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TheEffects of Decision Aid Recommendations on Users' Cognitive Processes, Memories, and Judgments

Forrest Douglas Roberts
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To the Graduate Council:

I am submitting herewith a thesis written by Forrest Douglas Roberts entitled "TheEffects of Decision Aid Recommendations on Users’ Cognitive Processes, Memories, and Judgments." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Business Administration.

Jacob M. Rose, Major Professor

We have read this thesis and recommend its acceptance:

Bruce Behn, Jon Woodroof, Esteban Walker

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Vice Provost and Dean of
Graduate Studies

(Original signatures are on file in the Graduate Student Services Office.)

The Effects of Decision Aid Recommendations on Users' Cognitive Processes, Memories, and Judgments

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Forrest Douglas Roberts
May 2002

Dedication

This dissertation is dedicated to my wife, Joanna, and son, Forrest, for their loving support during my graduate studies. Their encouragement and emotional assistance was integral to my successful completion.

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Abstract

This study extends the existing decision aid literature by examining the influence of decision aid recommendations on users' memories, decision processes, and judgments. Existing research suggests that decision aids can be beneficial in a variety of settings. Judgments or decisions, the outputs of the decision-making process, are the focus of most of the decision aid research. This study offers a more comprehensive investigation of the impact of decision aids by examining both the outputs of the decision-making process and the inputs and processes that lead to judgment and decision-making. An experiment is conducted that examines the influence of decision aid recommendations on memory patterns, search, cue usage, and judgments. Specifically, the study focuses on how positive and negative decision aid recommendations and the timing of receipt of the decision aid recommendation differentially affect these components of the decision process.

The key findings of the research are: (1) decision aid recommendations create strong affective responses that are encoded in memory and cause users to reconstruct memories of financial data to be consistent with the affective response, (2) receiving a decision aid recommendation at the start of a task creates a strong initial response that acts as an initial hypothesis wherein users' subsequent information search patterns exhibit a confirming bias, (3) receiving a decision aid recommendation later in the task creates a strong response that initiates professional skepticism and causes users' subsequent information search patterns to exhibit a disconfirming bias, (4) decision aid recommendations influence the choice of information cues users believe to be important, (5) decision aid recommendations exert influence on users' judgments, with the amount

of influence diminishing as additional information is received, and (6) working memory capacity is a determinant in the ability to recall financial information but does not determine the extent of influence decision aid recommendations have on users. These findings, when considered together, validate the need for a more complete examination of how decision aids impact the entire decision-making process to identify potential negative consequences in addition to proposed benefits. This research demonstrates that task structure can be manipulated to mitigate certain undesirable consequences of decision aid use.

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CHAPTER I

INTRODUCTION

Accounting firms implement decision aids to support decision-making processes because aids are immune to many human information-processing limitations. The general ability of decision aids to outperform the judgment of unaided individuals has been supported in a variety of tasks. Decision aids are particularly valuable in environments where decision tasks involve heavy information loads or severe cognitive burdens. In these environments, information integration demands increase and decision quality typically decreases (Hwang and Lin 1999; Roch et al. 2000) because human decision-makers are more prone to exhibit decision biases, rely on simple decision heuristics, or become overwhelmed by processing demands and make judgment errors.

To cope with increased information load, financial decision-makers may rely on affective responses rather than the numerical data itself (Kida and Smith 1995). Affective responses are summary positive or negative attitudes developed toward a set of data. Affective responses to numerical data stored in long-term memory appear to be relatively immune to high load environments, while memory for numerical data seems to deteriorate rapidly as load increases (Roberts and Rose 2002). Research has shown that financial decision-makers use affective responses stored in memory as primary inputs to decision-making (Kida et al. 1998, 2001; Rose 2001). These studies demonstrate that reliance on affective responses can lead to inferior decision outcomes. While affective responses may be developed toward a set of data, research has also shown that affective responses may be developed toward something peripheral or unrelated to the data with similar memory and decision consequences (Kida et al. 2001; Rose 2001).

Decision-makers in high load situations are prone to rely heavily on affective responses, and decision aids are often employed in high load environments where they are most beneficial to users. While empirical evidence suggests that decision aids are beneficial, a critical and unexplored issue concerns the potential for decision aids themselves to create affective responses and how these affective responses affect user memory and behavior. As decision aids are becoming widely available for a large assortment of tasks, it is important to understand their impact on decision-makers. Although numerous studies have examined how decision aids affect decision outcomes, few have directly examined how decision aids affect users' judgment and decision-making processes. The lack of process studies makes it difficult to model decision processes in aided environments or to understand the effects of decision aids on users and decision outcomes.

The primary objective of the proposed research is to investigate the effects of decision aids on their users by examining how decision aid recommendations are incorporated into users' decision-making processes. Specifically, this study will investigate the effects of decision aid recommendations on users' memories, searches for information, cue usages, and judgments. Given that decision aids are often implemented in environments where users may rely heavily on affective responses to data or peripheral cues, it is expected that decision aid recommendations will create affective responses that will be encoded in memory. Further, the affective responses created by aid recommendations will affect users' memory patterns, information search strategies, cue usages, and judgments in potentially non-optimal ways. Finally, this research posits that the effects of aid recommendations on decision processes will be dependent upon the timing of the decision aid's recommendation. When the aid's recommendation is received early in the decision process, it is expected that information search patterns, cue usage, and judgments will change. When the aid recommendation is received near the end of the decision process, however, memory reconstruction effects are anticipated.

Results from this study will contribute to research of financial decision processes, decision aids, and memory of financial data, and will extend the emerging literature examining the effects of affective responses to data and peripheral cues on decision-making. The results of this study will be of interest to academics because the results make it possible to model financial decision-making processes in aided environments. In addition to academic appeal, this study will be useful to practitioners because understanding the effects of decision aids on decision processes is necessary for decision aid designers and firms considering aid implementation. Aid designers need process data to maximize the effectiveness of the aid, while minimizing potential biasing effects, and aid implementers need to understand the potential biases and dysfunctional behavior that aids may produce. The research will also contribute to the decision aid reliance literature. Researchers have traditionally measured reliance by comparing decisions with aid advice. When user decisions match aid recommendations, it has been assumed that aid users relied on the decision aid. As Kachelmeier and Messier (1990) and Rose (2002) suggest, agreement with the aid does not always translate to reliance on the aid, and disagreement does not necessarily indicate a lack of reliance. Aid users may incorporate aid advice into their decision process and still make decisions that do not conform to aid recommendations. The process measures employed in this study will make it possible to examine how aid recommendations are used, irrespective of agreement between the user's decision and the aid's advice. Further, by manipulating the timing of aid recommendations, this study will demonstrate that the method used to measure reliance will depend on the portion of the decision process that an aid affects. Lastly, the results of the study will add to the literature on memory of financial data and the effect of affective responses on decision-making through examination of the impact of decision aid recommendations on memory and affective responses.

