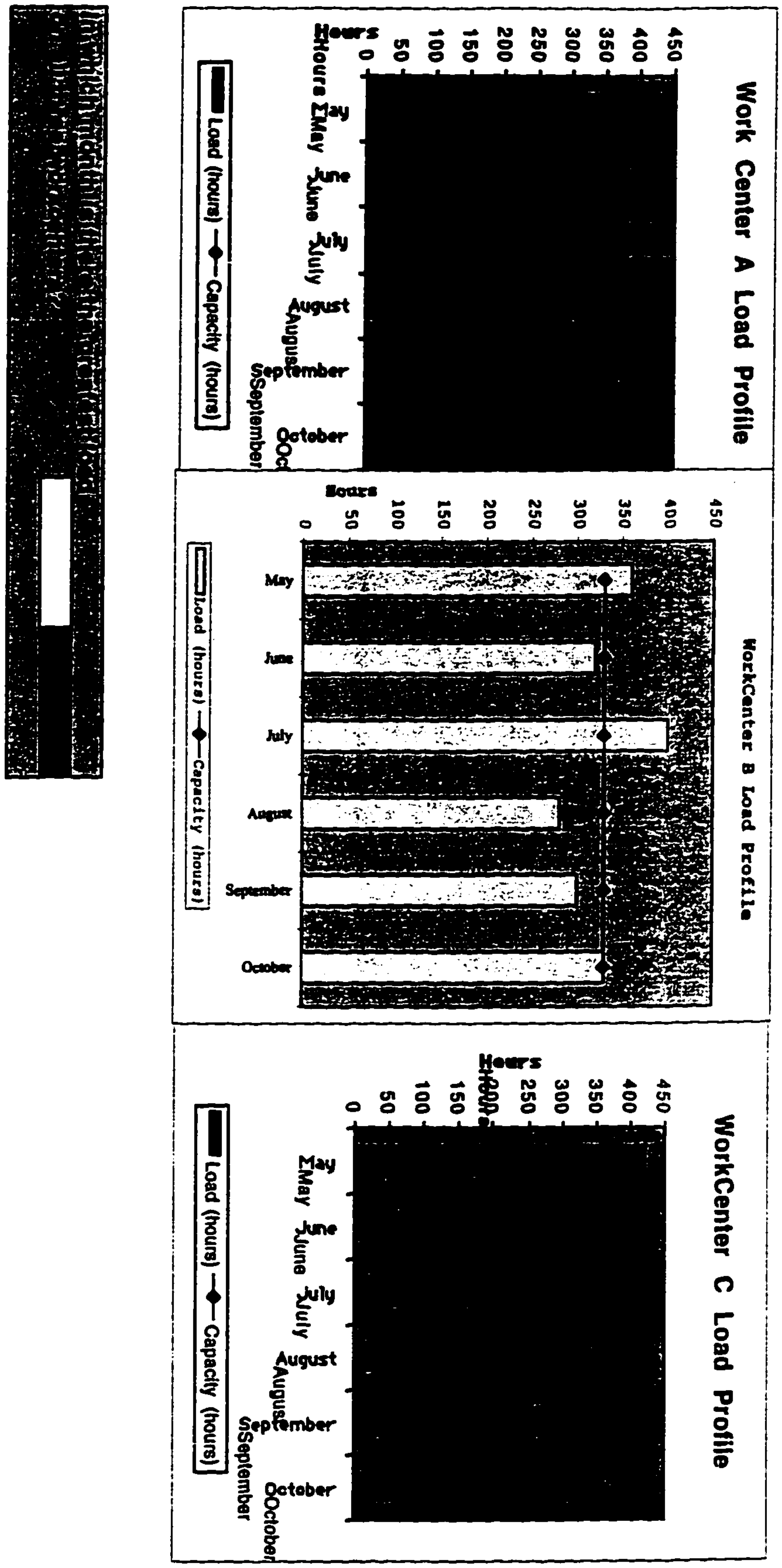
Appendix C
Simple-Spatial Experimental Task

SPA1

Work Center Load Profiles

	May	June	July	August	September	October
Work Center A						
Capacity (hours	380	380	380	380	380	380
Load (hours)	400	380	440	360	280	300
Work Center B						
Capacity (hours	330	330	330	330	330	330
Load (hours)	360	320	400	280	300	330
Work Center C						
Capacity (hours	360	360	360	360	360	360
Load (hours)	420	300	400	340	320	360

In which month is there the greatest load on all three work centers?


Work Center A Load Profile
Hours
0
50
100
150
200
250
300
350
400
450
May
June
July
August
September
October
Load (hours)
Capacity (hours)
WorkCenter B Load Profile
Hours
May
June
July
August
September
October
Load (hours)
Capacity (hours)
WorkCenter C Load Profile
Hours
May
June
July
August
September
October
Load (hours)
Capacity (hours)

SPA1

Appendix D
Complex-Symbolic Experimental Task

FL1

Warehouse Location Decision Making Task

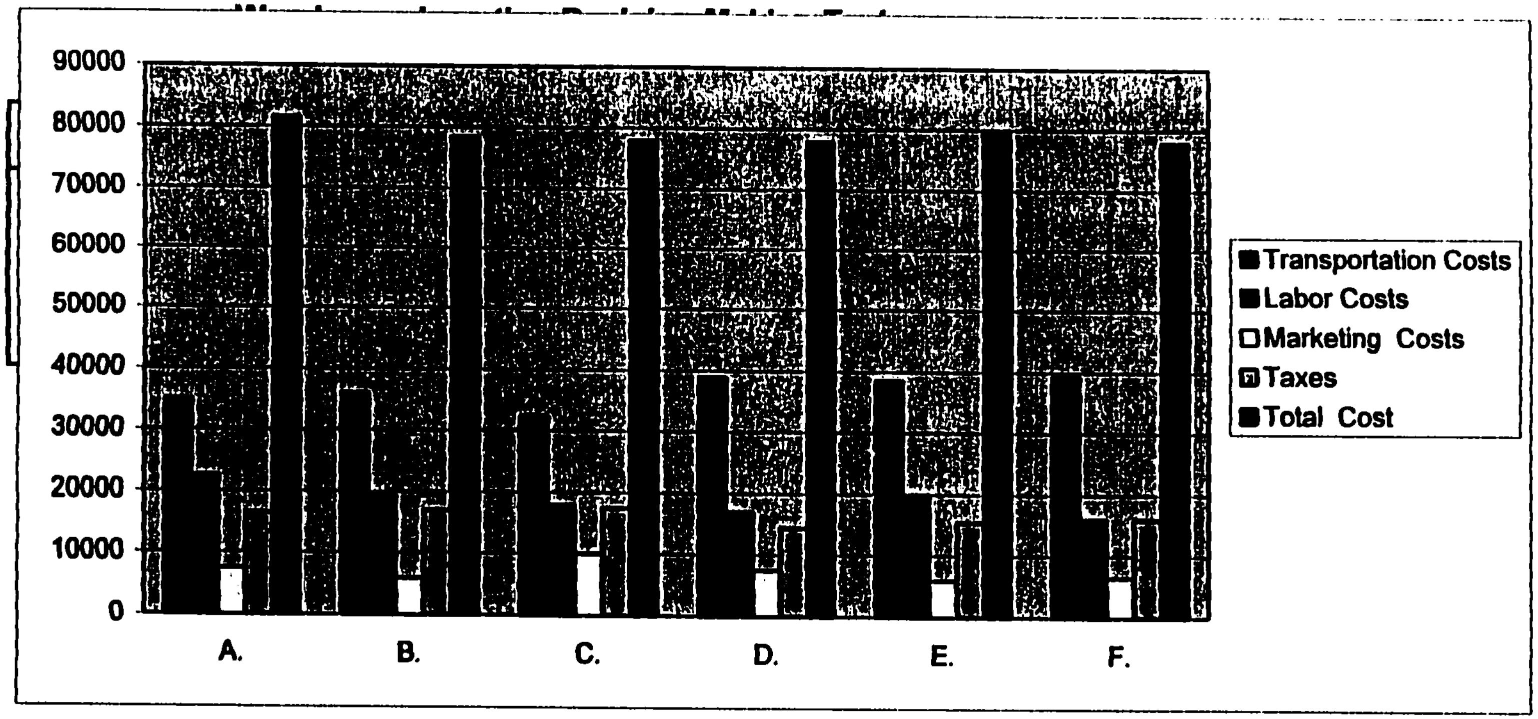
Warehouse Location	Transportation Costs	Labor Costs	Marketing Costs	Taxes	Total Cost
A.	35000	22500	7500	16500	81500
B.	36000	19500	6000	17000	78500
C.	32500	18000	10000	17500	78000
D.	39000	17000	7500	14500	78000
E.	38500	20000	6000	15500	80000
F.	39500	16000	6500	16000	78000

Decision Rules

1. **Total Cost less than or equal to $78,500.**
2. **Transportation costs no more than 50% of Total Cost.**
3. **Marketing costs no more than 10% of Total Cost.**

	Enter the Warehouses you wish to open in order beginning with the lowest cost warehouse. Only open warehouses that meet the decision rules.
1	
2	
3	
4	
5	
6	

FL1



Decision Rules

1. Total Cost less than or equal to $78,500.
2. Transportation costs no more than 50% of Total Cost.
3. Marketing costs no more than 10% of Total Cost.

	Enter the Warehouses you wish to open in order beginning with the lowest cost warehouse. Only open warehouses that meet the decision rules.
1	
2	
3	
4	
5	
6	

Appendix E
Complex-Spatial Experimental Task

Period 3

Production Planning Problem

The Optimal Level of Inventory is 320 gallons.

Total Cost to Date	$40,000
Average Cost/Period	$20,000

Current Inventory	320
Current Workforce	500

Sales Forecast for 3 Periods

Period	3	4	5
Sales Forecast			
Blue Paint	500	500	600
Red Paint	600	700	700
Green Paint	700	700	700
Yellow Paint	800	800	800

Units to Produce	2600	2700	2800
Workforce Level	500	500	500

Ending Inventory	320	420	520
Workforce Level Change Cost	$0	$0	$0
Worker Over/Idle Cost	$44,180	$14,580	$980
Non-Optimal Inventory Cost	$0	$2,000	$8,000
Total Cost	$44,180	$16,580	$8,980

Actual Demand for Available Periods

Period	1	2
Sales Forecast		
Blue Paint	700	650
Red Paint	700	550
Green Paint	650	650
Yellow Paint	663	664
Total Paint	2713	2514

Units to Produce	2800
Workforce Level	500

Period 3

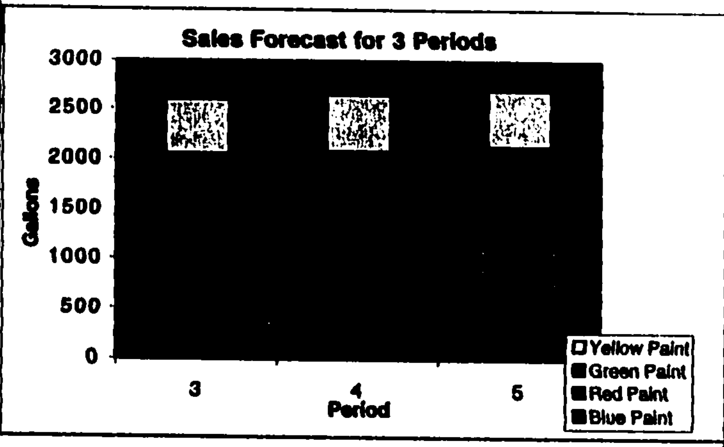
Production Planning Problem

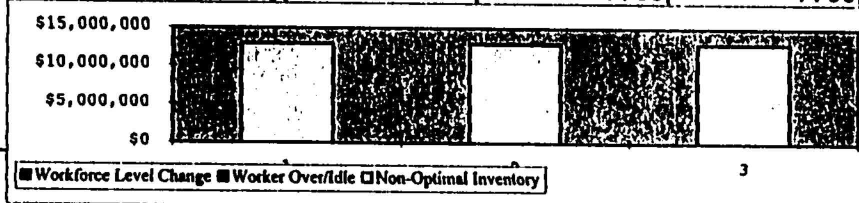
Total Cost to Date	$23,435,369
Average Cost/Period	$11,717,685

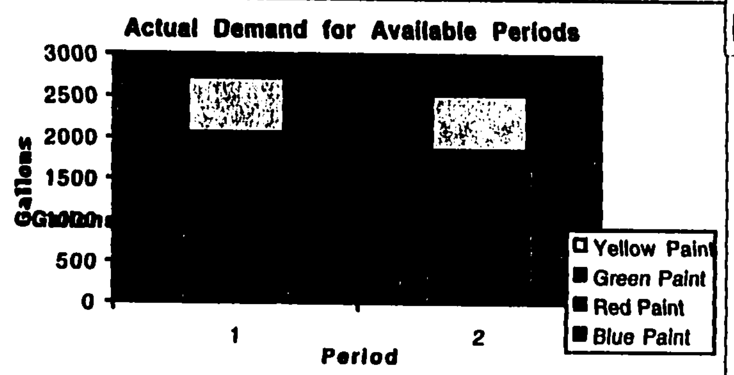
The Optimal Level of Inventory is 320 gallons.

Current Inventory	-5106
Current Workforce	0

Units to Produce	0	0	0
Workforce Level	0	0	0
Ending Inventory	-7706	-7706	-7706







Units to Produce	0
Workforce Level	0

Appendix F
Experimental Interruption Tasks

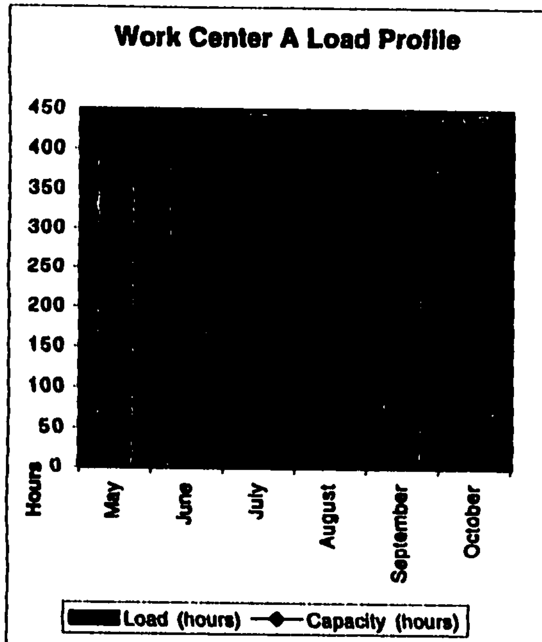
[redacted]

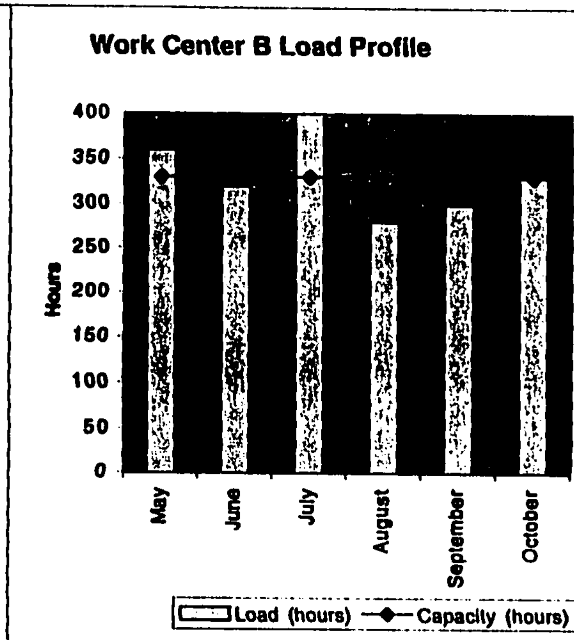
Work Center Load Profiles

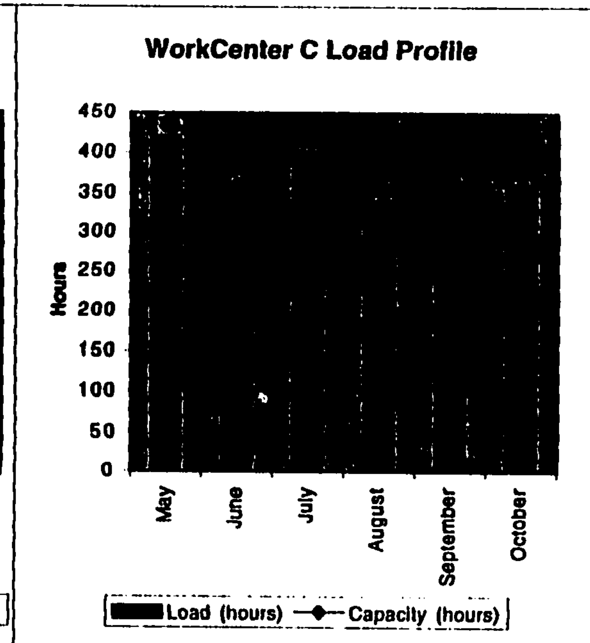
	May	June	July	August	September	October
Work Center A						
Capacity (hours	380	380	380	380	380	380
Load (hours)	400	380	440	360	280	300
Work Center B						
Capacity (hours	330	330	330	330	330	330
Load (hours)	360	320	400	280	300	330
Work Center C						
Capacity (hours	360	360	360	360	360	360
Load (hours)	420	300	400	340	320	360