CHAPTER II

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Human Judgment and Decision-making

Numerous descriptions of the stages of decision-making exist (Beach and Mitchell 1978; Libby 1981; Einhorn and Hogarth 1981), all of which entail information processing evolving through three central stages: inputs, processing, and outputs (Libby and Lewis 1977; Arnold 1997). Two primary inputs to decision-making are environmental information cues and memory contents. Processing includes the cognitive decision processes individuals go through to arrive at an output. This includes problem identification, hypothesis generation and evaluation, internal and external information search, cue usage, changes to memory structures and schemas, attention, and strategy (Bonner and Pennington 1991; Woffard and Goodwin 1990). Outputs are the decisions or judgments made. Errors or bias in inputs and/or decision processes may adversely affect outputs.

Individuals are fallible in forming judgments and making decisions (Libby and Lewis 1977), and they are prone to a variety of cognitive biases that may negatively affect performance. While decision-makers are generally good at selecting and coding information, they are poor at integrating it (Dawes 1979; Libby 1981; Bazerman 1994; Bonner and Pennington 1991) due to their limited ability to retain, retrieve, use, and process information (Libby et al. 2001). They tend to be unreliable and inconsistent in decision-making, due to the influences of mood, subjective interpretations, and random fluctuations in decision-making (Bazerman 1994). They are rationally bounded with a tendency to satisfice and avoid cognitive effort through the use of heuristics (Libby and Lewis 1977; Hogarth 1993; Kleinmuntz 1990; Todd and Benbasat 1994). While heuristics can be efficient and effective, they can also lead to sub-optimal performance. These limitations and biases affect both experienced and inexperienced decision-makers alike (Smith and Kida 1991). In short, both inputs and cognitive factors are the basis for individuals' less than optimal decision-making.

To fully understand and improve judgment and decision-making, the underlying decision processes involved and the variables affecting the processes must be examined (Kadous 1996; Libby and Luft 1993; Sutton 1993). Svenson (1979) notes:

> "Human decision-making cannot be understood simply by studying final decisions. The perceptual, emotional, and cognitive processes which ultimately lead to the choice of a decision alternative must also be studied if we want to gain an adequate understanding of human decision-making."

Although outcomes may be the focus, the processes leading up to those outcomes ultimately define the outcomes. While early judgment and decision-making research focused on inputs and outcomes (Kadous 1996), research is moving beyond treating the processing stage as a "black box," to examining the actual processes involved in getting from inputs to outputs.

Inputs to Judgment and Decision-making

Two primary inputs to decision-making are environmental information cues (external information) and contents of memory (internal information). Task structure and the nature of the environment dictate the relative usage of these two types of inputs to the decision-making process. Additionally, individual characteristics determine the relative influence of these inputs.

External Information

A traditional objective of accounting is supplying information to individuals that is useful to decision-making. Improving accounting information based decisions may be accomplished by improving the information set or increasing the ability of decision-makers to use the information provided (Libby and Lewis 1977). While individuals have little control over the content of environmental information cues, they do exercise control over the selection and integration of cues. A considerable amount of research has examined the effect external information has on decision-making. Findings support that decision-making is affected by the amount of information presented and the way information is presented. Increasing the amount of information generally increases integration demands and decreases decision-making performance (Hwang and Lin 1999). The way information is presented can have a significant impact on decision-making as well (DeSanctis and Jarvenpaa 1989; Davis et al. 1987; Iselin 1989; Stone and Schkade 1991; Frownfelter-Lohrke 1998). Depending on task type, some presentation formats allow performance improvements over other formats (e.g., tables versus graphs). While existing research has examined how accounting information system (AIS) design can mitigate the deleterious effects of increased amounts of information and improve decision-making through the presentation of external information, there are certain situations where memory is the primary input to decision-making and research is warranted here.

Memory

Unlike external information, individuals exercise considerable control over the contents and organization of their memories. Individuals direct the choice of information and the method of encoding that information into their memories. One line of research examining the influence of memory on decision-making explored memory organization and memory content. Differences in the organization of memory lead to differences in recall ability (Frederick 1991). When there is a mis-match between task structure and knowledge structures, performance ability in certain tasks and audit decisions suffers (Nelson et al. 1995; Ricchiute 1992). Thus, the importance of memory organization on decision processes is evident.

Memory content can affect decision-making when memory is a primary input to decision-making. Despite the availability of external information, decision-makers often rely on their memories for many decisions. Time pressure, costs of external search, the routine nature of the task, or confidence in one's memory may cause decision-makers to forgo external information search and search for information solely from memory (Hulland and Kleinmuntz 1994; Moeckel and Plumlee 1989). Because of the task environment and the general overconfidence of decision-makers in their often-inaccurate memories, memory becomes a prime input to decision-making even when external search can yield the data upon which memories are based. When memories are inputs to decision-making, bias in those memories can affect the decision processes and the final judgment in non-optimal ways.

Errors and bias in memory may exist for numerous reasons. Poor learning environments and inadequate attention can introduce and intensify errors and bias in memory. Another potential source of bias is the use of affective responses to data. Affective responses are summary positive or negative attitudes developed toward a set of numerical data. Supported by psychology research, Kida and Smith (1995) proposed that memory traces for numerical data are relatively weak, hard to retrieve, and more easily erased compared to affective responses to the data. Fuzzy processing preference theory argues people have a natural cognitive habit to use global gist (affective responses) due to the ease in processing and the reality that reasoning accuracy approaches that of verbatim traces (Brainerd and Reyna 1993). As individuals are cognitive misers (Simon 1956), the use of summary evaluations is one mechanism to reduce cognitive effort (Hulland and Kleinmuntz 1994). Indeed, Kida and Smith's review of the research in a variety of disciplines indicates the extensive use of evaluative responses.