[redacted]

[redacted]


Work Center A Load Profile
Hours
0
50
100
150
200
250
300
350
400
450
May
June
July
August
September
October
Load (hours)
Capacity (hours)


Work Center B Load Profile
Hours
0
50
100
150
200
250
300
350
400
May
June
July
August
September
October
Load (hours)
Capacity (hours)


WorkCenter C Load Profile
Hours
0
50
100
150
200
250
300
350
400
450
May
June
July
August
September
October
Load (hours)
Capacity (hours)

[redacted]

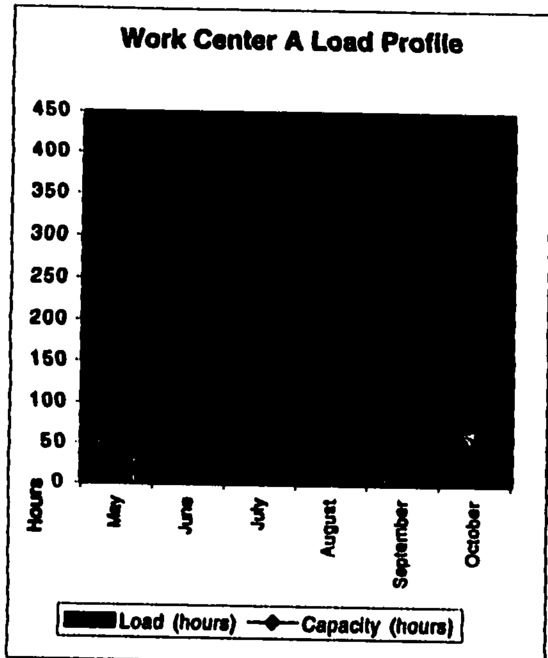
Work Center Load Profiles

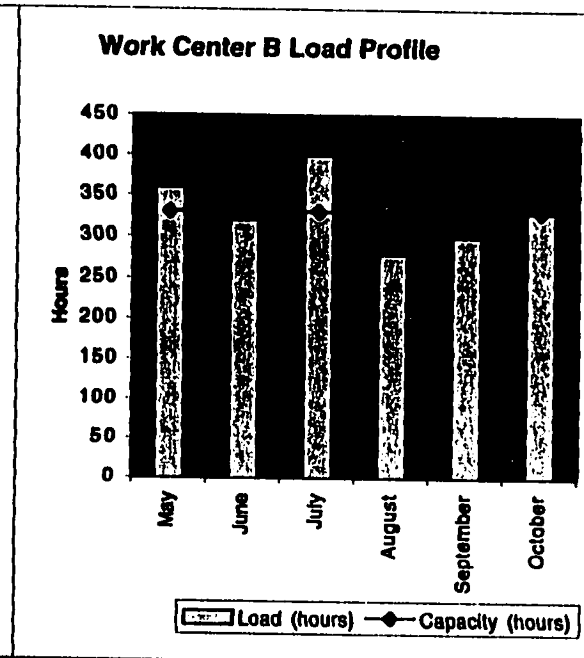
	May	June	July	August	September	October
Work Center A						
Capacity (hours	380	380	380	380	380	380
Load (hours)	400	380	440	360	280	300
Work Center B						
Capacity (hours	330	330	330	330	330	330
Load (hours)	360	320	400	280	300	330
Work Center C						
Capacity (hours	360	360	360	360	360	360
Load (hours)	420	300	400	340	320	360

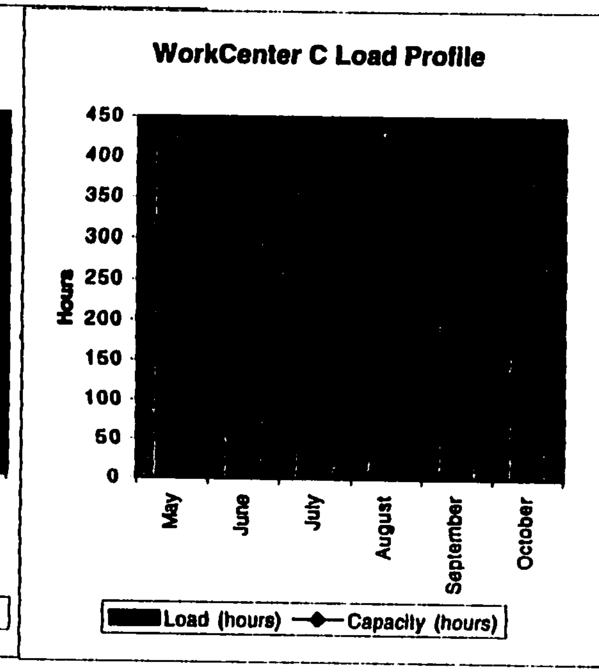
[redacted]

SPTask1

[redacted]







[redacted]

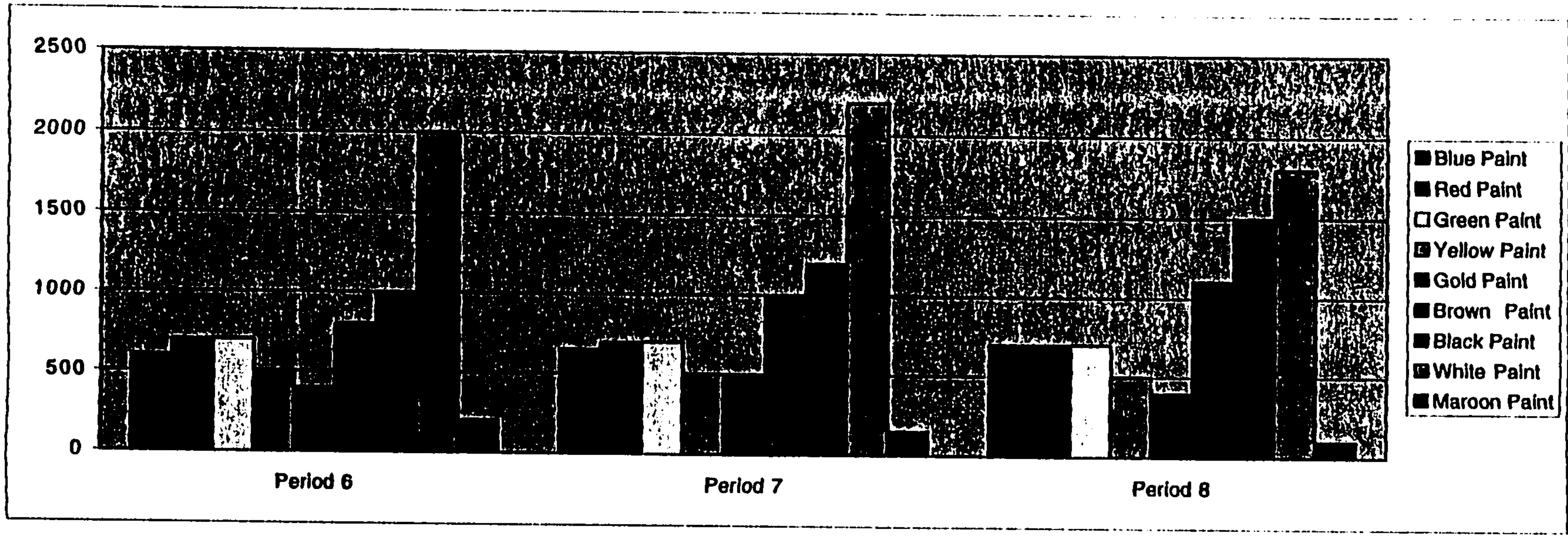
Your Manager has [illegible] into your office and requested you to provide the following information:

[illegible] Sales Forecast for 3 Periods

Period	2	3	4
Sales Forecast			
Blue Paint	600	650	700
Red Paint	700	700	700
Green Paint	700	700	700
Yellow Paint	500	500	500
Gold Paint	400	500	400
Brown Paint	800	1000	1100
Black Paint	1000	1200	1500
White Paint	2000	2200	1800
Maroon Paint	200	150	100

[redacted]

[illegible]


2500
2000
1500
1000
500
0
Period 6
Period 7
Period 8
Blue Paint
Red Paint
Green Paint
Yellow Paint
Gold Paint
Brown Paint
Black Paint
White Paint
Maroon Paint

[redacted]

Your Manager has just walked into your office and requested you to provide the following information:

Facility Location Costs

Warehouse Location	Transportation Costs	Labor Costs	Marketing Costs	Taxes	Total Cost
A.	35000	19500	7500	16500	78500
B.	35500	18000	8500	16000	78000
C.	31500	18500	6500	19000	75500
D.	37500	18500	7500	15000	78500
E.	36000	19000	7000	17500	79500
F.	37500	18000	7500	18500	81500
G.	39000	17000	7000	14500	77500
H.	32000	18500	7500	19000	77000

[redacted]

Appendix G
World Wide Web Experimental Sign-up Directions

Instructions for Signing Up for P301 Experiments

YOU MUST SIGN-UP TO ENTER THE EXPERIMENTAL POOL BY FEB. 2

If you have any questions, please e-mail the BUSEXP account. Please direct all inquiries to this e-mail address.

Signing up for P301 experiments is a 2 step process. Step 1 involves accessing the world wide web and providing some details about yourself. This step provides you access to the available experiments that will occur during the semester. Step 2 involves checking your e-mail for the day and time of specific experiments. Experiments are filled on a first come, first serve basis, so those students that respond most promptly to their e-mail are most likely to get their preferred time.

STEP 1
1. Go to any UCS Cluster on campus and select Windows Applications from the Main Menu. Get Windows up and running on the PC.

2. Once in Windows, double-click on the NETSCAPE icon within the Program Manager.

3. Double-click on the NETSCAPE icon.

4. Go the FILE menu option and select OPEN LOCATION. You will get a box asking you to enter the location. Type the following URL location:

http://www.indiana.edu/~s210topi/p301survey.html

This must be typed using lower case letters as illustrated above.

5. Fill-in the information requested. You must fill in all the information or the system will not register you for the experiment.

6. Click on SEND INFORMATION.

7. You should now receive a box asking for your e-mail address and password. Please enter this information to forward the information from (5) to the BUSEXP account.

8. Select FILE from the menu and choose EXIT to get out of Netscape.

STEP 2

1. Experiments for P301 will be run in March and April. During this time, you will receive e-mail messages informing you of the time and date for experiments. You can reply to these messages indicating your preferred time or you can send a message to BUSEXP. A confirmation message will be sent to you over e-mail informing you of the time, date, and location of your experiment.

If you have any questions, please e-mail the BUSEXP account. Please direct all inquiries to this e-mail address.

Please remember sign-up deadline is **February 2.** All P301 students must sign up to enter the experimental pool by this date.

Appendix H
Experimental Script

Experimental Protocol
Interruption Study
3/21/96

Pre-experiment preparation

* subject sign-in sheet
* envelopes containing consent forms, pre-test questionnaire
* pencils
* experimental log
* clock
* Stop signs for BUS417
* example diskette

Pre-Experimental setup
1) Turn off all PCs
2) Turn on PCs and select Windows Run from menu
3) Open Microsoft Excel
4) Insert treatment disk and open the only file on the disk
5) For each diskette:
    * Select Startup Treatment sheet tab
    * Click on the OK button
    * Select Full Screen and then remove Full Screen icon
    * Select Tools from the menu and remove sheet-tabs

The PC is now ready for use.

Insert the example disk into the Instructor's PC where Excel is running.
Open the following file:

Graph when running the NIG and IG treatments
Table when running the NIT and IT treatments
Combo when running any of the LFSD, LFSC, HFSD, or HFSC treatments

---

Greeting and Introduction

* Subjects will enter the lab individually as they arrive, sign in, and then be seated at any available PC. Ask subjects not to open envelopes or touch PC.

* Once all subjects are seated, begin script

Script:

Hello, my name is <name>. I am a graduate student in the School of Business and will be assisting you today with this session. Thank you for taking time to participate in this session. If you have any questions, please do not hesitate to ask me.

At this time, please remove the green sheets from your envelope. This document is titled "IUB Informed Consent Statement". Please take a few moments to read and sign this paper. It is important that you do this so that we can be sure that you are willing to participate in this session. There is another copy of this Informed Consent Statement that you may take with you at the end of the session in case you have any questions.

[Wait until all subjects have completed reading and signing the consent form]

I would like to highlight a couple of items on the informed consent statement. First, it indicates that you will receive 10 points of P301 credit for your participation today. At the conclusion of these experiments next week, we will provide each P301 instructor a roster indicating the students who have participated. You do not have to do anything.

Second, the informed consent statement talks about compensation for participating today. This compensation is structured so that the top 10% of performers will receive $10 for their effort. Participants in the top 11-25% will receive $5, and participants in the 26-50% will receive $2. Performance is based on the percentage of problems you solve correctly divided by the time it takes you to perform. Therefore, we are asking you to work as accurately and quickly as possible.

Now, please remove the document titled "Questionnaire".

We are going to perform two short tests that examine cognitive ability. Each test will last 3 minutes and the tests are two parts of the same activity. [Read the instructions from the Spatial Orientation cover page].

Are there any questions.......

OK, you have three minutes beginning now.. [Use the clock for timing]

3 minutes later: Time is up and please turn the page. Give them 1 minute rest.

OK, you have three minutes beginning now.. [Use the clock for timing]

3 minutes later: Time is up, please turn the questionnaire back to the front page and insert this and the consent statement into your envelope. Please put

the envelope towards the back end of your table as you will not need it for the rest of today's session.

[Wait until all subjects have put papers away]

Now, in this session we will be working individually. We would like for you to act as an operations manager that has to perform a number of operations and production management tasks. As a high-level Manager working in a corporate environment, you are likely to experience subordinates and bosses asking you for information in addition to the tasks you have been asked to perform.

I would like to briefly introduce you to the tasks that you will perform and the decision support system that you will use to help you solve these tasks. You may not perform these tasks in the same order as I will present them here, however, you will perform each task. After each task, you will be asked to fill out a brief questionnaire within the decision support system.

[Turn the RGB unit on so all subjects can see the projected image]

[4 Task Treatments] [IG/NIG/IT/NIT]

[Show spatial screen shot from example diskette]

This WorkCenter Planning task provides you information about three machine centers over a 6 month period. For each workcenter, the available hours of capacity and the hours of workload scheduled on the machine are provided for each month. You will be asked a number of questions about this information, such as the question show here.
<read question>.
<Obtain answer> **440**

You will be asked to perform two different tasks similar to this one. Each task is made up of 6 questions.

Are there any questions?

[2 and 4 Task Treatment] [HFSC/HFSD/LFSD/LFSC]

[Show facility location screen shot]

This facility location task asks you to determine which warehouse locations to open. You will be given six scenarios. Each scenario will provide you cost information on six different warehouses. Any or all of the six warehouses can be opened as long as the warehouse costs meet the opening criteria. This criteria is:

The total warehouse cost must be less than or equal to $78,500
Transportation costs must be not more than 50% of the total cost
Marketing costs must be no more than 10% of the total cost

Each warehouse location should be evaluated on this criteria. Any warehouse that meets this criteria should be opened. The warehouses that are to be opened should be entered into the input area beginning with the lowest cost warehouse.

Solution to example problem: **C and F**

Are there are questions?

[Show aggregate planning screen shot]

This production planning task asks you to determine how many gallons of paint you should produce each period and how many workers you should employ. Your goal is to produce the amount of paint required at the lowest possible cost.
[Explain all the information on the screen]

* *Total cost to date/Average cost to date. Help you keep track of your overall cost performance.*
* *3 periods of forecast demand. This is only the forecasted demand. Actual demand for that period may be somewhat different.*
* *Optimal level of inventory. Your company would like to maintain some safety stock. The value of safety stock that is optimal is 320 gallons.*
* *The current inventory and current workforce values indicate what your current levels are at the beginning of the period .*
* *The Potential Solutions box allows you to display multiple scenarios to determine the lowest cost for this period.*

<Enter three production decisions>
<2800, 500 2850, 500 2900, 500>

*As you can see, decision **2850, 500** provides us with the lowest cost. I can continue to try and improve my cost or I can enter these values into my final solution.*

Put in different scenarios, but include **2845,500**

If I want to improve my solution cost, the simulated results should help me identify what changes I should make to my decision.

After I enter my final solution, I click on OK. Please check and make sure you have entered your solution in the red INPUT area and not just the green *simulated results area. Once you click on OK, you cannot go back to a screen. Once you have checked for your solution, click on OK and move to the next period.*

[Show the questionnaire sheet]

After you complete a task, you will receive a questionnaire that looks similar to this. You can click on the bar to move the button or you can click and drag the button to the position that reflects your belief about this question. Use the down arrow or page down key to move between questions. You will click on an OK button after the last question to send you to the next task.

Are there any questions?

Now we are ready to begin the tasks. The DSS will only allow you to enter information into the red boxes labeled INPUT. After typing in your response, you must hit the ENTER key. After you answer the question for a task, use the mouse to move to the OK button and click on OK using the left mouse button. This will move you to the next question, task, or questionnaire. Information screens have been placed throughout the DSS to provide you information about the task, or ask you for your name . The final screen you should see also has a maroon bar at the top. This one thanks you for your time and says that you can leave. Once you reach this screen, you are free to go. Please leave your envelope at your desk and I will retrieve your disk from your computer.

We will notify all students who have won a cash award for today's session during the first week of April. Remember, those awards will be distributed to the students that have the most correct solutions in the shortest amount of time.

You may now begin using your decision support system. I can not help you with the answers If you have questions, however, please raise your hand.

All treatments except IG/NIG

* Click on End button on final screen
* Select File Save
* Remove diskette and place in packet

IG/NIG Treatment

* Click on End button on final screen
* Select File Save As option as save file to C:

* Once file has been saved to hard drive,
* Insert blank floppy diskette
* Select File Save As option and save file to A:

Appendix I
IUB Informed Consent Statement

IUB INFORMED CONSENT STATEMENT
Computer Decision Making Study

You are invited to participate in a research study. The purpose of this study is to examine group decision making processes.

INFORMATION

1. You will first be asked to answer an individual questionnaire.

2. Next, you will first be presented with a computerized decision support system. This system will present you with some information and ask you to enter your best answer(s) into the decision support system.

3. After each decision making task, you will be asked to fill out a questionnaire.

4. Approximate time for the experiment is two hours.

RISKS

There are no known risks associated with participating in this experiment.

BENEFITS

Your participation in this study will help business researchers better understand how individuals make decisions. By studying computer-based decision making, researchers can devise strategies for making more effective decisions and building more effective decision support systems in organizations.

CONFIDENTIALITY

The information in the study records will be kept confidential. Data will be stored securely and will be made available only to persons conducting the study unless you specifically give permission in writing to do otherwise. No reference will be made in oral or written reports which could link you to the study.

COMPENSATION

For participating in this study you will receive 10 points towards your P301 grade. If you withdraw from the study prior to completion you will not receive P301 points for the experiment participation.

Cash awards will be given for the student that has the most accurate answers across all decision tasks that are to be performed. If there is a tie, the student who responds to all the tasks most quickly will be given the award. The cash award will be $20.

Other ways to earn the same amount of credit are to participate in other experiments, or to complete a paper under the supervision of the P301 course instructor.

CONTACT

If you have questions at any time about the study or the procedures, or you experience adverse effects as a result of participating in this study, you may contact the researcher, Cheri Speier, at the School of Business, Dept. of Accounting and Information Systems (BU560), phone: (812) 855-8966. If you have questions about your rights as a subject, contact the office for the Human Subjects Committee, Bryan Hall 10, Indiana University, Bloomington, IN 47405, (812) 855-3067.

PARTICIPATION

Your participation in this study is voluntary; you may decline to participate and select one of the other options listed in the COMPENSATION section. If you decide to participate, you may withdraw from the study without penalty, but you will not recieve the credit or be eligible for any cash awards. If you withdraw from the study prior to completion, your data will be destroyed.

CONSENT

I have read and understand the above information. I have received a copy of this form. I agree to participate in this study.

Subject's signature_________________________________
Date________

Investigator's signature_________________________________
Date________

Appendix J
Spatial Orientation Pretest

Name ______________________________

CARD ROTATIONS TEST — S-1 (Rev.)

This is a test of your ability to see differences in figures. Look at the 5 triangle-shaped cards drawn below.

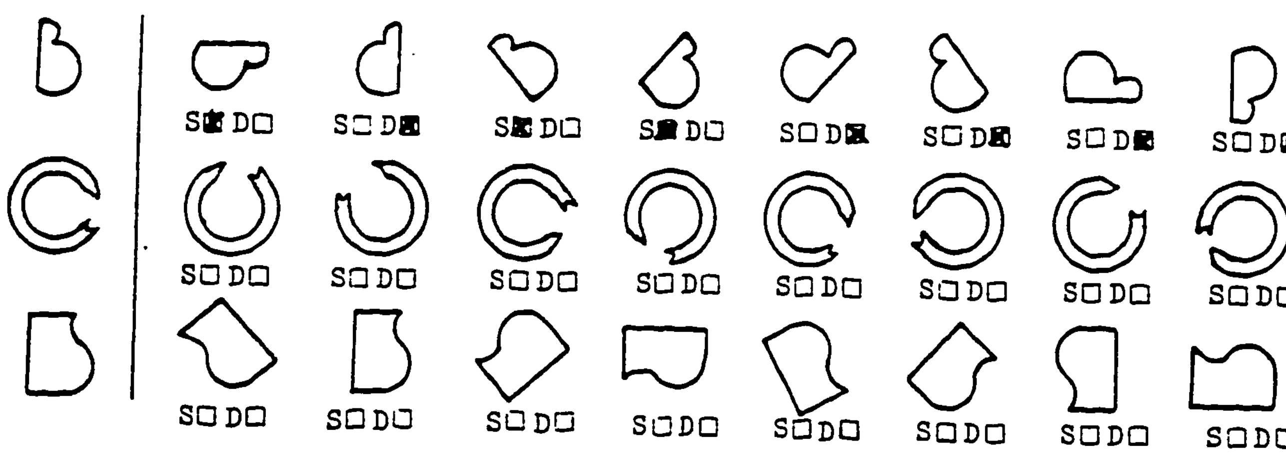
All of these drawings are of the same card, which has been slid around into different positions on the page.

Now look at the 2 cards below:

These two cards are not alike. The first cannot be made to look like the second by sliding it around on the page. It would have to be flipped over or made differently.

Each problem in this test consists of one card on the left of a vertical line and eight cards on the right. You are to decide whether each of the eight cards on the right is the same as or different from the card at the left. Mark the box beside the S if it is the same as the one at the beginning of the row. Mark the box beside the D if it is different from the one at the beginning of the row.

Practice on the following rows. The first row has been correctly marked for you.



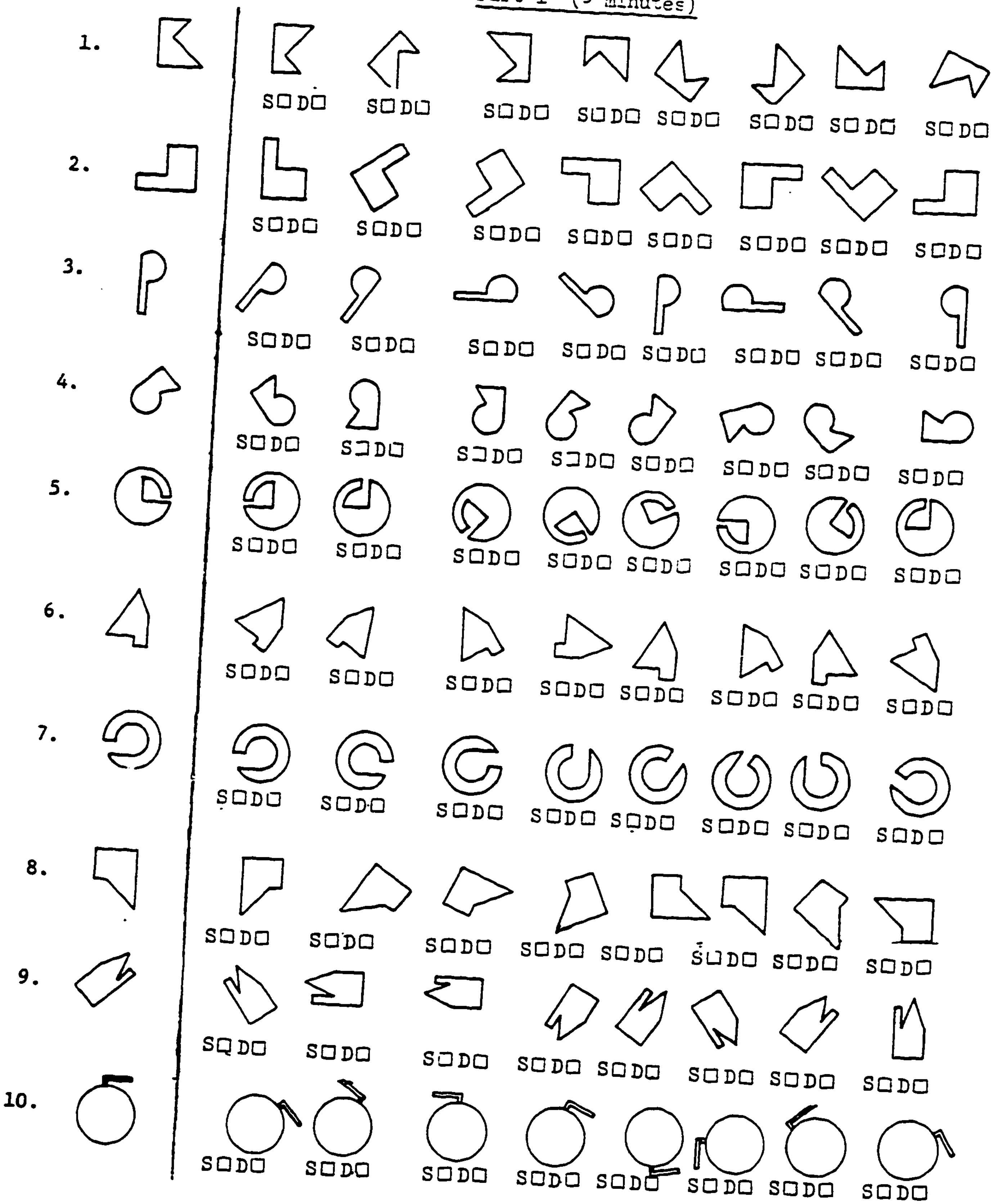
Your score on this test will be the number of items answered correctly minus the number answered incorrectly. Therefore, it will not be to your advantage to guess, unless you have some idea whether the card is the same or different. Work as quickly as you can without sacrificing accuracy.

You will have 3 minutes for each of the two parts of this test. Each part has 1 page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Page 2

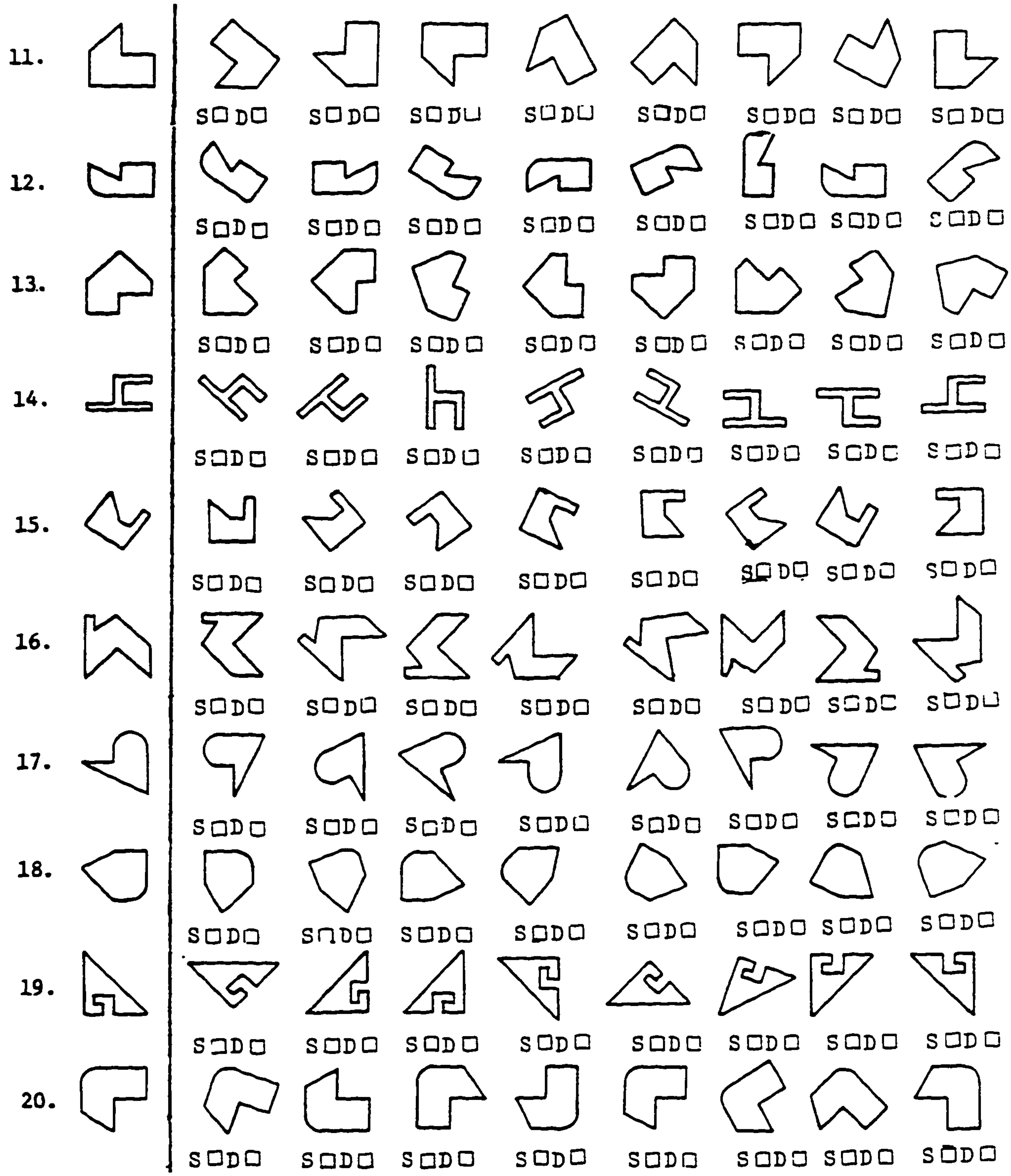
Part 1 (3 minutes)



DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

STOP.

Part 2 (3 minutes)



DO NOT GO BACK TO PART 1 AND

DO NOT GO ON TO ANY OTHER TEST UNTIL ASKED TO DO SO. STOP.

Appendix K
Experimental Session Training Materials

Results Period 3

Production Planning Problem

Total Cost to Date	$56,359
Average Cost/Period	$18,786

Sales Forecast for 3 Periods			
Period	3	4	5
Sales Forecast			
Blue Paint	500	500	600
Red Paint	600	700	700
Green Paint	700	700	700
Yellow Paint	800	800	800

Actual Demand for Available Periods			
Period	1	2	3
Sales Forecast			
Blue Paint	700	650	650
Red Paint	700	550	650
Green Paint	650	650	750
Yellow Paint	663	664	663
Total Paint	2713	2514	2713

The Optimal Level of Inventory is 320 gallons.

Current Inventory	606
Current Workforce	500

[redacted]

Units to Produce	2800
Workforce Level	500

[redacted]

Ending Inventory	606
Workforce Level Change Cost	$0
Worker Over/Idle Cost	$0
Non-Optimal Inventory Cost	$16,359
Total Cost	$16,359

[redacted]

Click on OK when you are ready to make production decisions for the next period.