While this heuristic may prove useful and effective in many situations, it may prove detrimental in others. Kida et al. (1998) validated the differential encoding of affective responses to numerical data. They found that affective responses to financial data are more accurately recalled than are the data themselves. In addition, managers often reconstructed their memories for financial data to match affective responses to the data and made investment decisions influenced by affective responses. Rose (2001) extended these findings to reveal that affective responses could be generated by something unrelated to the data. He found that multimedia peripheral cues could cause an affective response and influence memory patterns and investment decisions. Kida et al. (2001) found that information related to other persons involved in the decision scenario generated affective responses that had an affect on decision choice. The result of reliance on affective responses to data for decision-making is the potential for sub-optimal decision-making. Kida et al. (1998, 2001) and Rose (2001) all demonstrated that reliance on affective responses led to inferior investment decisions in certain decision contexts.

Cognitive Processes in Judgment and Decision-making

To better understand decision-making and to overcome deficiencies in decision-making requires an examination of the decision processes in addition to the inputs and outputs. As such, the focus of much judgment and decision-making research is on information processing. The current study focuses on two primary decision processes: information search and cue usage, both important components in the judgment and decision-making process.

Information Search

Information search is an important component of judgment and decision-making. Information search strategies are related to search effectiveness and overall performance (Cloyd 1995), and bias in search can lead to reduced performance levels. Failing to consider all relevant information or halting search prematurely can negatively influence performance. A wide body of literature has examined factors affecting search behavior. The structure of the task, the task environment, individual factors, and interactions between these three influence information search.

Search behavior is affected by variations in presentation format (Svenson 1979; Ford et al. 1989). For example, Stone and Schkade (1991) found linguistic formats led to less compensatory search as compared to numerical formats. Swain and Haka (2000) found that increases in information load also affect search behavior, with the proportion of information search reduced and the variability of search patterns increased. Accountability and motivation factors have also been found to affect search strategies (Lee et al. 1999).

Individual differences may also affect search strategies. Both experience and prior knowledge are associated with search behavior (Bedard et al. 1992; Hunton and McEwen 1997; Bedard and Mock 1992; Bouwman et al. 1987; Bonner and Pennington 1991). Personality type of the decision-maker (Kelliher 1990) and decision-makers' problem solving strategies influence search (Moon and Keasey 1992). Less persistent characteristics can also influence search. For example, an individual's mood affects his/her search strategies, with positive moods associated with more carefree and heuristic styles and negative moods associated with more systematic and purposeful styles (Hirt et al. 1997; Mittal and Ross 1998).

Cue Usage

Cue usage is another important part of judgment and decision-making. Both proper information choice and information integration are necessary for optimal decision-making. Improper choice and/or mis-weighting of cues leads to poor performance. Individuals are generally good at selecting and coding information, yet poor at combining cues (Dawes 1979; Libby 1981; Bazerman 1994; Bonner and Pennington 1991). In fact, a general inability to integrate information is a primary reason human judgment and decision-making is often less than optimal.

A large body of research has examined how individuals combine information to arrive at a decision, generally from one of three approaches: lens model, probabilistic judgment, and cognitive style (Libby and Lewis 1977). Results of lens model studies demonstrate that complex human decision processes can be accurately predicted and cue usage estimated with simple linear models. Probabilistic studies, using Bayes' theorem, reveal that decision-makers use simplifying heuristics in information processing. Studies on cognitive style show it to be an important moderating factor in human information processing. Lens model and probabilistic studies only examine what cues people actually use and how they actually integrate them, while neglecting why cues were selected. Additionally, lens model studies fail to consider attention and memory, assuming all available cues are attended to (Birnberg and Shields 1984).

In sum, judgment and decision-making suffers from a variety of cognitive biases. These biases may arise due to the structure of the task, the nature of the environment, or the characteristics of the decision-maker. Exploration of methods or techniques to mitigate or overcome these biases and improve judgment and decision-making is warranted.

Improving Individual Judgment and Decision-Making

A variety of strategies exist to improve decision-making (Libby 1981; Bazerman 1994). Prior to determining how a deficiency may be corrected, it is first necessary to identify the source of the deficiency (Bonner 1999). If the source of the deficiency is the person, training may be beneficial if the decision-maker lacks the knowledge and skills needed for the task. Experience and expertise acquired on the job may also eliminate deficiencies. Informing the individual of the potential bias has been suggested as a means to improve judgment. However, research has shown this to be ineffective as people continue to make biased decisions even when informed of their tendencies to do so (Bazerman 1994; Kahneman and Tversky 1979). Similarly, a process of adjusting the individual's intuitive predictions in light of known biases that could be present has been suggested (Kahneman and Tversky 1979). If the source of the deficiency is the task or the environment, changing the structure of the task or the environment may alleviate some of the problems. The use of decision aids has been suggested as one potential solution to deficiencies resulting from people and task structures.

Decision Aids

Decision aids have been recommended to support the decision-making process and help users overcome human information processing limitations and deficiencies (Libby 1981; Messier 1995; Brown and Eining 1997; Krishnamoorthy et al. 1999; Bonner et al. 1996). From simple linear models to sophisticated expert systems employing artificial intelligence, decision aids can offer improvement to the decision-making process in tasks or environments where individuals have proven to perform at less than optimal levels. Decision aids can provide assistance in many ways, from imposing structure to the problem (Todd and Benbasat 1994), decomposing and recombining the problem (Bonner et al. 1996), generating alternate hypotheses (Chu 1991), making a recommendation, or providing a final solution (Kowalczyk and Wolfe

1998). The superiority of models, even improper ones, over people in making predictions has been widely supported, in both accounting and non-accounting settings (Hogarth 1993; Kleinmuntz 1990; Bell and Carcello 2000; Peterson and Pitz 1986; Whitecotten 1996; Hoch and Schkade 1996; Dawes 1979; Goldstein and Hogarth 1997).

In general, individuals' integration processes are well approximated by linear models and people appear to rely on a relatively small subset of available data. Decision aids may be able to correct for human inconsistency and the mis-weighting of cues that contributes to poor performance (Libby 1981; Bazerman 1994). Decision aids are not subject to many of the cognitive biases that individuals are, such as inconsistency, the inappropriate use of heuristics, and the tendency to satisfice. For example, Butler (1985) demonstrated a simple decision aid could help overcome the tendency to underweight or ignore distribution information.

Types of Decision Aids

Gorry and Scott-Morton (1971) provide a classification of decision structure at three levels: structured, semi-structured, and unstructured (Messier 1995). Decision aids have been proposed at all three levels: deterministic decision aids at the structured level, decision support systems at the semi-structured level, and expert systems at the unstructured level. The user's input in the decision-making process relative to the decision aid's input increases from structured tasks to unstructured tasks.