Work Center Load Profiles

	May	June	July	August	September	October
Work Center A						
Capacity (hours	380	380	380	380	380	380
Load (hours)	400	380	440	360	280	300
Work Center B						
Capacity (hours	330	330	330	330	330	330
Load (hours)	360	320	400	280	300	330
Work Center C						
Capacity (hours	360	360	360	360	360	360
Load (hours)	420	300	400	340	320	360

In which month is there the greatest load on all three workcenters?

[redacted]

Inventory Report

Part Type	Amount on Hand	Demand	Reorder Point	Reorder Quantity
Tires	7000	7500	5000	1500
Wheels	8000	10000	12000	1500
Brakes	10000	6500	8000	1000
Engines	1500	1000	2000	500
Doors	12000	8000	10000	2500
Seats	18000	7500	10000	3000
Transmission	2000	2500	3000	750
Controls	1500	3000	2000	750
Radios	1000	1500	1000	500
Windows	6000	8500	5000	1500

[redacted]

Appendix L
Pilot Results

This appendix will present the instrument validation and hypothesis testing results of the two pilot studies condcuted in the Fall of 1995. Section 1 describes the goals and general results of the pilot studies. Section 2 presents the factor loadings and reliablilities of the two instruments. Finally, Section 3 presents the results of the hypothesis testing from Pilot Study 2 using ANOVA testing.

L.1 Description of Pilot Studies

L.1.1 Pilot Study 1

The purpose of the first study was to 1) finalize and test the experimental protocol and to 2) test the computer-based decision support system. One-hundred seventeen subjects enrolled in K201 (a different subject pool than will be used in the main study) participated. The data collection revealed some problems in both the experimental procedure and the DSS. Changes were made in the protocol to increase the length of the training session, particularly for the complex-spatial task. In addition, a number of minor and some major problems were identified in the programming of the DSS. These problems varied by treatment and precluded statistical analysis of the data. Modifications were made to the Excel/Visual Basic program to remedy the problems. Further testing of the modified DSS program was planned but canceled due to a complete network outage during the scheduled experimental sessions.

Different subjects in this initial study performed the experimental tasks with the interruption level set and 3, 4, or 5 interruptions per task. The goal in establishing the operational level of this variable was to create attentional overload without making these subjects overly frustrated or unable to complete the primary tasks. Post-experimental feedback suggested that all three settings induced a sense of frustration in the subjects. Many subjects indicated a need to backtrack to activities previously completed to perform the primary task. A setting of 4 interruptions per task was established as the operationalization level for the second pilot study as it was the average of those tested. Results of the second pilot study (see Appendix L) confirmed that the established level resulted in significant differences in decision accuracy and decision time between subjects experiencing interruptions and those not experiencing interruptions.

L.1.2 Pilot Study 2

The second pilot study was conducted to test 1) the tasks, 2) the instrument, 3) the operationalization of interruption frequency, 4) the operationalization of interruption content, and 5) to test modifications made to the DSS. This pilot study consisted of the Presentation and Interruption Dimension experiments presented in this Chapter using the procedures described. One-hundred ninety-seven subjects participated from the same subject pool (P301 students) that will be used in the main data collection. Results from the second pilot study met the specified objectives.

With respect to the experimental tasks, Wheeler and Mennecke (1995) suggest 4 attributes relevant to individual decision making that can be used to judge the adequacy of a task: 1) appropriateness of the task for the subjects, 2) subject intellectual engagement, 3) control for subject differences, and 4) the level of task complexity. Subjects indicated they had sufficient operations management experience to perform the complex tasks. In addition, post-experimental feedback suggested that subjects found the tasks engaging. Subjects were able to easily navigate through the DSS using point and click movements giving no inherent advantage to subjects more familiar with computers. Neither the DSS nor the operationalizations of the tasks used in this study had been used by any subject prior to participating in the experiment. Finally, the level of task complexity was successfully manipulated via careful task design. This was evident by the significant differences in decision accuracy and decision time between the simple and complex tasks. After evaluating the tasks against this criteria, it was felt that the tasks used in this study were appropriate for subjects to perform.

Even though the tasks were believed to be suitable, a problem was identified with the complex-symbolic task. Very little variation existed in the data used to complete this decision task. Subjects were asked to make distinctions between potential facilities where the cost differential was as little as $500. In the graphical Information Presentation treatment, the cost scale was presented in increments of $10,000, making the ability to perceive a $500 difference impossible for human perception. This lack of variation made the task very difficult to perform using the graphical information format. Modifications were made in the main study to provide greater variation in the data used in this task to allow human perceptual processes to make the necessary distinctions.

Principle components factor analysis was used to assess the validity of the post-test instruments. Both instruments exhibited acceptable psychometric properties (factor loadings and reliabilities are presented in Appendix F). A six-factor solution was expected from the Bailey and Pearson (1983) instrument and a five-factor solution was obtained. All of Bailey and Pearson's items related to information correctness and precision loaded on a single factor. This factor was refined to reduce the number of items yet maintain overall reliability and was labeled information quality. A six-factor solution was expected from the Spurrier et al. (1994) instrument and the items measuring attitudes toward interruptions and a six-factor solution was obtained. However, the items measuring intuitive approach did not appear as a factor and were dropped. The items associated with the Use of Information construct formed two different constructs, one labeled the Use of Tables and the second labeled the Use of Graphs. The Use of Information construct generally examines preferences between graph and table presentation formats. However, the focus on graphs and tables in this research study appears to have created a distinction between the items resulting in different constructs.

Interruption frequency was operationalized in the pilot as four interruptions per task in the low frequency treatment and eight interruptions per task in the high frequency treatment. Both the low and high level of interruption frequency resulted in significant performance differences when compared to the control group. However, there were no significant differences between the low and high frequency conditions. The high interruption frequency was adjusted to 12 interruptions per task in main study to further determine if significant differences exist.

The content of the interruption was operationalized as the use of the same data to solve interruption tasks and primary tasks in the similar condition and the use of different data to solve interruption and primary tasks in the different condition. Significant differences in decision accuracy were seen across treatments suggesting that this operationalization is adequate.

The final objective of this pilot study was to test modifications made to the DSS. Minor changes were made to improve collecting decision time data for each of the primary and interruption tasks were also identified.

Although not a primary objective of this pilot study, a statistical examination of each of the hypotheses was performed. Overall, support for the hypotheses was mixed. Generally, hypotheses examining the influence of interruptions on different task types, the use of different presentation formats with task types, the moderating influence of information presentation and interruptions on task, and interruption content had some support. Hypotheses examining interruption frequency was not supported. A possible explanation of or some of the non-significant findings is related to sample size. The sample size used in the pilot study was approximately 20 subjects per cell. This cell size would allow for the detection of large effects at an alpha level of .05 and a minimum power level of .80. Medium and small size effects could not be detected with the sample sizes used in the pilot studies. Complete pilot results are presented in Appendix F.

L.2 Instrument Validation

Principle components factor analysis using varimax rotation was used to assess both the Bailey and Pearson (1983) and the modified Spurrier et al. (1994) instrument (the modification added items measuring attitudes toward interruptions). The Bailey and Pearson instrument had a five factor solution explaining 79.7% of the variance. The Spurrier et al. instrument had a six factor solution explaining 70.5% of the variance. Two of the constructs from the Spurrier et al. instrument were made up of only 2 items and, therefore, Cronbach's Alpha was not calculated for the Perception of Interruption and the Use of Graphs constructs. Tables L-1 and L-2 present the factor loadings (by questionnaire item number), the factor eigenvalues, and reliabilities associated with each scale.

Table L-1

Bailey and Pearson Factor Loadings and Reliabilites from Pilot 2

Factor Label	Item Number	Factor Loading	Eigenvalue	Cronbach's Alpha
Information Quality	2-A	.833	10.00	.907
	2-B	.829		
	3-C	.639		
	3-D	.671		
Information Usefulness	8-A	.839	1.96	.921
	8-B	.855		
	8-C	.656		
	8-D	.776		
Information Comprehensiveness	5-A	.817	1.26	.921
	5-C	.850		
	5-D	.804		
Information Format	6-B	.686	1.03	.868
	6-C	.815		
	6-D	.807		
Information Reliability	4-A	.838	.89	.914
	4-B	.821		
	4-D	.750		

Table L-2

Spurrier et al. Factor Loadings and Reliabilites from Pilot 2

Factor Label	Item Number	Factor Loading	Eigenvalue	Cronbach's Alpha
Task Importance	13 16 30	.817 .865 .749	5.31	.843
Use of Tables	24 26 28	.744 .654 .836	1.91	.628
Perception of Interruptions	14 20	.877 .829	1.73	----
Use of Graphs	18 22	.773 .714	1.20	----
Rationale Approach	12 19 23 29	.644 .724 .807 .521	.972	.804
Confidence	10 15 27	.711 .771 .735	.856	.785

L.3 Results of Hypothesis Testing

A preliminary analysis of the hypotheses proposed in this study was conducted using ANOVA. Each hypothesis is presented along with the ANOVA results and where appropriate, the dependent variable means.

Hypothesis Testing for Hypotheses H1A-D

H1A hypothesized that simple tasks would be performed more accurately with interruptions than without interruptions. No significant effect was found and therefore, this hypothesis was not supported.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 62)	P-level
Decision Accuracy Simple-Symbolic	4	2	1.582	.21
Decision Accuracy Simple-Spatial	1	2	.324	.57

H1B hypothesized that simple tasks would be performed more quickly with interruptions than without interruptions. Significant effects were found, however, not in the direction hypothesized.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 62)	P-level
Decision Time Simple-Symbolic	5155278	1113212	4.63	.04
Decision Time Simple-Spatial	7939351	1343416	5.910	.02

Dependent Variable	Mean No Interruption	Mean Interruption
Decision Time Simple-Symbolic	1688.49	2270.14
Decision Time Simple-Spatial	2008.52	2730.34

H1C hypothesized that complex tasks would be performed less accurately with interruptions than without interruptions. A marginally significant effect was found in the hypothesized direction.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 52)	P-level
Decision Accuracy Complex-Symbolic	253.52	63.19	4.012	.051
Decision Accuracy Complex-Spatial	.283E+11	.212E+11	1.333	.25

Dependent Variable	Mean No Interruption	Mean Interruption
Decision Accuracy Complex-Symbolic	561.25	613.87

H1D hypothesized that complex tasks would be performed less quickly with interruptions than without interruptions. No significant effect was found and therefore, this hypothesis was not supported.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 52)	P-level
Decision Time Complex-Symbolic	32813.18	34919.07	.949	.34
Decision Time Complex-Spatial	7332.73	4158.987	1.763	.19

Results suggest that H1A and H1C were not supported. H1B was statistically significant for both simple tasks, however, not in the direction hypothesized. There was mixed support for H1D. Interruptions that occur during complex-symbolic tasks resulted in decreased decision accuracy when compared to tasks that were not interrupted.

Hypothesis Testing for Hypotheses H2A-H

H2A hypothesized that simple-symbolic tasks would be performed more accurately with tables than with graphs. A significant effect was found in the direction hypothesized.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 62)	P-level
Decision Accuracy Simple-Symbolic	50	2	22.591	.00

Dependent Variable	Mean Graphs	Mean Tables
Decision Accuracy Simple-Symbolic	2.5	4.32

H2B hypothesized that simple-symbolic tasks would be performed more quickly with tables than with graphs. A significant effect was found, however, not in the direction hypothesized.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 62)	P-level
Decision Time Simple-Symbolic	4963173	1113212	4.458	.04

Dependent Variable	Mean Graphs	Mean Tables
Decision Time Simple-Symbolic	1694	2264

H2C: Simple-spatial tasks performed more accurately with graphs-NOT SUPPORTED

H2C hypothesized that simple-spatial tasks would be performed more accurately with graphs than with tables. No siginficant effects were found and the hypothesis was not supported.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 62)	P-level
Decision Accuracy Simple-Spatial	1	2	.507	.48

H2D hypothesized that simple-spatial tasks would be performed more quickly with graphs than with tables. A significant effect was found in the direction hypothesized.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 62)	P-level
Decision Time Simple-Spatial	6472109	1343416	4.817	.03

Dependent Variable	Mean Graphs	Mean Tables
Decision Time Simple-Spatial	2043.57	2695.29

H2E hypothesized that feasibly-solvable complex-symbolic tasks would be performed more accurately with tables than with graphs. A significant effect was found in the direction hypothesized.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 52)	P-level
Decision Accuracy Complex-Symbolic	948	66.18	14.32	.00

Dependent Variable	Mean Graphs	Mean Tables
Decision Accuracy Complex-Symbolic	32.39	41.28

H2F hypothesized that feasibly-solvable complex-symbolic tasks would be performed more quickly with tables than with graphs. A significant effect was found in the direction hypothesized.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 52)	P-level
Decision Time Complex-Symbolic	1282948	37336.99	34.361	.00

Dependent Variable	Mean Graphs	Mean Tables
Decision Time Complex-Symbolic	758.16	431.18

H2G hypothesized that feasibly-solvable complex-spatial tasks would be performed more accurately with graphs than with tables. No significant effects were found and therefore, this hypothesis was not supported.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 52)	P-level
Decision Accuracy Complex-Spatial	.455E+10	.256E+11	.178	.67

H2H hypothesized that feasibly-solvable complex-spatial tasks would be performed more quickly with graphs than with tables. No significant effects were found and therefore, this hypothesis was not supported.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 52)	P-level
Decision Time Complex-Spatial	2050	4330	.474	.49

Hypotheses 2C, 2G, and 2H were not supported while hypotheses 2A, 2D, 2E, and 2F were statistically significant in support of Cognitive Fit Theory. Hypothesis 2B was also statistically significant, however, in the opposite direction from what is predicted by Cognitive Fit Theory. A closer examination of the 2B results suggested that a marginally significant interaction exists between the presentation format and interruption ($p = .06$). Subjects in the no interruption/graph treatment were able to complete the simple-symbolic task much more quickly than the other three treatments. The remaining treatments all had comparable decision times.

A closer examination of Hypothesis 2C was also performed. A significant interaction between interruption and presentation was found ($p = .03$). The decision accuracy means are comparable between graphs and tables when there are no interruptions. However, when interruptions occur, decision accuracy is maintained when using graphs but significantly impaired when using tables.

DECISION ACCURACY MEANS FOR SIMPLE-SPATIAL TASKS

INTERRUPTION	PRESENTATION	MEAN DECISION ACCURACY
I	G	4.8
N	T	4.75
N	G	4.7
I	T	4.25

Hypothesis Testing for Hypotheses H3A-C

H3A hypothesized that when decision makers are interrupted, simple-symbolic tasks will be performed more quickly when using graphs. No significant effects were found and therefore, this hypothesis was not supported.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 29)	P-level
Decision Time Simple-Symbolic	118134.1	646115	.183	.67

H3B hypothesized that when decision makers are interrupted interrupted, complex-symbolic tasks will be performed more accurately when using graphs. Significant effects were found, however, not in the direction hypothesized.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 110)	P-level
Decision Accuracy Complex-Symbolic	1120	83.3	13.42	.00

H3C hypothesized that when decision makers are interrupted, complex-symbolic tasks will be performed more quickly when using graphs. Significant effects were found in the direction hypothesized.

Dependent Variable	Mean Square Effect	Mean Square Error	F dof (1, 110)	P-level
Decision Time Complex-Symbolic	.184E+11	.191E+10	9.666	.00

Hypothesis H3A was not statistically significant, however, the results were in the direction hypothesized. The mean for decision time when using graphs was 2146 and when using tables was 2271. Hypothesis H3B was significant, however, not in the direction hypothesized. The mean for decision accuracy when using graphs was 30.15 and when using tables was 40.02. These means are comparable to the mean values for decision time when there were no interruption occurrences (see H2E). As noted in the dissertation proposal, the information used in this task will be slightly modified in the main study. In order to successfully perform this task, subjects needed to select between facility locations that might differ by $500. When using graphs, the scale ranged from 0 to 80,000 in increments of 10,000. This small distinction was difficult, and perhaps impossible, to perform. Modifications will be made in the main study to obtain a more fair test of this hypothesis.

H3C was statistically significant in the direction hypothesized. The mean for decision time when using graphs was 808.08 and when using tables was 1865.36. This finding is particularly interesting in light of the results of H2F. The test of H2F suggested that the use of tables results in significantly quicker decisions when no interruptions occur. However, H3C suggests that when interrupted, graphs result in significantly faster decisions.

Hypothesis Testing for Hypotheses H4A-B

H4A hypothesized that complex tasks would be performed less accurately as the interruption frequency increased. No significant effects were found and this hypothesis was not supported.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 68)	P-level
Decision Accuracy Complex-Symbolic	244.89	1402.29	.174	.68
Decision Accuracy Complex-Spatial	.431E+10	.202E+11	.153	.71

H4B hypothesized that complex tasks would be performed less quickly as the interruption frequency increased. No significant effects were found and this hypothesis was not supported.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 68)	P-level
Decision Time Complex-Symbolic	5816.93	32864.11	.177	.62
Decision Time Complex-Spatial	7830.64	78200.48	.100	.76

Hypotheses 4A and 4B were not supported. A stronger manipulation will be used in main study to determine if interruption frequency significantly influences decision accuracy and/or decision time.

Hypothesis Testing for Hypotheses H5A-B

H5A hypothesized that complex tasks would be performed less accurately as the interruption content is more similar to the primary task content. Significant effects were found in the direction hypothesized.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 68)	P-level
Decision Accuracy Complex-Symbolic	228.63	1566.41	.146	.72
Decision Accuracy Complex-Spatial	.168E+12	.256E+11	6.550	.01

H5A hypothesized that complex tasks would be performed less quickly as the interruption content is more similar to the primary task content. No sigificant effects were found and therefore, this hypothesis was not supported.

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 68)	P-level
Decision Time Complex-Symbolic	4425.34	34573	.128	.70
Decision Time Complex-Spatial	7750	78500	.098	.75

Hypothesis 5A has mixed support and Hypothesis 5B was not supported by the data. When performing complex-spatial tasks, the mean for decision accuracy when using interruption data similar to the task data was 217169 and when using interruption data different to the task was 119049. This finding gives partial support to the influence of the interruption content on decision accuracy.

Appendix M
Full Results of Hypothesis and Post-Hoc Statistical Analysis

M-1 Hypothesis Testing Results
Testing of Hypothesis 1

Table M1-1
H1A1 ANCOVA for Interruptions on Decision Accuracy for the Simple-Symbolic Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-value
Decision Accuracy Simple-Symbolic	11.131	17.791	.626	.430

Dependent Variable	Mean No Interruption	Mean Interruption
Decision Accuracy Simple-Symbolic	3.30	3.87

Table M1-2
H1A2 ANCOVA for Interruptions on Decision Accuracy for the Simple-Spatial Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-value
Decision Accuracy Simple-Spatial	.115	.028	4.080	.045

Dependent Variable	Mean No Interruption	Mean Interruption
Decision Accuracy Simple-Spatial	.735	.793

Table M1-3
Control Variables for Decision Accuracy on Simple-Symbolic Tasks

	Mean Square Effect	Mean Square Error	F (3, 131)	P-value
Control Variables	61.757	17.090	3.613	.015

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	-1.074	.763	-.120	-1.408	.161
Domain Expertise	.140	.068	.178	2.043	.043
Spatial Orientation	.035	.024	.123	1.443	.151

Table M1-4
H1B1 ANCOVA for Interruptions on Decision Time for the Simple-Symbolic Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1,132)	P-value
Decision Time Simple-Symbolic	8144.12	2862.61	2.845	.094

Dependent Variable	Mean No Interruption	Mean Interruption
Decision Time Simple-Symbolic	154.43	138.95

Table M1-5
H1B2 ANCOVA for Interruptions on Decision Time for the Simple-Spatial Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1,132)	P-value
Decision Time Simple-Spatial	1717.04	606.91	2.829	.095

Dependent Variable	Mean No Interruption	Mean Interruption
Decision Time Simple-Spatial	57.32	42.62

Table M1-6
H1C1 ANCOVA for Interruptions on Decision Accuracy for the Complex-Symbolic Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-value
Decision Accuracy Complex-Symbolic	.119	.023	5.261	.023

Dependent Variable	Mean No Interruption	Mean Interruption
Decision Accuracy Complex-Symbolic	.756	.702

Table M1-7
H1C2 ANCOVA for Interruptions on Decision Accuracy for the Complex-Spatial Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-value
Decision Accuracy Complex-Spatial	1396.027	459.04	3.041	.084

Dependent Variable	Mean No Interruption	Mean Interruption
Decision Accuracy Complex-Spatial	11.71	19.36

Table M1-8
Control Variables for Decision Accuracy on Complex-Symbolic Tasks

	Mean Square Effect	Mean Square Error	F (3,129)	P-value
Control Variables	.0667	.0225	2.959	.015

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	-.023	.028	-.071	-.804	.423
Domain Expertise	.006	.003	.195	2.182	.031
Spatial Orientation	.001	.001	.073	.849	.398

Table M1-9
H1D1 ANCOVA for Interruptions on Decision Time for the Complex-Symbolic Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 103)	P-value
Decision Time Complex-Symbolic	68036.69	19917.74	3.415	.067

Dependent Variable	Mean No Interruption	Mean Interruption
Decision Time Complex-Symbolic	306.29	366.77

Table M1-10
H1D2 ANCOVA for Interruptions on Decision Time for the Complex-Spatial Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 103)	P-value
Decision Time Complex-Spatial	81689.81	307433.9	.265	.607

Dependent Variable	Mean No Interruption	Mean Interruption
Decision Time Complex-Spatial	1074.611	1007.611

Table M1-11
Linear Regression Results Assessing the Influence of Interruption Decision Accuracy and Decision Time on the Complex-Spatial Task

Variable	Beta	Standard Error	B	Standard Error	t	p-level
Interruption	.055	.099	63.737	114.537	.556	.579
Gender	.162	.096	197.204	116.469	1.693	.093
Exam	-.057	.098	-6.137	10.463	-.587	.559
Spatial Orientation	.088	.098	3.216	3.581	.898	.371
Interruption Decision Accuracy	-.172	.094	-34.028	18.474	-1.842	.064
Interruption Decision Time	.259	.097	3.397	1.27	2.683	.009

Table M1-12
Control Variables for Decision Time on Complex-Spatial Tasks

	Mean Square Effect	Mean Square Error	F (4,127)	P-value
Control Variables	863640.8	303404.4	2.791	.021

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	197.204	116.469	.160	1.69	.093
Domain Expertise	-6.137	10.463	-.057	-.587	.559
Spatial Orientation	3.216	3.581	.086	.898	.371
Interruption Decision Time	2.297	1.266	.253	2.68	.009
Interruption Decision Accuracy	-34.028	18.473	-.173	-1.842	.068

Testing of Hypotheses 2

Table M1-13
H2A ANCOVA for Information Presentation Format on Decision Accuracy for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 132)	P-value
Decision Accuracy Simple-Symbolic	74.281	17.790	4.175	.043

Dependent Variable	Mean Graphs	Mean Tables
Decision Accuracy Simple-Symbolic	4.33	2.85

Table M-14
Control Variables for Decision Accuracy on Simple-Symbolic Tasks

	Mean Square Effect	Mean Square Error	F (3, 131)	P-value
Control Variables	55.424	16.752	3.309	.023

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	-.884	.760	-.095	-1.11	.268
Domain Expertise	.132	.068	.170	1.959	.050
Spatial Orientation	.0379	.0234	.140	1.63	.105

Table M1-15
H2B ANCOVA for Information Presentation Format on Decision Time for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-value
Decision Time Simple-Symbolic	20268.52	2866.209	7.072	.009

Dependent Variable	Mean Graphs	Mean Tables
Decision Time Simple-Symbolic	134.80	158.57

Table M1-16
H2C ANCOVA for Information Presentation Format on Decision Accuracy for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 132)	P-value
Decision Accuracy Simple-Spatial	.2995	.028	10.654	.001

Dependent Variable	Mean Graphs	Mean Tables
Decision Accuracy Simple-Spatial	.811	.717

Table M1-17
Control Variables for Decision Accuracy on Simple-Spatial Tasks

	Mean Square Effect	Mean Square Error	F (3, 131)	P-value
Control Variables	.058	.028	2.059	.108

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	.021	.031	.058	.669	.504
Domain Expertise	.001	.003	.034	.395	.693
Spatial Orientation	.002	.001	.194	2.23	.028

Table M1-18
H2D ANCOVA for Information Presentation Format on Decision Time for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 132)	P-value
Decision Time Simple-Spatial	6957.79	606.91	11.46	.001

Dependent Variable	Mean Graphs	Mean Tables
Decision Time Simple-Spatial	41.83	58.11

Table M1-19
H2E ANCOVA for Information Presentation Format on Decision Accuracy for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 127)	P-value
Decision Accuracy Complex-Symbolic	.1219	.0217	5.618	.019

Dependent Variable	Mean Graphs	Mean Tables
Decision Accuracy Complex-Symbolic	.704	.753

Table M1-20
Control Variables for Decision Accuracy and Information Presentation Format on Complex-Symbolic Tasks

	Mean Square Effect	Mean Square Error	F (3,128)	P-value
Control Variables	.090	.022	4.168	.002

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	-.026	.028	-.078	-.937	.351
Domain Expertise	.006	.002	.221	2.571	.011
Spatial Orientation	.001	.001	.084	.986	.325

Table M1-21
H2F ANCOVA for Information Presentation Format on Decision Time for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 103)	P-value
Decision Time Complex-Symbolic	2837282	280680.6	10.109	.002

Dependent Variable	Mean Graphs	Mean Tables
Decision Time Complex-Symbolic	846.19	1225.64

Table M1-22
H2G ANCOVA for Information Presentation Format on Decision Accuracy for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-value
Decision Accuracy Complex-Spatial	1759.38	459.04	2.832	.050

Dependent Variable	Mean Graphs	Mean Tables
Decision Accuracy Complex-Spatial	11.15	19.19

Table M1-23
H2H ANCOVA for Information Presentation Format on Decision Time for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-value
Decision Time Complex-Spatial	3334154	300604.0	11.092	.001

Dependent Variable	Mean Graphs	Mean Tables
Decision Time Complex-Spatial	846.19	1225.64

Testing of Hypothesis 3

Table M1-24
H3A ANCOVA for Information Presentation Format on Decision Time for Simple-Symbolic Tasks With Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 66)	P-value
Decision Time Simple-Symbolic	10304.23	2823.470	3.650	.048

Dependent Variable	Mean Graphs	Mean Tables
Decision Time Simple-Symbolic	130.09	147.80

Table M1-25
H3B ANCOVA for Information Presentation Format on Decision Accuracy for Complex-Symbolic Tasks With Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 60)	P-value
Decision Accuracy Complex-Symbolic	.031	.019	.1576	.214

Dependent Variable	Mean Graphs	Mean Tables
Decision Accuracy Complex-Symbolic	.729	.678

Table M1-26
Control Variables for Decision Accuracy, Information Presentation Format, and Interruptions on Complex-Symbolic Tasks

	Mean Square Effect	Mean Square Error	F (5, 125))	P-value
Control Variables	.065	.020	3.340	.007

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	-.043	.027	-.140	-1.587	.115
Domain Expertise	.004	.002	.151	1.686	.094
Spatial Orientation	.001	.001	.120	1.394	.166

Table M1-27
Information Presentation Format, Interruptions, and Decision Accuracy on Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1,125)	P-value
Decision Accuracy Complex-Symbolic Task	.293	.020	15.012	.000

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	.729	--------	.165	.140	.005**
NI	G	.679		--------	.946	.000***
I	T	.677			--------	.000***
NI	T	.829				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Table M1-28
H3C ANCOVA for Information Presentation Format on Decision Time for Complex-Symbolic Tasks With Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 61)	P-value
Decision Time Complex-Symbolic	4815.122	23190.71	.208	.650

Dependent Variable	Mean Graphs	Mean Tables
Decision Time Complex-Symbolic	1296.88	1316.67

Testing of Hypothesis 4

Table M1-29
H4A1 Interruption Frequency and Decision Accuracy for the Complex-Spatial Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 74)	P-value
Decision Accuracy Complex-Symbolic	.933	.021	4.05	.039

Dependent Variable	Mean Low Frequency	Mean High Frequency
Decision Accuracy Complex-Symbolic	.870	.794

Table M1-30
H4A2 Interruption Frequency and Decision Accuracy on the Complex-Spatial Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 74)	P-value
Decision Accuracy Complex-Spatial	18.037	343.44	.053	.819

Dependent Variable	Mean Low Frequency	Mean High Frequency
Decision Accuracy Complex-Spatial	10.08	11.00

Table M1-31
Control Variables for Decision Accuracy and Interruption Frequency on Complex-Spatial Tasks

	Mean Square Effect	Mean Square Error	F (3, 131)	P-value
Control Variables	1020.248	342.782	2.98	.037

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	1.202	4.534	.029	.265	.792
Domain Expertise	-.861	.447	-.212	-1.927	.058
Spatial Orientation	-.318	.142	-.247	-2.242	.028

Table M1-32
H4B1 Interruption Frequency and Decision Time for the Complex-Symbolic Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 68)	P-value
Decision Time Complex-Symbolic	.298 E12	.118 E11	25.216	.000

Dependent Variable	Mean Low Frequency	Mean High Frequency
Decision Time Complex-Symbolic	832.8	1437.09

Table M1-33
H4B2 Interruption Frequency and Decision Time on the Complex-Spatial Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 68)	P-value
Decision Time Complex-Spatial	.151 E13	.578 E10	26.129	.000

Dependent Variable	Mean Low Frequency	Mean High Frequency
Decision Time Complex-Spatial	1216.5	2232.29

Table M1-34
Linear Regression Results Assessing the Influence of Interruption Decision Accuracy and Decision Time on Complex-Symbolic Tasks

Variable	Beta	Standard Error	B	Standard Error	t	p-level
Frequency	-.705	.140	-5662.5	1127.63	-5.022	.000
Gender	-.122	.0606	-49554.1	24291.23	-2.04	.044
Domain Expertise	.077	.551	245.5	1816.00	.135	.893
Spatial Orientation	.101	.060	1312.4	783.75	1.674	.097
Interruption Decision Accuracy	-.148	.138	-14.9	13.93	-1.072	.286
Interruption Decision Time	-.209	.060	-1585.4	454.00	-3.492	.001

Table M1-35
Linear Regression Results Assessing the Influence of Interruption Decision Accuracy and Decision Time on Complex-Spatial Tasks

Variable	Beta	Standard Error	B	Standard Error	t	p-level
Frequency	-1.135	.076	-8730.8	584.59	-14.935	.000
Gender	-.030	.052	-11563.0	19935.52	-.580	.564
Domain Expertise	.007	.051	258.5	1919.00	.135	.893
Spatial Orientation	.046	.052	551.7	621.96	.887	.378
Interruption Decision Accuracy	-.387	.067	-11404.1	1980.30	-5.759	.000
Interruption Decision Time	-.941	.062	-86.2	131.82	-.654	.515

Table M1-36
Control Variables for Decision Time and Interruption Frequency on Complex-Symbolic Tasks

	Mean Square Effect	Mean Square Error	F (5, 72)	P-value
Control Variables	.360 E11	.140E 11	3.457	.007

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	-56704.0	25455.45	-.241	-2.228	.029
Domain Expertise	-1219.5	2461.96	-.052	-.495	.622
Spatial Orientation	1253.7	784.58	.171	1.598	.114
Interruption Decision Time	-19.1	14.12	-.145	-1.350	.181
Interruption Decision Accuracy	-2665.3	906.22	-.316	-2.941	.004

Table M1-37
Control Variables and Decision Time and Interruption Frequency on Complex-Spatial Tasks

	Mean Square Effect	Mean Square Error	F (5, 72)	P-value
Control Variables	.483 E11	.627E 10	7.700	.000

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	-11563.0	19935.52	-.057	-.580	.564
Domain Expertise	258.5	1919.00	.013	.135	.893
Spatial Orientation	551.7	621.96	.087	.887	.387
Interruption Decision Time	-86.2	131.82	.064	-.653	.515
Interruption Decision Accuracy	-11404.1	1980.30	-.565	-5.759	.000

Testing of Hypothsis 5

Table M1-38
H5A1 Interruption Content and Decision Accuracy on the Complex-Symbolic Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 74)	P-value
Decision Accuracy Complex-Symbolic	.032	.022	1.436	.235

Dependent Variable	Mean Similar Content	Mean Different Content
Decision Accuracy Complex-Symbolic	.851	.812

Table M1-39
H5A2 Interruption Content and Decision Accuracy on the Complex-Spatial Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 74)	P-value
Decision Accuracy Complex-Spatial	2.113	333.15	.006	.937

Dependent Variable	Mean Similar Content	Mean Different Content
Decision Accuracy Complex-Spatial	10.125	10.914

Table M1-40

Control Variables for Decision Accuracy and Interruption Content on Complex-Spatial Tasks