Deterministic decision aids are the type most commonly studied (Rose 2002). Examples include bankruptcy prediction and earnings forecast models. These regression-based models provide unbiased predictions based on inputs from a large set of positive and negative test cases. Moving toward unstructured tasks, decision support systems and expert systems increasingly become more intuitive, often using if-then and logic rules to arrive at recommendations. Users should view the aid's recommendation as another input into their decision-making processes. Even with deterministic decision aids, there exists the potential for "broken leg" cues (Meehl 1954) -- variables relevant to the situation but unaccounted for in the aid. The true strength of decision aids lies in the combination of man and model (Kleinmuntz 1990; Arnold and Sutton 1997; Camerer and Johnson 1997; Ashton and Willingham 1988).

Effects of Decision Aids

Decision aids may have both positive and negative consequences (Ashton and Willingham 1988). In addition to improvement in decisions, use of decision aids may improve learning (Eining and Dorr 1991; Rose 2002), although some studies question this finding (Murphy 1990; Glover et al. 1997). Decision aids may also reduce cognitive effort (Sutton 1993; Brown and Eining 1996), freeing up cognitive resources. Lowe and Reckers (1997) found aids could focus auditor attention, reduce hindsight effects, and increase the effectiveness of judgments. Aids can also improve performance through task structuring. For example, decision aids can assist in improving conditional probability judgments through decomposing and aggregating the judgment and "matching" users' knowledge structures with task structures (Bonner et al. 1996), and can encourage superior choice strategies (Todd and Benbasat 1994).

Decision aids may have unintended negative effects, with improvements in one area at the expense of other areas (Bonner 1999). Ashton (1990) found the presence of decision aids in environments where performance incentives were employed seemed to exert a pressure to perform that resulted in poorer performance. Performance suffered, not because individuals relied or failed to rely on the aid, but merely because the aid was present. Similarly, Boatsman et al. (1997) found the presence of an aid seemed to affect user decisions in negative ways. In addition to ignoring the aid, they found purposeful shifting away from the aid's advice and an increasing instance of this when the consequences of being wrong were increased. Kachalmeier and Messier (1990) found evidence indicating that users sometimes "worked backwards." Users expended cognitive effort manipulating the inputs to the aid to arrive at their predetermined output, appearing to have relied on the aid. Decision aids may also instill an unfounded confidence. For example, Kotteman et al. (1994) found users of a what-if analysis decision aid exhibited higher confidence yet worse performance than non-users.

Others suggest that prolonged use of decision aids will have potential long-term negative effects such as less expertise, less advancement of the profession, and a de-skilling of accounting professionals (Sutton 1993; Arnold and Sutton 1998). Arnold and Sutton (1998) note that in situations of high task complexity and low user task experience, the aid may become the primary basis, or even the sole basis, for the final decision. This subjugation may have consequences beyond the current relegation of decisions to the aid. They posit that it could lead to a generation of professionals unable to perform basic tasks due to the dominance of the technology used from the beginning of their careers.

Decision Aid Reliance

Despite the proven performance superiority of decision aids over individuals in many tasks, there is a general tendency to avoid relying on the aid (Rose 2002). However, reliance is a key determinant of a decision aid's success (Whitecotten 1996). Generally, increased reliance leads to performance improvements, although there is the chance the aid does not take into account all relevant information. A large amount of research has examined factors affecting reliance (Rose 2002). For example, face validity, involvement in the aid's development, and prior experience with the aid increased reliance (Brown and Eining 1997; Whitecotten and Butler 1998; Whitecotten 1996), while revealing the algorithm and decision framing had no effect on reliance (Brown and Jones 1998). As users' confidence in their abilities increase, reliance decreases (Whitecotten 1996; Arnold and Sutton 1998) and reliance may decrease when performance pressures are present (Ashton 1990; Boatsman et al. 1997).

A common bond among decision aid reliance studies is the measurement of reliance. Reliance is generally measured as agreement with the aid. However, agreement with the aid may indicate something other than reliance, such as circumventing the aid, or "working backward," as found by Kachalmeier and Messier (1990). Reliance, as measured in these studies, does not necessarily capture whether the user relied on the aid nor whether they adopted the aid's recommendation in any capacity outside the final decision. This lack of process information leaves a void in understanding the complete influence decision aids have on users.

While this shortcoming has been widely noted, little has been done to address it (Rose 2002; Brown and Eining 1997; Whitecotten and Butler 1998). The influence decision aids may have on the decision-making process goes beyond the final outcome or decision made. The decision aid may have an effect on the decision processes employed without being manifested in the outcome. In other words, users may incorporate the aid into their decision processes but may not agree with the aid. The lack of an underlying theory or explanation of decision aid reliance is one indication of the need for additional research in the area. While models do exist (Brown and Jones 1998; Arnold and Sutton 1998), they do not fit into a cohesive overall model. Before such an endeavor can be realized, it will be necessary to more fully understand the decision processes influenced by the aid and determine how to appropriately measure reliance (Rose 2002).

Summary

While numerous studies have examined how decision aids affect decision outcomes and users' behaviors toward the task, few have directly examined how decision aids affect users' decision processes (Brown and Eining 1997). The lack of process studies makes it impossible to model decision processes in aided environments or to fully understand the effects of decision aids on users and decision outcomes. While research has provided both positive and negative support for decision aids, other potential consequences have yet to be examined. One unexplored possibility is if and how decision aids may affect the inputs to decision-making, particularly the user's memory. In addition, other decision processes possibly affected by the aid, such as information search, have yet to be considered. It is possible that decision aids implemented to help overcome deficiencies in certain decision processes may themselves be the cause of errors and bias in inputs and other decision processes.

Information and Cognitive Load

Certain tasks and environments tend to exacerbate the limitations and biases inherent in individual decision-making. Complexity Theory (Streufert and Castore 1971) proposes two kinds of complexity that have the potential to affect behavior: individual differences in conceptual structure and environmental complexity. In addition to the content of information, environmental complexity includes the amount of information, or information load. Information processing involves combining and integrating informational cues. This process requires the use of working memory -- the "workspace" within memory, which is separate from long-term memory and responsible for temporary storage and information processing (Newel and Simon 1972; Baddeley 1992; Richardson 1996). As working memory is very limited in size (Miller 1956; Baddeley 1992), an individual can only handle a limited amount of information at any one time.

Schick et al. (1990) define information load as a function of user attention and time pressure rather than the amount of information provided. This description fits the definition of a similar construct: cognitive load. Cognitive load refers to the burden placed on working memory when completing a task (Sweller 1999). Reductions in the amount of working memory available for processing information due to cognitive load should have the same effect as overloading working memory with information.

Due to human limitations, increases in information or cognitive load can have deleterious effects on an already imperfect setting (Kanaan 1993). Increases in information load decrease decision quality (Chervany and Dickson 1974; Iselin 1993; Shields 1983; Helgeson and Ursic 1993; Hwang and Lin 1999), increase time spent on the task (Casey 1980; Iselin 1989; Iselin 1990; Helgeson and Ursic 1993), decrease information processing ability (Simnett 1996), and affect search strategies (Shields 1980; Ford et al. 1989). Increased information load also decreases search (Streufert et al. 1965; Swain and Haka 2000), increases search variability (Cook 1993; Shields 1980; Swain and Haka 2000), and causes one to shift from compensatory to non-compensatory search strategies (Swain and Haka 2000; Cook 1993).

As proposed by Kida and Smith (1995), Roberts and Rose (2002) examined whether increased information load resulted in greater reliance on affective responses. Their results suggest that memories for numerical values rapidly disappear as information load increases, while affective responses appear to be essentially immune to increases in load. Similar to Hulland and Kleinmuntz (1994), who found that increased search costs lead to greater reliance on summary evaluations, decision-makers may rely on affective responses rather than the numerical data itself to cope with increased information load.

Cognitive load has not been as widely examined but appears to have a similar effect. Results support the notion that cognitive load consumes an individual's working memory (Sweller 1999). Increased cognitive load can be detrimental to learning (Sweller 1999; Baddeley et al. 1984), lead to a greater reliance on stereotypes, cause a greater instance of anchoring, and lead to an increased inability to adequately adjust from an initial anchor (Roch et al. 2000). Speier et al. (1999) found interruptions in complex tasks, a form of cognitive load, decreased performance and increased decision time.

Roberts and Rose's (2002) initial findings suggest that increased cognitive loads also lead to increased reliance on affective responses.

Research has explored techniques to overcome the negative effects of increased load. Numerous studies have found presentation format to minimize negative effects of information overload (Bergstrom and Stoll 1990; Chervany and Dickson 1974; Stone and Schkade 1991; Stocks and Tuttle 1998). Increased involvement may also overcome some of the effects of increased information (Hahn et al. 1992). Others have suggested that one can learn to process higher loads through task learning (Iselin 1989), training (Harvey et al. 1961; Schroder et al. 1967), or improved ways of thinking (Schick et al. 1990). However, the use of decision aids is particularly appealing.

It is precisely in high load situations where decision aids may be of greatest assistance and benefit (Gadenne and Iselin 2000). As load increases, individual performance tends to decrease. Decision aids are designed to reduce cognitive burdens and perform tasks that are difficult for individuals. As a result, decision aids should be able to offer the most improvement in high load environments and are often employed in these environments. However, these situations may also be where individuals are prone to rely on affective responses. The possibility exists for the decision aid itself to have unintended negative consequences due to the very environment which promotes its use. An unexplored issue concerns the potential for the decision aid to create a strong affective response that affects user memory and behavior.

Effect of Decision Aid Recommendations on Decision-making

While Kida et al. (1998) found affective responses resulted from numerical data, there are other potential sources of affective responses. Petty and Cacioppo's (1986) Elaboration Likelihood Model posits that persuasion may come from actual data or from "peripheral" cues outside the data. For decision-makers inexperienced in a task, peripheral cues are often the basis of the attitude toward the message more so than is the actual data. Based on Petty and Cacioppo's model, Rose (2001) examined the effect of multimedia financial disclosures on affect. He found decision-makers were affected by peripheral multimedia, unrelated to and even inconsistent with the numerical data. Despite the financial data clearly indicating the superiority of alternate choices, subjects reconstructed memories of financial data to match the media-induced affective response and made investment choices consistent with affective responses to the multimedia. Kida et al. (2001) demonstrated managers' tendency to reject decision alternatives that elicited a negative affective response (based on something unrelated to the financial data) even though the alternatives had higher expected values in a financial sense.

While Kida and Smith (1995) suggest decision aids as one way of combating the prevalence of affect and directing decision-makers to focus on the numerical data, perhaps the decision aid itself may be the cause of an affective response. This is especially likely because of the tendency to employ decision aids in high load situations, and high load situations lead to increased reliance on affective responses. Just as data and peripheral cues can lead to creating an affective response that is used in decision-making, the decision aid recommendation itself may cause an affective response. Indeed, the deterministic aids essentially take a number of cues and arrive at an overall evaluative, or affective, response. The implication is that decision aids may create a strong response that does not take into account all relevant cues and may conflict with an optimal evaluation of the available data.

It is expected that decision-makers will form an affective response based on the aid recommendation. Consistent with the findings of Kida et al. (1998; 2001) and Rose (2001), the affective response generated by the aid recommendation is expected to be stronger than the numerical data. The affective response will dominate judgments even when it is inconsistent with the numerical data. Decision-makers will encode the affective response in memory, reconstruct memories for financial data to match the affective response, and use the affective response as an input in their decision-making processes. When numerical data indicate an evaluative response inconsistent with the decision aid recommendation, it is expected the affective response generated by the aid recommendation will influence the user and subsequent decision processes. Individual and task differences will moderate the effect the affective responses will have on users' decision processes. Figure 1 presents the model depicting the relevant constructs and expectations (all figures and tables are located in the Appendix).

Effect of Decision Aid Recommendations on Memory

Prior research in psychology of mood and memory has focused on learning and recall. Mood can cause selective learning, or mood-congruent learning, with greater encoding of information matching the mood of the individual at the time of exposure (Bower 1981; Bower et al. 1981; Isen 1984). Bower (1981) notes that mood has been found to affect the salience of mood-congruous material. In recall, positive moods result in greater retrieval of positive cues relative to negative cues and vice versa (Sinclair 1988; Isen 1984; Petty et al. 1993). Kida and Smith's (1995) model proposes that affective responses to financial data are more persistent in memory than are the financial data themselves and may act as a mood state facilitating mood-congruent recall. Kida et al. (1998, 2001) and Rose (2001) provide support for this proposition. It is expected that the decision aid recommendation will create an affective response. As in Kida et al. (1998) and Rose (2001), the affective response, rather than the numerical data, will be encoded in memory and will cause memories for the numerical data to be reconstructed to match the affective response. This leads to the first hypothesis:

> H1: Decision-makers using a decision aid will reconstruct memory for financial data to match the affective response induced by the aid recommendation.