	Mean Square Effect	Mean Square Error	F (5, 125))	P-value
Control Variables	1016.385	341.920	2.973	.037

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	1.120	4.480	.028	.250	.803
Domain Expertise	.868	.438	.218	1.078	.051
Spatial Orientation	.314	.138	.252	2.274	.026

Table M1-41
H5B1 Interruption Content and Decision Time on the Complex-Symbolic Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 74)	P-value
Decision Time Complex-Symbolic	.114 E12	.984 E10	11.62	.001

Dependent Variable	Mean Similar Content	Mean Different Content
Decision Time Complex-Symbolic	1110	1848

Table M1-42
H5B2 Interruption Content and Decision Time on the Complex-Spatial Task

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 74)	P-value
Decision Time Complex-Spatial	.221 E13	.312 E12	7.08	.009

Dependent Variable	Mean Similar Content	Mean Different Content
Decision Time Complex-Spatial	1319	1824

Table M1-43
Linear Regression Results Assessing the Influence of Interruption Decision Accuracy and Decision Time

Variable	Beta	Standard Error	B	Standard Error	t	p-level
Content	.119	.065	44793.2	24505.69	1.828	.070
Gender	-.206	.065	-83052.9	26286.97	-3.160	.002
Domain Expertise	.007	.051	258.5	1919.00	.135	.893
Spatial Orientation	.070	.066	915.8	863.98	1.06	.292
Interruption Decision Accuracy	-.854	.068	-76.1	6.87	-11.082	.000
Interruption Decision Time	-.163	.067	-1238.1	505.30	-2.450	.016

Table M1-44
Control Variables for Decision Time and Interruption Content on Complex-Symbolic Tasks

	Mean Square Effect	Mean Square Error	F (5, 72)	P-value
Control Variables	.352 E12	.136 E11	25.896	.000

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	-86687.3	28513.7	-.218	-3.04	.003
Domain Expertise	52.4	2800.26	.001	.019	.985
Spatial Orientation	963.5	894.87	.089	1.077	.285
Interruption Decision Time	-79.1	7.70	-.784	-10.278	.000
Interruption Decision Accuracy	-2159.1	1036.72	-.154	-2.083	.041

Table M1-45
Control Variables for Decision Time and Interruption Content on Complex-Spatial Tasks

	Mean Square Effect	Mean Square Error	F (3, 74)	P-value
Control Variables	.858 E11	.298 E11	2.881	.041

Variable	B-weight	Standard Error	Beta	t	p-value
Gender	-91708.3	41799.51	-.244	-2.194	.031
Domain Expertise	4900.9	4094.24	.132	1.197	.235
Spatial Orientation	-1409.2	1289.48	-.121	-1.093	.278

Appendix M-2: Interruptions as Dependent Variables

Table M-2-1
Influence of Interruptions on Interuption Decision Accuracy for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-level
Decision Accuracy Simple-Symbolic Task	425.898	235.520	1.851	.176

Dependent Variable	Mean No Interruptions	Mean Interruptions
Decision Accuracy Simple Symbolic Task	5.50	2.85

Table M-2-2
Influence of Interruptions on Interuption Decision Time for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-level
Decision Time Simple-Symbolic Task	14378.92	1838.74	7.820	.007

Dependent Variable	Mean No Interruptions	Mean Interruptions
Decision Time Simple Symbolic Task	37.40	76.40

Table M-2-3
Influence of Interruptions on Interuption Decision Accuracy for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-level
Decision Accuracy Simple-Spatial Task	469.66	247.86	1,895	.164

Dependent Variable	Mean No Interruptions	Mean Interruptions
Decision Accuracy Simple SpatialTask	5.56	2.77

Table M-2-4
Influence of Interruptions on Interuption Decision Time for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-level
Decision Time Simple-Spatial Task	13840.02	1744.877	7.931	.006

Dependent Variable	Mean No Interruptions	Mean Interruptions
Decision Time Simple-SpatialTask	79.26	102.09

Table M-2-5
Influence of Interruptions on Interuption Decision Accuracy or Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 129)	P-level
Decision Accuracy Complex-Symbolic Task	.561	1.100	.554	.458

Dependent Variable	Mean No Interruptions	Mean Interruptions
Decision Accuracy Complex-Symbolic Task	3.12	3.02

Table M-2-6
Influence of Interruptions on Interuption Decision Time for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-level
Decision Time Complex-Symbolic Task	108976.7	111144.8	.980	.332

Dependent Variable	Mean No Interruptions	Mean Interruptions
Decision Time Complex-Symbolic Task	49.23	58.47

Table M-2-7
Influence of Interruptions on Interuption Decision Accuracy for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-level
Decision Accuracy Complex-Spatial Task	.6174	10.69	.058	.810

Dependent Variable	Mean No Interruptions	Mean Interruptions
Decision Accuracy Complex-Spatial Task	12.07	12.02

Table M-2-8
Influence of Interruptions on Interuption Decision Time for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 131)	P-level
Decision Time Complex-Spatial Task	4246.51	1935.50	2.19	.141

Dependent Variable	Mean No Interruptions	Mean Interruptions
Decision Time Complex-Spatial Task	126.82	113.60

Appendix M-3: Task Type and Work Environment

Significnat Perceptual Resutls

Table M-3-1
Interruption Treatment and Perception of Interruptions on Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 135)	P-level
Perception of Interruptions Simple-Symbolic Task	8.501	.562	15.12	.000

Dependent Variable	Mean No Interruptions	Mean Interruptions
Perception of Interruptions Simple Symbolic Task	3.58	3.02

Table M-3-2
Interruption Treatment and Perception of Interruptions on Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 105)	P-level
Perception of Interruptions Simple-Spatial	6.251	.727	8.597	.004

Dependent Variable	Mean No Interruptions	Mean Interruptions
Perception of Interruptions Simple-Spatial	3.576	3.090

Table M-3-3
Interruption Treatment and Perception of Interruptions on Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 105)	P-level
Perception of Interruptions Complex Symbolic Task	6.4714	.8056	8.033	.005

Dependent Variable	Mean No Interruptions	Mean Interruptions
Perception of Interruptions Complex-Symbolic Task	3.58	3.15

Table M-3-4
Interruption Treatment and Amount of Information on Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 105)	P-level
Amount of Information Simple-Spatial	5.859	1.353	4.33	.040

Dependent Variable	Mean No Interruptions	Mean Interruptions
Amount of Information Simple-Spatial	3.14	3.61

Table M-3-5
Interruption Treatment and Amount of Information on Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Amount of Information Complex-Symbolic Task	3.399	1.190	2.86	.093

Dependent Variable	Mean No Interruptions	Mean Interruptions
Amount of Information Complex-Symbolic Task	3.16	3.48

Table M-3-6
Interruption Treatment and Confidence in Solution on Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 105)	P-level
Confidence Simple-Symbolic	9.299	1.892	4.914	.029

Dependent Variable	Mean No Interruptions	Mean Interruptions
Confidence Simple Symbolic	4.10	4.69

Table M-3-7
Interruption Treatment and Rational Problem Solving Approach on Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 105)	P-level
Rational Approach Simple-Symbolic	4.831	1.445	3.34	.070

Dependent Variable	Mean No Interruptions	Mean Interruptions
Rational Approach Simple Symbolic	4.53	4.96

Non-Significant Perceptual Results

Simple-Symbolic Tasks

Table M-3-8
Interruption Treatment and Information Quality for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Simple-Symbolic	.0665	1.4772	.045	.832

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Quality Simple-Symbolic	2.82	2.88

Table M-3-9
Interruption Treatment and Information Precision for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Simple-Symbolic	.2940	1.2636	.233	.631

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Precision Simple-Symbolic	2.95	2.84

Table M-3-10
Interruption Treatment and Information Reliability for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Simple-Symbolic	.8829	1.5533	.568	.453

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Reliability Simple-Symbolic	3.02	2.84

Table M-3-11
Interruption Treatment and Information Comprehensiveness for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Comprehensiveness Simple-Symbolic	.0792	1.489	.053	.818

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Comprehensiveness Simple-Symbolic	2.78	2.73

Table M-3-12
Interruption Treatment and Information Format for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Simple-Symbolic	.3395	1.1773	.2884	.5923

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Format Simple-Symbolic	2.73	2.62

Table M-3-13
Interruption Treatment and Information Overall for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Simple-Symbolic	.0000	1.3138	.000	.999

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Overall Simple-Symbolic	2.82	2.82

Table M-3-14
Interruption Treatment and Amount of Information for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Amount of Information Simple-Symbolic	2.3036	1.5605	1.476	.227

Dependent Variable	Mean No Interruptions	Mean Interruptions
Amount of Information Simple-Symbolic	2.92	3.22

Table M-3-15
Interruption Treatment and Rationale Problem Solving Approach for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Rationale Approach Simple-Symbolic	4.8316	1.4450	3.344	.07

Dependent Variable	Mean No Interruptions	Mean Interruptions
Rationale Approach Simple-Symbolic	4.53	4.96

Table M-3-16
Interruption Treatment and Use of Tables
for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Simple-Symbolic	2.1465	1.7390	1.234	.269

Dependent Variable	Mean No Interruptions	Mean Interruptions
Use of Tables Simple-Symbolic	4.29	4.57

Table M-3-17
Interruption Treatment and Solution Importance
for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Simple-Symbolic	.0122	1.7752	.007	.934

Dependent Variable	Mean No Interruptions	Mean Interruptions
Solution Importance Simple-Symbolic	4.79	4.81

Table M-3-18
Interruption Treatment and Use of Graphs
for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Simple-Symbolic	1.7998	1.1276	1.5960	.209

Dependent Variable	Mean No Interruptions	Mean Interruptions
Use of Graphs Simple-Symbolic	4.22	4.49

Simple-Spatial Tasks

Table M-3-19
Interruption Treatment and Information Quality for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Simple-Spatial	.0555	1.3910	.0399	.842

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Quality Simple-Spatial	3.06	3.10

Table M-3-20
Interruption Treatment and Information Precision for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Simple-Spatial	.0074	1.3515	.0055	.940

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Precision Simple-Spatial	4.79	4.81

Table M-3-21
Interruption Treatment and Information Reliability for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Simple-Spatial	.0061	1.4673	.004	.948

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Reliability Simple-Spatial	3.16	3.14

Table M-3-22
Interruption Treatment and Information Comprehensiveness for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Comprehensiveness Simple-Spatial	.1251	1.3453	.093	.761

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Comprehensiveness Simple-Spatial	2.94	3.01

Table M-3-23
Interruption Treatment and Information Format for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Simple-Spatial	.0019	1.4833	.001	.972

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Format Simple-Spatial	2.92	2.93

Table M-3-24
Interruption Treatment and Information Overall for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Simple-Spatial	.2079	1.324	.157	.693

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Overall Simple-Spatial	3.10	3.19

Table M-3-25
Interruption Treatment and Confidence for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Confidence Simple-Spatial	.3050	1.4908	.205	.652

Dependent Variable	Mean No Interruptions	Mean Interruptions
Confidence Simple-Spatial	4.23	4.33

Table M-3-26
Interruption Treatment and Rationale Problem Solving Approach for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Rationale Approach Simple-Spatial	.3049	1.4908	.205	.652

Dependent Variable	Mean No Interruptions	Mean Interruptions
Rationale Approach Simple-Spatial	4.56	4.34

Table M-3-27
Interruption Treatment and Use of Tables for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Simple-Spatial	1.2549	1.5052	.834	.363

Dependent Variable	Mean No Interruptions	Mean Interruptions
Use of Tables Simple-Spatial	4.35	4.43

Table M-3-28
Interruption Treatment and Solution Importance for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Simple-Spatial	.1678	1.5869	.106	.746

Dependent Variable	Mean No Interruptions	Mean Interruptions
Solution Importance Simple-Spatial	4.83	4.65

Table M-3-29
Interruption Treatment and Use of Graphs for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Simple-Spatial	.8361	1.6705	.500	.481

Dependent Variable	Mean No Interruptions	Mean Interruptions
Use of Graphs Simple-Spatial	4.19	4.41

<u>Complex-Symbolic Tasks</u>

Table M-3-30
Interruption Treatment and Information Quality for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Complex-Symbolic	1.1034	1.7545	.629	.429

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Quality Complex-Symbolic	3.26	3.08

Table M-3-31
Interruption Treatment and Information Precision for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Complex-Symbolic	.5005	1.7478	.286	.593

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Precision Complex-Symbolic	3.23	3.11

Table M-3-32
Interruption Treatment and Information Reliability for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Complex-Symbolic	2.5850	1.7140	1.508	.222

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Reliability Complex-Symbolic	3.31	3.03

Table M-3-33
Interruption Treatment and Information Comprehensiveness for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Comprehensiveness Complex-Symbolic	.5955	1.7662	.337	.562

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Comprehensiveness Complex-Symbolic	3.13	2.99

Table M-3-34
Interruption Treatment and Information Format for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Complex-Symbolic	0041	1.921	.002	.963

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Format Complex-Symbolic	3.07	3.08

Table M-3-35
Interruption Treatment and Information Overall for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Complex-Symbolic	.2224	1.4983	.148	.701

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Overall Complex-Symbolic	3.15	3.07

Table M-3-36
Interruption Treatment and Confidence for Complex-SymbolicTasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Confidence Complex-Symbolic	.9444	1.841	.513	.475

Dependent Variable	Mean No Interruptions	Mean Interruptions
Confidence Complex-Symbolic	4.17	4.33

Table M-3-37
Interruption Treatment and Amount of Information for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Amount of Information Complex-Symbolic	3.3988	1.1898	2.856	.093

Dependent Variable	Mean No Interruptions	Mean Interruptions
Amount of Information Complex-Symbolic	3.16	3.48

Table M-3-38
Interruption Treatment and Rationale Problem Solving Approach for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Rationale Approach Complex-Symbolic	.5313	1.479	.359	.550

Dependent Variable	Mean No Interruptions	Mean Interruptions
Rationale Approach Complex-Symbolic	4.75	4.63

Table M-3-39
Interruption Treatment and Use of Tables for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Complex-Symbolic	.1838	1.5566	.118	.732

Dependent Variable	Mean No Interruptions	Mean Interruptions
Use of Tables Complex-Symbolic	4.36	4.29

Table M-3-40
Interruption Treatment and Solution Importance for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Complex-Symbolic	.0033	1.6366	.002	.964

Dependent Variable	Mean No Interruptions	Mean Interruptions
Solution Importance Complex-Symbolic	4.73	4.72

Table M-3-41
Interruption Treatment and Use of Graphs for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Complex-Symbolic	.9724	.9025	1.077	.301

Dependent Variable	Mean No Interruptions	Mean Interruptions
Use of Graphs Complex-Symbolic	4.31	4.14

Complex-Spatial Tasks

Table M-3-42
Interruption Treatment and Information Quality for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Complex-Spatial	.629	1.658	.379	.538

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Quality Complex-Spatial	3.85	3.72

Table M-3-43
Interruption Treatment and Information Precision for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Complex-Spatial	.0556	1.6467	.0337	.854

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Precision Complex-Spatial	3.75	3.70

Table M-3-44
Interruption Treatment and Information Reliability for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Complex-Spatial	.8897	1.638	.543	.462

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Reliability Complex-Spatial	3.77	3.61

Table M-3-45
Interruption Treatment and Information Comprehensiveness for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Comprehensiveness Complex-Spatial	.629	2.003	.314	.576

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Comprehensiveness Complex-Spatial	3.47	3.61

Table M-3-46
Interruption Treatment and Information Format for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Complex-Spatial	.8497	1.5535	.547	.461

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Format Complex-Spatial	3.44	3.60

Table M-3-47
Interruption Treatment and Information Overall for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Complex-Spatial	.1176	1.661	.071	.791

Dependent Variable	Mean No Interruptions	Mean Interruptions
Information Overall Complex-Spatial	3.44	3.50

Table M-3-48
Interruption Treatment and Confidence for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Confidence Complex-Spatial	.2091	1.906	.110	.741

Dependent Variable	Mean No Interruptions	Mean Interruptions
Confidence Complex-Spatial	3.00	2.92

Table M-3-49
Interruption Treatment and Perception of Interruptions for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Perception of Interruptions Complex-Spatial	.0032	.4673	.007	.933

Dependent Variable	Mean No Interruptions	Mean Interruptions
Perception of Interruptions Complex-Spatial	3.54	3.55

Table M-3-50
Interruption Treatment and Amount of Information for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Amount of Information Complex-Spatial	3.243	1.757	1.845	.177