Effect of Decision Aid Recommendations on Information Search and Cue Usage

Despite the extensive number of studies examining search behavior, no one model explaining the role of information search in decision-making has emerged. This current study extends information search research by exploring the role of decision aids on search behavior. While decision aids have been suggested to provide direction to information search (Bouwman et al. 1987), unintended consequences might arise from their use. Additionally, the study will extend research on cue usage focusing on the effects of task structure on cue usage and exploring why individuals choose specific cues. Specifically, this study will investigate the effects of a decision aid recommendation on cue selection and integration. The decision aid recommendation itself may influence information search and cue usage. Two literatures provide support for this hypothesis.

Research in psychology suggests moods have an effect on decision processes. As previously discussed, affective responses to data are a form of mood state. If the decision aid recommendation induces an affective response, this affective response can affect decision processes. Research in accounting suggests individuals tend to seek to confirm their initial hypothesis (Klayman and Ha 1987; Danos et al. 1989). The affective response generated by the decision aid recommendation may be the basis for the initial hypothesis, with users then exhibiting confirmatory behavior.

Effect of Mood on Decision Processes

There is a long record of research in psychology on the effects of mood (a.k.a. affect) on decision processes. Mood is defined as feelings or emotions. This research finds evidence that mood can have powerful effects on the cognitive processes and performance of individuals and that changes in mood affect subjects' processing strategies (Hirt et al. 1997; Bower 1981). While there is general agreement that decision-making does not follow rational patterns as prescribed by normative models, Etzioni (1988) additionally argues that most choices are of an emotional and affective nature to the exclusion of true information processing, and logical and empirical cues are themselves really manifestations of affective responses when used. Other research on affect shows that different affective states can lead to differential problem solving strategies and information processing. Tenopir et al. (1991) found search strategies differed according to the searcher's affective goals in a search task involving searching a database of online magazines with novice searchers.

While Kida and Smith’s (1995) model defines affect as an evaluative form in response to data rather than as an individual's emotion or feeling state, Rose (2001) provides support that this type of affect maps into the notion of affect used in psychology. His results found affective responses encoded in memory and used as inputs to financial decision-making could be driven by something totally unrelated to the data. He found that affect induced by peripheral cues, specifically, happy and sad multimedia video clips, led to affective response driven decision-making. Along the same line, Kida et al. (2001) demonstrated that affective responses could be generated by information about the participants in a task.

Confirmation Bias

Accounting research provides evidence that individuals tend to seek evidence that supports their initial hypothesis (Klayman and Ha 1987; Danos et al. 1989). Despite the scientific advantage of seeking disconfirming evidence to test a hypothesis, people are prone to selectively remember information consistent with the hypothesis (Harris 1981). While evidence against confirmation bias exists in accounting and auditing settings (Ashton and Ashton 1988; Arnold 1997; Church 1990; Kida 1984; Smith and Kida 1991), findings suggest that novices are more prone to confirmation bias (Bonner and Pennington 1991; Kaplan and Reckers 1989). This provides initial support for the notion that novice decision-makers, the individuals likely to be assisted by deterministic decision aids, would exhibit a confirmation bias.

What is unclear is whether the decision aid recommendation provides an initial hypothesis different from what would exist in the absence of an aid. However, research provides support for this argument. Dukerich and Nichols (1991) found search affected by the implication of a single cause in the problem description. Just as an explanation of a hypothetical outcome makes that outcome appear more likely to occur in the future (Sherman et al. 1983), Swinney (1993, 1995) found that negative expert system explanations caused users to perceive greater likelihood that an event would occur. Hoch and Schkade's (1996) results provide support that providing a decision aid may allow decision-makers to form an initial anchor. Finally, Kowalczyk and Wolfe (1998) found that an expert system recommendation did cause an anchor effect that persisted even in light of contrary evidence.

When the affective response generated by the aid recommendation is stronger than the numerical data, the decision aid recommendation becomes the basis for the initial anchor. As previous research suggests, initial belief may affect search strategy with the tendency to confirm. For the same reason, the choice of information (cue usage) will be consistent with the initial hypothesis. This leads to the second hypothesis:

> H2: Decision-makers using a decision aid will exhibit search patterns and cue usage patterns influenced by the decision aid recommendation.
>
>> H2a: Decision-makers using a decision aid will search more positive (negative) information when the decision aid's recommendation is positive (negative).
>>
>> H2b: Decision-makers using a decision aid will rank positive (negative) information cues as more important than negative (positive) cues when the aid's recommendation is positive (negative).

Timing of the Decision Aid Recommendation

A decision aid may be introduced into the decision-making process at any point prior to final judgment. The effect on the decision processes and behavior of the user can be expected to vary dependent on when the aid recommendation is received. It is expected that providing aid recommendations early in the decision-making process will subsequently affect search and cue usage, but will not cause memory reconstruction. By providing or influencing the formation of an initial anchor, the aid recommendation will bias subsequent behavior. Confirmation bias will affect search and cue usage. However, memory cannot be altered because no memory traces exist at this point.

On the other hand, receiving the recommendation late in the decision-making process is expected to affect memory and cause reconstruction effects, but not decision processes. When the aid recommendation creates a strong affective response, the aid recommendation is expected to cause an affective response that is more durable than previous memory traces, essentially overriding any existing memory traces. Due to its greater ease in retrieval, this affective response will be retrieved from memory, with users reconstructing memories to match the aid recommendation-induced affective response. However, providing the aid at the end of the decision-making process leaves no opportunity for the aid to influence search or cue usage. This leads to the third hypothesis:

> H3: The time at which the decision aid's recommendation is introduced will affect the level of influence the decision aid recommendation has on the decision-maker’s memory and cognitive processes.

H3a: Decision-makers receiving the decision aid's recommendation early in the decision-making process will exhibit less memory reconstruction effects than those receiving the aid's recommendation late in the decision-making process.

H3b: Decision-makers receiving the decision aid's recommendation early in the decision-making process will exhibit search patterns different from those receiving the aid's recommendation late in the decision-making process.

H3c: Decision-makers receiving the decision aid's recommendation early in the decision-making process will exhibit cue usage patterns different from those receiving the aid's recommendation late in the decision-making process.

Effect of Decision Aid Recommendations on Final Judgment

The literature on anchoring and adjustment has established that people are prone to adopt an initial anchor and make adjustments to the anchor to arrive at a decision. These adjustments, however, tend to be insufficient, and final decisions are biased toward the initial anchor even in light of overwhelming evidence contrary to that which caused the initial anchor (Tversky and Kahneman 1974; Smith and Kida 1991; Ashton and Ashton 1988; Arnold 1997). Anderson et al. (1980) found that subjects failed to make appropriate revisions to their beliefs even after the initial evidence leading to individuals' beliefs were totally discredited; this occurred even when the evidence leading to the initial belief was weak at best. Thus, decisions are often a function of the first information encountered (Arnold 1997), whether or not that first information is valid.