Dependent Variable	Mean No Interruptions	Mean Interruptions
Amount of Information Complex-Spatial	4.36	3.96

Table M-3-51
Interruption Treatment and Rationale Problem Solving Approach for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Rationale Approach Complex-Spatial	.0204	1.812	.011	.916

Dependent Variable	Mean No Interruptions	Mean Interruptions
Rationale Approach Complex-Spatial	4.36	4.34

Table M-3-52
Interruption Treatment and Use of Tables for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Complex-Spatial	.5312	.5149	1.031	.312

Dependent Variable	Mean No Interruptions	Mean Interruptions
Use of Tables Complex-Spatial	4.10	3.98

Table M-3-53
Interruption Treatment and Solution Importance for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Complex-Spatial	.0008	1.880	.000	.983

Dependent Variable	Mean No Interruptions	Mean Interruptions
Solution Importance Complex-Spatial	4.63	4.63

Table M-3-54
Interruption Treatment and Use of Graphs for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Complex-Spatial	1.0588	1.0212	1.036	.310

Dependent Variable	Mean No Interruptions	Mean Interruptions
Use of Graphs Complex-Spatial	4.10	4.27

Appendix M-4: Task Type and Information Presentation Format

Table M-4-1
Information Presentation Treatment and Number of Interruptions on Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 101)	P-level
Number of Interruptions Simple-Symbolic Task	3.441	1.129	3.04	.083

Dependent Variable	Mean Graphs	Mean Tables
Number of Interruptions Simple Symbolic Task	3.40	3.03

Table M-4-2
Interruption Treatment and Number of Interruptions on Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 102)	P-level
Number of Interruptions Simple-Spatial	4.533	.995	4.55	.035

Dependent Variable	Mean Graphs	Mean Tables
Number of Interruptions Simple-Spatial	2.88	3.31

Table M-4-3
Interruption Treatment and Number of Interruptions on Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 129)	P-level
Number of Interruptions Complex Symbolic Task	16.261	2.687	6.05	.015

Dependent Variable	Mean Graphs	Mean Tables
Number of Interruptions Complex-Symbolic Task	2.51	1.80

Table M-4-4
Information Presentation Treatment and Solution Confidence on Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 101)	P-level
Confidence Simple-Symbolic Task	6.713	1.916	3.50	.064

Dependent Variable	Mean Graphs	Mean Tables
Confidence Simple Symbolic Task	4.06	4.57

Table M-4-5
Information Presentation Treatment and Solution Confidence on Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 105)	P-level
Confidence Simple-Spatial Task	10.527	1.393	7.55	.007

Dependent Variable	Mean Graphs	Mean Tables
Confidence Simple-Spatial Task	3.89	4.53

Table M-4-6
Information Presentation Treatment and Solution Confidence on Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 105)	P-level
Confidence Complex-Spatial Task	7.257	1.853	3.92	.050

Dependent Variable	Mean Graphs	Mean Tables
Confidence Complex-Spatial Task	2.73	3.19

Table M-4-7
Information Presentation Treatment and Perception of Interruptions on Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Perception of Interruptions Complex-Symbolic Task	3.224	.829	3.884	.050

Dependent Variable	Mean Graphs	Mean Tables
Perception of Interruptions Complex-Symbolic Task	3.21	3.52

Table M-4-8
Information Presentation Treatment and Rational Approach on Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Perception of Interruptions Complex-Spatial Task	7.052	1.761	4.01	.047

Dependent Variable	Mean Graphs	Mean Tables
Perception of Interruptions Complex-Spatial Task	4.12	4.57

Table M-4-9
Information Presentation Treatment and Information Comprehensiveness on Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Comprehensiveness Complex-SymbolicTask	9.718	1.939	4.73	.031

Dependent Variable	Mean Graphs	Mean Tables
Information Comprehensiveness Complex-Symbolic Task	3.80	3.28

Non-Significant Perceptual Results
Simple-Symbolic Tasks

Table M-4-10
Information Presentation Treatment and Information Quality for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Simple-Symbolic	.0081	.9097	.009	.925

Dependent Variable	Graph	Tables
Information Quality Simple-Symbolic	2.98	2.75

Table M-4-11
Information Presentation Treatment and Information Precision for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Simple-Symbolic	1.3521	1.4649	.023	.339

Dependent Variable	Graph	Tables
Information Precision Simple-Symbolic	2.99	2.84

Table M-4-12
Information Presentation Treatment and Information Reliability for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Simple-Symbolic	.5379	1.2613	.426	.515

Dependent Variable	Graphs	Tables
Information Reliability Simple-Symbolic	3.02	2.87

Table M-4-13
Information Presentation Treatment and Information Comprehensiveness for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Comprehensiveness Simple-Symbolic	.5799	1.5561	.373	.543

Dependent Variable	Graphs	Tables
Information Comprehensiveness Simple-Symbolic	2.88	2.68

Table M-4-15
Information Presentation Treatment and Information Format for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Simple-Symbolic	1.0105	1.4807	.682	.411

Dependent Variable	Graphs	Tables
Information Format Simple-Symbolic	2.56	2.76

Table M-4-16
Information Presentation Treatment and Information Overall for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Simple-Symbolic	1.0059	1.1708	.859	.356

Dependent Variable	Graphs	Tables
Information Overall Simple-Symbolic	2.81	2.83

Table M-4-16
Information Presentation Treatment and Amount of Information for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Amount of Information Simple-Symbolic	.0061	1.3137	.005	.946

Dependent Variable	Graphs	Tables
Amount of Information Simple-Symbolic	3.17	3.46

Table M-4-17
Information Presentation Treatment and Rationale Problem Solving Approach for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Rationale Approach Simple-Symbolic	.0691	.6427	.107	.743

Dependent Variable	Graphs	Tables
Rationale Approach Simple-Symbolic	2.98	3.10

Table M-4-18
Information Presentation Treatment and Use of Tables for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Simple-Symbolic	.3295	1.579	.209	.649

Dependent Variable	Graphs	Tables
Use of Tables Simple-Symbolic	4.24	4.47

Table M-4-19
Information Presentation Treatment and Solution Importance for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Simple-Symbolic	1.214	1.479	.821	.367

Dependent Variable	Graphs	Tables
Solution Importance Simple-Symbolic	4.98	4.68

Table M-4-20
Information Presentation Treatment and Use of Graphs for Simple-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Simple-Symbolic	.4450	1.7552	.2535	.616

Dependent Variable	Graphs	Tables
Use of Graphs Simple-Symbolic	4.44	4.28

Simple-Spatial Tasks

Table M-4-21
Information Presentation Treatment and Information Quality for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Simple-Spatial	2.2299	1.7541	1.271	.262

Dependent Variable	Graphs	Tables
Information Quality Simple-Spatial	3.19	3.01

Table M-4-22
Information Presentation Treatment and Information Precision for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Simple-Spatial	.6634	1.1384	.583	.447

Dependent Variable	Graphs	Tables
Information Precision Simple-Spatial	3.21	3.07

Table M-4-23
Information Presentation Treatment and Information Reliability for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Simple-Spatial	.7470	1.3844	.540	.464

Dependent Variable	Graphs	Tables
Information Reliability Simple-Spatial	3.35	3.10

Table M-4-24
Information Presentation Treatment and Information Comprehensiveness for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Comprehensiveness Simple-Spatial	.4698	1.3569	.3688	.545

Dependent Variable	Graphs	Tables
Information Comprehensiveness Simple-Spatial	3.14	2.85

Table M-4-26
Information Presentation Treatment and Information Format for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Simple-Spatial	2.8884	1.4399	2.005	.159

Dependent Variable	Graphs	Tables
Information Format Simple-Spatial	2.78	3.03

Table M-4-27
Information Presentation Treatment and Information Overall for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Simple-Spatial	2.1328	1.3262	1.608	.208

Dependent Variable	Graphs	Tables
Information Overall Simple-Spatial	3.13	3.19

Table M-4-28
Information Presentation Treatment and Confidence for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Confidence Simple-Spatial	1.5853	1.4682	1.079	.301

Dependent Variable	Graphs	Tables
Confidence Simple-Spatial	3.30	3.40

Table M-4-29
Information Presentation Treatment and Rationale Problem Solving Approach for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Rationale Approach Simple-Spatial	.0006	1.326	.000	.983

Dependent Variable	Graphs	Tables
Rationale Approach Simple-Spatial	4.39	4.37

Table M-4-30
Information Presentation Treatment and Use of Tables for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Simple-Spatial	.2248	.7845	.2866	.593

Dependent Variable	Graphs	Tables
Use of Tables Simple-Spatial	4.56	4.40

Table M-4-31
Information Presentation Treatment and Solution Importance for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Simple-Spatial	.8850	1.4011	.631	.429

Dependent Variable	Graphs	Tables
Solution Importance Simple-Spatial	4.76	4.73

Table M-4-32
Information Presentation Treatment and Use of Graphs for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Simple-Spatial	.6989	1.510	.463	.498

Dependent Variable	Graphs	Tables
Use of Graphs Simple-Spatial	4.22	4.34

Complex-Symbolic Tasks

Table M-4-33
Information Presentation Treatment and Information Quality for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Complex-Symbolic	.3235	1.0267	.315	.576

Dependent Variable	Graphs	Tables
Information Quality Complex-Symbolic	3.26	3.07

Table M-4-34
Information Presentation Treatment and Information Precision for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Complex-Symbolic	1.2605	1.7533	.7189	.398

Dependent Variable	Graphs	Tables
Information Precision Complex-Symbolic	3.26	3.08

Table M-4-35
Information Presentation Treatment and Information Reliability for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Complex-Symbolic	1.0753	1.7435	.618	.433

Dependent Variable	Graphs	Tables
Information Reliability Complex-Symbolic	3.23	3.08

Table M-4-36
Information Presentation Treatment and Information Comprehensiveness for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Comprehensiveness Complex-Symbolic	1.0740	1.7252	.623	.431

Dependent Variable	Graphs	Tables
Information Comprehensiveness Complex-Symbolic	3.18	2.94

Table M-4-37
Information Presentation Treatment and Information Format for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Complex-Symbolic	.20309	1.7555	1.156	.284

Dependent Variable	Graphs	Tables
Information Format Complex-Symbolic	3.00	3.14

Table M-4-38
Information Presentation Treatment and Information Overall for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Complex-Symbolic	.7501	1.9154	.392	.533

Dependent Variable	Graphs	Tables
Information Overall Complex-Symbolic	3.12	3.20

Table M-4-39
Information Presentation Treatment and Confidence for Complex-SymbolicTasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Confidence Complex-Symbolic	1.1085	1.4917	.743	.390

Dependent Variable	Graphs	Tables
Confidence Complex-Symbolic	4.13	4.37

Table M-4-40
Information Presentation Treatment and Amount of Information for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Amount of Information Complex-Symbolic	1.9222	1.8343	1.047	.308

Dependent Variable	Graphs	Tables
Amount of Information Complex-Symbolic	3.17	3.46

Table M-4-41
Information Presentation Treatment and Rationale Problem Solving Approach for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Rationale Approach Complex-Symbolic	2.9009	1.1935	2.430	.121

Dependent Variable	Graphs	Tables
Rationale Approach Complex-Symbolic	4.71	4.67

Table M-4-42
Information Presentation Treatment and Use of Tables for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Complex-Symbolic	.0607	1.4827	.041	.840

Dependent Variable	Graphs	Tables
Use of Tables Complex-Symbolic	4.34	4.30

Table M-4-43
Information Presentation Treatment and Solution Importance for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Complex-Symbolic	.0515	1.5575	.033	.856

Dependent Variable	Graphs	Tables
Solution Importance Complex-Symbolic	4.71	4.74

Table M-4-44
Information Presentation Treatment and Use of Graphs for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Complex-Symbolic	.04778	1.6362	.029	.865

Dependent Variable	Graphs	Tables
Use of Graphs Complex-Symbolic	4.21	4.23

Complex-Spatial Tasks

Table M-4-45
Information Presentation Treatment and Information Quality for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Complex-Spatial	1.1821	.6842	1.728	.192

Dependent Variable	Graphs	Tables
Information Quality Complex-Spatial	3.82	3.75

Table M-4-46
Information Presentation Treatment and Information Precision for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Complex-Spatial	.1372	1.6614	.083	.774

Dependent Variable	Graphs	Tables
Information Precision Complex-Spatial	3.90	3.55

Table M-4-47
Information Presentation Treatment and Information Reliability for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Complex-Spatial	3.9567	1.6175	2.446	.120

Dependent Variable	Graphs	Tables
Information Reliability Complex-Spatial	3.81	3.58

Table M-4-48
Information Presentation Treatment and Information Format for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Complex-Spatial	1.8551	1.6309	1.137	.288

Dependent Variable	Graphs	Tables
Information Format Complex-Spatial	3.62	3.41

Table M-4-49
Information Presentation Treatment and Information Overall for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Complex-Spatial	1.5003	1.5487	.969	.327

Dependent Variable	Graphs	Tables
Information Overall Complex-Spatial	3.61	3.34

Table M-4-50
Information Presentation Treatment and Perception of Interruptions for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Perception of Interruptions Complex-Spatial	2.6399	1.6424	1.607	.207

Dependent Variable	Graphs	Tables
Perception of Interruptions Complex-Spatial	3.55	3.54

Table M-4-51
Information Presentation Treatment and Amount of Information for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Amount of Information Complex-Spatial	.0013	.4673	.003	.958

Dependent Variable	Graphs	Tables
Amount of Information Complex-Spatial	3.76	3.85

Table M-4-52
Information Presentation Treatment and Use of Tables for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Complex-Spatial	.4024	1.778	.226	.635

Dependent Variable	Graphs	Tables
Use of Tables Complex-Spatial	4.00	4.08

Table M-4-53
Information Presentation Treatment and Solution Importance for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Complex-Spatial	.2159	.5172	.418	.519

Dependent Variable	Graphs	Tables
Solution Importance Complex-Spatial	4.60	4.67

Table M-4-54Information Presentation Treatment and Use of Graphs for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Complex-Spatial	.1422	1.8793	.076	.784

Dependent Variable	Graphs	Tables
Use of Graphs Complex-Spatial	4.13	4.23

Appendix M-5: Task Type, Information Presentation Format, and Work Enviornment

Appendix M-5A: Decision Accuracy and Decision Time

Table M-5-1A
ANCOVA for Information Presentation Format on Decision Accuracy for Simple-Symbolic Tasks With Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 132)	P-level
Decision Accuracy Simple-Symbolic	48.333	17.618	2.743	.102

Dependent Variable	Graphs	Tables
Decision Accuracy Simple-Symbolic	4.721	3.034

Table M-5-2A
Post-Hoc Comparison of Group Means

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	4.72	--------	.454	.102	.047**
NI	G	3.94		--------	.377	.217
I	T	3.03			--------	.718
NI	T	2.67				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Table M-5-3A
ANCOVA for Information Presentation Format on Decision Accuracy for Simple-Spatial Tasks With Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 63)	P-level
Decision Accuracy Simple-Spatial Task	.108	.016	6.694	.012

Dependent Variable	Graphs	Tables
Decision Accuracy Simple-Spatial Task	.828	.757

Table M-5-4A
ANCOVA for Information Presentation Format on Decision Accuracy for Simple-Spatial Tasks With Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 66)	P-level
Decision Time Complex-Spatial	.0177	.0281	.630	.429

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	.828	--------	.394	.083*	.000***
NI	G	.793		--------	.381	.005**
I	T	.757			--------	.045**
NI	T	.676				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Table M-5-5A
ANCOVA for Information Presentation Format on Decision Time for Simple-Spatial Tasks With Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 60)	P-level
Decision Time Simple-Spatial Task	6574.07	940.61	6.989	.010

Dependent Variable	Graphs	Tables
Decision Time Simple-Spatial Task	28.879	50.906

Table 5-6A
ANCOVA for Information Presentation Format on Decision Time for Simple-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 66)	P-level
Decision Time SImple-Spatial	9059.521	863.464	10.492	.002

Post-Hoc Comparison of Information Presentation Format and Interruptions on Decision Time for Simple-Spatial Tasks

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	32.45	--------	.012**	.000***	.046**
NI	G	50.91		--------	.041**	.568
I	T	63.53			--------	.013**
NI	T	46.80				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Table M-5-7A
ANCOVA for Information Presentation Format on Decision Accuracy for Complex-Spatial Tasks With Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 50)	P-level
Decision Accuracy Complex-Spatial Task	724.599	615.034	1.194	.280