How and where individuals actually set their initial anchor can vary. Decision aid design has been proposed to mitigate the negative effects of anchoring and adjustment (Arnold and Sutton 1997). However, as noted above, limited research suggests that the decision aid recommendation, by providing a solution or recommendation, may influence or create the initial anchor (Hoch and Schkade 1996; Swinney 1993, 1995; Kowalczyk and Wolfe 1998).

The decision aid recommendation is expected to provide an initial hypothesis or anchor. This is expected to lead to confirmatory search and cue usage as well as bias in memory. This direct influence on the decision processes will indirectly affect the outcome, the final judgment. The user's final judgment is expected to adhere closer to the aid recommendation than would be expected in the absence of an aid. Adjustments from the anchor will not be sufficient with the final judgment biased toward the aid-influenced anchor. This leads to the fourth hypothesis:

> H4: Decision-makers using a decision aid will reach more positive (negative) final judgments when the aid's recommendation is positive (negative).

Effect of Working Memory Capacity on Memory and Decision Processes

In judgment and decision-making research, individual differences can affect decision-making. For example, cognitive styles have been found to be an important determinant of decision-making (Chan 1995). Individuals differ in their cognitive make-up in numerous ways. One individual difference that should moderate the relationship between aid recommendations and decision processes is working memory capacity. Working memory is the construct that refers to the system underlying the maintenance of task-relevant information during the performance of a cognitive task (Miyake and Shah 1999). It is the “workspace” within memory, separate from long-term memory, responsible for temporary storage and information processing (Newel and Simon 1972;

Baddeley 1992; Richardson 1996). A variety of models have been proposed to articulate the conceptual structure of working memory within human memory (Miyake and Shah 1999). General agreement among these models is that working memory is of very limited capacity, this limited capacity is central to the limitations individuals encounter in information processing, and individuals differ in their working memory capacities (Miller 1956; Baddeley 1992; Engle 1996).

In cognitive psychology, individual differences in working memory capacities have received a great deal of attention (Klein and Fiss 1999). Working memory capacity is a relatively stable individual difference that is related to performance on a variety of cognitive tasks (Klein and Fiss 1999; Baddeley 1992; Anderson 1995; Engle 1996). For example, individuals with higher working memory capacities have better global comprehension, better memory for specific details, are better at following directions (Engle 1996), make optional elaborative inferences (St. George et al. 1997), and are better at suppressing and enhancing responses (Rosen 1996; Rosen and Engle 1998).

Research examining working memory capacity's effect on memory primarily examine encoding and retrieval. Encoding and retrieval appear to require resources under the participant's control (Naveh-Benjamin et al. 2000; Conway and Engle 1994). Constraints on working memory capacity or controlled attention, caused by either individual differences in capacity or by the addition of cognitive load, profoundly influence retrieval (Baddeley et al. 1984; Rosen and Engle 1997). In general, subjects with greater working memory capacities have more attentional resources to draw upon than do subjects with lower capacities, independent of the task involved (Conway and

Engle 1996). Therefore, differences in working memory capacities may result in differential effects on tasks requiring memory.

Working memory's limited capacity restricts the amount of data that can be considered simultaneously (Libby 1981), and poor integration performance is often due to limits in working memory capacity. St. George et al.'s (1997) results regarding elaborative inferences suggest that limited working memory hinders activities requiring the combination of cues both current and prior. Based on Just and Carpenter's (1992) Capacity Constrained Comprehension model, limits in the working memory capacity of individuals hinder the ability to make necessary inferences in reading.

While St. George et al.'s results are based on reading tasks, their findings reflect outcomes that can be expected in financial data analysis tasks. In fact, Kida and Smith (1995) suggest that individuals' limited working memory capacities may be a cause of the tendency to rely on affect. Individuals may rely on summary evaluations in an attempt to conserve limited cognitive resources (Hulland and Kleinmuntz 1994). If individuals with low working memory capacities rely more on affect, then the affective response created by a decision aid's recommendation can be expected to exert more influence on users with lower working memory capacities.

Essentially no research in accounting has examined the construct of working memory, despite its intuitive and theoretical appeal. Preliminary results of one study found that decision-makers' working memory capacities were determinants of their abilities to recall numerical data (Roberts and Rose 2002). Subjects with higher working memory capacities were able to recall significantly more numerical data than were subjects with lower working memory capacities. Interestingly, working memory capacity was not significant in recall of affective responses, suggesting that the memory mechanisms for storing and retrieving affect are less sensitive to working memory capacity than they are to other memory mechanisms. This leads to the fifth hypothesis:

> H5: Decision-makers' working memory capacities will be negatively associated with the amount of influence the decision aid has on their decision-making processes.
>
> > H5a: There will be a negative association between decision-makers' working memory capacity and memory reconstruction effects.
> >
> > H5b: There will be a negative association between decision-makers' working memory capacity and the influence of aid recommendations on judgments.

Summary

In summary, individuals may perform poorly when forming judgments and making decisions for a number of reasons. Poor inputs and/or poor processing are potential causes for poor decision-making. Decision aids may help overcome poor integration ability and are especially helpful in environments where decision tasks involve heavy information and cognitive loads. Indeed, decision aids can outperform people in many predictive tasks. However, in high load environments, people tend to rely on affective responses rather than numerical data. There is a great potential for decision aids to create affective responses and influence users' memory and behavior. The lack of process information in current studies has resulted in a failure to depict if and how the decision aid is actually incorporated into the users' decision-making process. Understanding the true impact of the decision aid on users' decision processes is necessary to model financial decision-making processes in aided environments. Further, modeling the decision process in aided environments is essential to appropriate decision aid design and implementation.

It is expected that decision aid recommendations will create affective responses that will be encoded in memory and will affect users' memory patterns, information search strategies, cue usage, and judgments. Further, it is expected that these effects will be dependent upon the timing of the aid recommendation. When the aid's recommendation is received early in the decision process, it is expected that information search patterns, cue usage, and judgments will change. When the aid recommendation is received near the end of the decision process, however, memory reconstruction effects are expected. Figure 2 depicts the operational model and lists the hypotheses to be tested.

CHAPTER III

RESEARCH METHOD

Experiment Objective

Two experiments were conducted to investigate how decision aid recommendations are incorporated into users' decision-making processes. Specifically, the study focuses on the effect of decision aid recommendations on users' memories, information searches, cue usages, and judgments. Further, the effect of the timing of the decision aid recommendation on these decision processes is examined.