Dependent Variable	Graphs	Tables
Decision Accuracy Complex-Spatial Task	15.866	22.947

Table M-5-8A
ANCOVA for Information Presentation Format and Interruptions on Decision Accuracy for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 66)	P-level
Decision Time Complex-Spatial	54.523	459.04	.119	.731

Post Hoc Comparisons for Information Presentation Format and Interruptions on Decision Accuracy

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	15.87	--------	.112	.23	.845
NI	G	6.44		--------	.006**	.072*
I	T	22.85			--------	.309
NI	T	16.99				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Table M-5-9A
ANCOVA for Information Presentation Format on Decision Time for Complex-Spatial Tasks With Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 50)	P-level
Decision Time Complex-Spatial Task	768571.9	335148.1	2.293	.136

Dependent Variable	Graphs	Tables
Decision Time Simple-Spatial Task	846.93	1166.04

Table M-5-10A
H3B ANCOVA for Information Presentation Format and Interruptions on Decision Accuracy for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 101)	P-level
Decision Time Complex-Spatial	54860.4	285353.3	.192	.662

Information Presentation Format, Interruptions, and Decision Accuracy

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	846.93	--------	.992	.033**	.004**
NI	G	845.42		--------	.034**	.004**
I	T	1168.296			--------	.839
NI	T	1100.690				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Appendix M-5B: Perceptual Measures

Table M-5-1B
Information Presentation Format, Interruptions, and Information Precision

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 132)	P-level
Information Precision Complex-Symbolic Task	5.982	1.721	3.48	.064

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	2.98	--------	.092*	.445	.873
NI	G	3.53		--------	.342	.063*
I	T	3.23			--------	.353
NI	T	2.94				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Table M-5-2B
Information Presentation Format, Interruptions, and Information Precision

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 132)	P-level
Information Precision Complex-Spatial Task	9.096	1.572	5.78	.017

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	4.14	--------	.113	.005**	.309
NI	G	3.65		--------	.224	.562
I	T	3.29			--------	.073*
NI	T	3.83				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Table M-5-3B
Information Presentation Format, Interruptions, and Perception of Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 103)	P-level
Perception of Interruptions Simple-Symbolic Task	1.494	.557	2.68	.104

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	3.18	--------	.287	.371	.028**
NI	G	3.44		--------	.011**	.137
I	T	2.96			--------	.000***
NI	T	3.74				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Table M-5-4B
Information Presentation Format, Interruptions, and Information Usefulness

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 132)	P-level
Information Usefulness Complex-Symbolic Task	5.113	1.47	3.47	.065

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	2.78	--------	.110	.055*	.362
NI	G	3.25		--------	.752	.487
I	T	3.35			--------	.309
NI	T	3.05				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Table M-5-5B
Information Presentation Format, Interruptions, and Information Usefulness

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 132)	P-level
Information Usefulness Complex-Spatial Task	5.236	1.627	3.2	.0759

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	3.48	--------	.141	.032**	.266
NI	G	3.39		--------	.493	.716
I	T	3.18			--------	.293
NI	T	3.50				--------

* Significant at .1   ** Significant at .05   *** Significant at .001

Table M-5-6B
Information Presentation Format, Interruptions, and Amount of Information

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 103)	P-level
Amount of Information Complex-Symbolic Task	4.803	1.150	4.18	.043

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	3.14	--------	.791	.012**	.943
NI	G	3.21		--------	.023**	.734
I	T	3.80			--------	.009**
NI	T	3.12				--------

* Significant at .1   ** Significant at .05   *** Significant at .001

Table M-5-7B
Information Presentation Format, Interruptions, and Information Reliability

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 103)	P-level
Information Reliability Simple-Spatial Task	4.742	1.420	3.34	.071

Table M-5-8B
Information Presentation Format, Interruptions, and Information Format

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 132)	P-level
Information Format Complex-Symbolic Task	7.34	1.89	3.89	.050

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	2.77	--------	.171	.068*	.663
NI	G	3.23		--------	.650	.245
I	T	3.38			--------	.161
NI	T	2.91				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Table M-5-9B
Information Presentation Format, Interruptions, and Number of Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 132)	P-level
Number of Interruptions Simple-Symbolic Task	11.064	1.036	10.68	.001

			Probabilities for Post-Hoc Tests			
Interruption	Presentation	Mean	I/G	NI/G	I/T	NI/T
I	G	2.67	--------	.003**	.121	.693
NI	G	3.7		--------	.051*	.001***
I	T	3.2			--------	.140
NI	T	2.81				--------

* Significant at .1 ** Significant at .05 *** Significant at .001

Appendix M-6: Interruption Frequency

Table M-6-1
Interruption Frequency and Information Usefulness

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 97)	P-level
Information Usefulness Complex-Symbolic Task	5.927	1.594	3.718	.057

Dependent Variable	Mean Low Frequency	Mean High Frequency
Information Usefulness Complex-Symbolic Task	3.17	2.68

Table M-6-2
Interruption Frequency and Information Format

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 97)	P-level
Information Format Complex-Symbolic Task	21.281	1.813	11.74	.001

Dependent Variable	Mean Low Frequency	Mean High Frequency
Information Format Complex-Symbolic Task	3.32	2.40

Table M-6-3
Interruption Frequency and Information Comprehensiveness

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 97)	P-level
Information Comprehensiveness Complex-Symbolic Task	10.022	1.824	5.49	.021

Dependent Variable	Mean Low Frequency	Mean High Frequency
Information Comprehensiveness Complex-Symbolic Task	3.23	2.59

Table M-6-4
Interruption Frequency and Information Reliability

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 97)	P-level
Information Reliability Complex-Symbolic Task	6.755	1.843	3.66	.059

Dependent Variable	Mean Low Frequency	Mean High Frequency
Information Reliability Complex-Symbolic Task	3.22	2.70

Table M-6-5
Interruption Frequency and Information Precision

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 97)	P-level
Information Precision Complex-Symbolic Task	8.247	1.900	4.34	.040

Dependent Variable	Mean Low Frequency	Mean High Frequency
Information Precision Complex-Symbolic Task	3.34	2.77

Table M-6-6
Interruption Frequency and Use of Tables

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 97)	P-level
Use of Tables Complex-Symbolic Task	5.257	1.792	2.93	.090

Dependent Variable	Mean Low Frequency	Mean High Frequency
Use of Tables Complex-Symbolic Task	4.63	4.16

Table M-6-7
Interruption Frequency and Confidence

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 97)	P-level
Confidence Complex-Spatial Task	8.892	1.254	7.090	.009

Dependent Variable	Mean Low Frequency	Mean High Frequency
Confidence Complex-Spatial Task	3.29	2.70

Table M-6-8
Interruption Frequency and Amount of Information

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 97)	P-level
Amount of Information Complex-Spatial Task	5.320	1.498	3.55	.062

Dependent Variable	Mean Low Frequency	Mean High Frequency
Amount of Information Complex-Spatial Task	3.42	3.89

Non-Significant Results
Complex-Symbolic Tasks

Table M-6-9
Interruption Frequency and Information Quality
for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Complex-Symbolic	3.3869	1.8700	1.811	.182

Dependent Variable	High Frequency	Low Frequency
Information Quality Complex-Symbolic	2.79	3.16

Table M-6-10
Interruption Frequency and Confidence for Complex-SymbolicTasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Confidence Complex-Symbolic	1.07231	1.12372	.954	.331

Dependent Variable	High Frequency	Low Frequency
Confidence Complex-Symbolic	4.49	4.22

Table M-6-11
Interruption Frequency and Amount of Information for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Amount of Information Complex-Symbolic	.0169	.8931	.0189	.891

Dependent Variable	High Frequency	Low Frequency
Amount of Information Complex-Symbolic	2.70	2.91

Table M-6-12
Interruption Frequency and Rationale Problem Solving Approach for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Rationale Approach Complex-Symbolic	2.3450	2.5276	.928	.338

Dependent Variable	High Frequency	Low Frequency
Rationale Approach Complex-Symbolic	4.98	4.73

Table M-6-13
Interruption Frequency and Use of Tables for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Complex-Symbolic	2.3807	2.5287	.941	.334

Dependent Variable	High Frequency	Low Frequency
Use of Tables Complex-Symbolic	4.17	4.73

Table M-6-14
Interruption Frequency and Solution Importance for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Complex-Symbolic	5.2574	1.79241	2.933	.090

Dependent Variable	High Frequency	Low Frequency
Solution Importance Complex-Symbolic	4.66	4.73

Table M-6-15
Interruption Frequency and Use of Graphs for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Complex-Symbolic	.3625	1.3148	.275	.601

Dependent Variable	High Frequency	Low Frequency
Use of Graphs Complex-Symbolic	4.07	4.43

Complex-Spatial Tasks

Table M-6-16
Interruption Frequency and Information Quality for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Complex-Spatial	1.5644	.1726	.491	.485

Dependent Variable	High Frequency	Low Frequency
Information Quality Complex-Spatial	3.78	3.52

Table M-6-17
Interruption Frequency and Information Precision for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Complex-Spatial	2.6922	1.4917	1.805	.182

Dependent Variable	High Frequency	Low Frequency
Information Precision Complex-Spatial	3.69	3.36

Table M-6-18
Interruption Frequency and Information Reliability for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Complex-Spatial	.3422	1.7878	.1914	.663

Dependent Variable	High Frequency	Low Frequency
Information Reliability Complex-Spatial	3.75	3.63

Table M-6-19
Interruption Frequency and Information Format for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Complex-Spatial	3.2813	1.7707	1.853	.177

Dependent Variable	High Frequency	Low Frequency
Information Format Complex-Spatial	3.343	3.23

Table M-6-20
Interruption Frequency and Information Overall for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Complex-Spatial	.3458	1.5165	.228	.634

Dependent Variable	High Frequency	Low Frequency
Information Overall Complex-Spatial	3.44	3.25

Table M-6-21
Interruption Frequency and Perception of Interruptions for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Perception of Interruptions Complex-Spatial	.9487	1.1894	.797	.374

Dependent Variable	High Frequency	Low Frequency
Perception of Interruptions Complex-Spatial	3.61	3.64

Table M-6-22
Interruption Frequency and Use of Tables for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Complex-Spatial	.0213	.5219	.040	.841

Dependent Variable	High Frequency	Low Frequency
Use of Tables Complex-Spatial	4.29	4.23

Table M-6-23
Interruption Frequency and Solution Importance for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Complex-Spatial	3.2317	1.3968	2.313	.131

Dependent Variable	High Frequency	Low Frequency
Solution Importance Complex-Spatial	4.66	4.73

Table M-6-24
Interruption Frequency and Use of Graphs for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Complex-Spatial	.0786	.51333	.190	.664

Dependent Variable	High Frequency	Low Frequency
Use of Graphs Complex-Spatial	4.07	4.43

Appendix M-7: Task/Interruption Content Similarity

Table M-7-1
Interruption Content and Perception of Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 95)	P-level
Perception of Interruptions Complex-Symbolic Task	2.822	.833	2.29	.069

Dependent Variable	Mean Similar Content	Mean Different Content
Perception of Interruptions Complex-Symbolic Task	3.18	3.53

Table M-7-2
Interruption Content and Perception of Interruptions

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 95)	P-level
Perception of Interruptions Complex-Spatial Task	1.899	.506	3.75	.056

Dependent Variable	Mean Similar Content	Mean Different Content
Perception of Interruptions Complex-Spatial Task	3.49	3.77

Non-Significant Results
Complex-Symbolic Tasks

Table M-7-3
Interruption Content and Information Quality
for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Complex-Symbolic	.1407	1.9035	.073	.786

Dependent Variable	Different Content	Similar Content
Information Quality Complex-Symbolic	2.95	3.02

Table M-7-4
Interruption Content and Information Precision for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Complex-Symbolic	.3267	1.9816	.1649	.686

Dependent Variable	Different Content	Similar Content
Information Precision Complex-Symbolic	3.12	3.01

Table M-7-5
Interruption Content and Information Reliability for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Complex-Symbolic	1.2860	1.8999	.676	.412

Dependent Variable	Different Content	Similar Content
Information Reliability Complex-Symbolic	3.08	2.85

Table M-7-6
Interruption Content and Information Comprehensiveness for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Comprehensiveness Complex-Symbolic	2.2212	1.9044	1.166	.283

Dependent Variable	Different Content	Similar Content
Information Comprehensiveness Complex-Symbolic	3.07	2.77

Table M-7-7
Interruption Content and Information Format
for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Complex-Symbolic	1.8756	2.0133	.932	.337

Dependent Variable	Different Content	Similar Content
Information Format Complex-Symbolic	3.01	2.73

Table M-7-8
Interruption Content and Information Overall
for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Complex-Symbolic	2.9438	1.691	1.812	.181

Dependent Variable	Different Content	Similar Content
Information Overall Complex-Symbolic	3.10	2.75

Table M-7-9
Interruption Content and Confidence
for Complex-SymbolicTasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Confidence Complex-Symbolic	1.8140	1.8446	.983	.324

Dependent Variable	Different Content	Similar Content
Confidence Complex-Symbolic	3.52	3.17

Table M-7-10
Interruption Content and Amount of Information for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Amount of Information Complex-Symbolic	3.0303	.8620	2.515	.064

Dependent Variable	Different Content	Similar Content
Amount of Information Complex-Symbolic	3.12	2.98

Table M-7-11
Interruption Content and Rationale Problem Solving Approach for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Rationale Approach Complex-Symbolic	.5000	1.6640	.3005	.584

Dependent Variable	Different Content	Similar Content
Rationale Approach Complex-Symbolic	4.97	4.94

Table M-7-12
Interruption Content and Use of Tables for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Complex-Symbolic	.02834	1.8391	.0154	.901

Dependent Variable	Different Content	Similar Content
Use of Tables Complex-Symbolic	4.58	4.22

Table M-7-13
Interruption Content and Solution Importance
for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Complex-Symbolic	3.1250	1.8146	1.722	.193

Dependent Variable	Different Content	Similar Content
Solution Importance Complex-Symbolic	4.74	4.92

Table M-7-14
Interruption Content and Use of Graphs
for Complex-Symbolic Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Complex-Symbolic	.7665	1.937	.396	.531

Dependent Variable	Different Content	Similar Content
Use of Graphs Complex-Symbolic	4.29	4.17

Complex-Spatial Tasks

Table M-7-15
Interruption Content and Information Quality
for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Quality Complex-Spatial	.2181	1.7400	.1253	.724

Dependent Variable	Different Content	Similar Content
Information Quality Complex-Spatial	3.60	3.64

Table M-7-16
Interruption Content and Information Precision for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Precision Complex-Spatial	.6913	1.5123	.457	.501

Dependent Variable	Different Content	Similar Content
Information Precision Complex-Spatial	3.44	3.61

Table M-7-17
Interruption Content and Information Reliability for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Reliability Complex-Spatial	.9979	1.7810	.560	.456

Dependent Variable	Different Content	Similar Content
Information Reliability Complex-Spatial	3.59	3.79

Table M-7-18
Interruption Content and Information Format for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Format Complex-Spatial	1.7972	1.7859	1.006	.318

Dependent Variable	Different Content	Similar Content
Information Format Complex-Spatial	3.21	3.36

Table M-7-19
Interruption Content and Information Overall
for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Information Overall Complex-Spatial	.5358	1.5146	.354	.553

Dependent Variable	Different Content	Similar Content
Information Overall Complex-Spatial	3.34	3.43

Table M-7-20
Interruption Content and Perception of Interruptions
for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Perception of Interruptions Complex-Spatial	.0000	1.1992	.000	.999

Dependent Variable	Different Content	Similar Content
Perception of Interruptions Complex-Spatial	3.03	2.97

Table M-7-21
Interruption Content and Use of Tables
for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Tables Complex-Spatial	.0907	1.3449	.0674	.796

Dependent Variable	Different Content	Similar Content
Use of Tables Complex-Spatial	3.60	3.69

Table M-7-23
Interruption Content and Solution Importance
for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Solution Importance Complex-Spatial	.2181	1.5506	.140	.708

Dependent Variable	Different Content	Similar Content
Solution Importance Complex-Spatial	4.47	4.27

Table M-7-24
Interruption Content and Use of Graphs
for Complex-Spatial Tasks

Dependent Variable	Mean Square Effect	Mean Square Error	F (1, 134)	P-level
Use of Graphs Complex-Spatial	1.1691	1.3712	.853	.358

Dependent Variable	Different Content	Similar Content
Use of Graphs Complex-Spatial	4.29	4.17

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