Experimental Task

The experimental task is an assessment of the likelihood of future financial problems for a firm (adapted from Kida et al. (1998)). The task involves examining a set of 14 financial statement ratios with prior year or industry comparative data. Subjects also examine a decision aid recommendation (except for a control group) and search additional information based on a subject-chosen subset of the financial ratios. Likelihood assessments of this nature are made in a variety of settings, from investment analysis to going-concern evaluations in auditing. Therefore, results may be generalizable to several tasks and environments rather than limited to a highly specific setting.

The analysis of financial ratios employed in this task is used in numerous settings, from fundamental analysis to analytical review procedures. While there are no authoritative mandates on the approach to analytical review procedures, SSARS No. 1

and SAS No. 23 both provide some direction on approaching the procedure, including comparison of current amounts with prior periods and industry-similar amounts (Mancuso 1992). Likewise, the availability and use of a decision aid in this type of environment and for this type of task is plausible. Decision aid use in practice is widespread (Ashton and Willingham 1988; Rose 2002). Audit programs, checklists, sample size formulas, and expert systems are a few of the decision aids auditors employ. Investment analysts use decision aids such as spreadsheets and regression models. The task, the information set, and the subjects (discussed next) fit well with the environment the study is emulating, the use of a decision aid in a deterministic task by novices.

Subjects

For experiment one, subjects were junior and senior accounting students enrolled in an accounting information systems course at the University of Tennessee in the Fall of 2001 who had the required background in financial statement analysis. For experiment two, subjects were University of Tennessee students enrolled in an undergraduate auditing class, Masters of Accounting students at the University of Tennessee and Appalachian State University, and MBA students at Appalachian State University and Seattle Pacific University.

Student subjects are preferred for two primary reasons. First, the subject of interest is a novice financial decision-maker in a high information load environment. Students have experience levels more closely matched to the experience levels of novice financial decision-makers than would professionals. While newly hired financial analysts might be preferable to students, students provide a convenient sample. In addition, the majority of subjects reported having accounting work experience of at least one year, suggesting they are reasonable surrogates for novice financial decision-makers. Second, experience and prior knowledge has been shown to affect decision aid use, search strategies and search effectiveness, and the ability to handle large information loads (Cloyd 1995; Spilker 1995; Salterio 1996; Spilker and Prawitt 1997; Hunton and McEwen 1997; Iselin 1996). Further, Moeckel (1990) found experienced subjects tended to reconstruct more from prior memories held in their long-term memory but found no reconstruction effects with novices. Therefore, the use of students also acts as a control by providing a relatively homogenous subject pool in terms of prior knowledge differences and experience.

To motivate effort during the task, subjects participated as a class exercise with course credit assigned for successful completion of the exercise. Further, subjects were told that monetary awards would be distributed to those performing in the top ten percentile. While performance was based on a particular aspect of the task (the memory task), subjects were not told the details of the performance-based compensation in order to promote effort during all phases of the experiment. To further motivate effort, subjects were told that another ten percent of subjects successfully completing the experiment would be randomly chosen to receive monetary awards.

Pilot Tests

Pilot tests were conducted to ensure the appropriateness of the task and experimental materials. Five accounting doctoral students and 15 undergraduate accounting students from the University of Tennessee participated in the pilot test.

Subjects were paid a base amount for completing the pilot instrument and were further motivated by additional performance-based compensation to top performers.

The ratio set used was adapted from the second experiment in Kida et al. (1998). The ratios used in Kida et al. were constructed to cause a strong overall unfavorable evaluation of the firm. The design of this study requires an overall neutral data set, with half of the ratios conveying moderately unfavorable impressions and half conveying moderately favorable impressions. As such, the firm and comparative ratio values were changed slightly to achieve an overall neutral reaction. Results of the pilot test confirmed that the intended effect was achieved.

Pilot tests also provided support that the additional information provided in the search procedure met three criteria: 1) subjects believed that the additional information added value to the assessment judgment, thus motivating search; 2) the additional information did not direct subsequent search choices; and 3) the additional information was of the same relative affective nature as the financial ratios alone. Comprehension of the decision aid recommendation and face validity of the decision aid were also validated.

Experimental Procedures

The study consists of two separate experiments. Experiment one assesses the effect of decision aids on users' memories, cue usages, and judgments (but not search). Experiment two is identical to experiment one except for the addition of search. The inclusion of search in experiment two introduces the possibility that results found for memory reconstruction and judgments may be due to differences in search patterns rather than the direct influence of the aid. Therefore, experiment one's primary purpose is to provide support for hypotheses one and four and rule out alternate hypotheses related to the effect that search may have on memories and judgments. Additionally, experiment one ensures the validity of the experimental materials used in experiment two.

Experiment One

For experiment one, subjects completed the experiment in their normal classroom under the supervision of the experimenter. A series of seven envelopes containing the various parts of the instrument were presented in a timed and sequential manner. Each part of the experiment was timed to allow adequate time to complete the task and eliminate the possibility that effects were due to differences in the time taken to complete the exercise.

The instrument consists of basic introductory information, a set of 14 financial ratios with comparative prior year or industry average information, a decision aid recommendation, a place to indicate likelihood assessments, demographic questions and manipulation checks, a memory reconstruction task, and a task to measure working memory capacity.

The experimental procedures followed one of two sequences as depicted in Figure 3. Timing of the aid recommendation, early or late, was crossed with one of two types of decision aid recommendation, positive or negative, yielding a 2 x 2 between-subjects design. Subjects were randomly assigned to one of the four experimental treatments. The materials in each sequence are identical, only the ordering is varied. Therefore, only the late introduction sequence is described.

Subjects were given a brief verbal description of the exercise they would be completing after receiving a paper-clipped stack of seven numbered envelopes containing the sequenced experimental materials. Subjects were then directed to open the first envelope containing introductory instructions explaining the nature of the task. Sufficient time was given to read the instructions.

Upon returning the instructions to envelope one, subjects opened envelope two. Envelope two contained a set of 14 current year financial ratios with comparative information, either the prior year's ratio for the firm or the industry average ratio value. Subjects were allowed ten minutes to scrutinize the data. They were not allowed to move on to the next envelope before the ten minutes expired. This was done to allow adequate consideration of the information and effort toward the task. The financial ratios used are adapted from Kida et al.'s (1998) second experiment and are constructed to yield an overall neutral evaluation of the firm. To insure correct interpretation of the ratios given, a supplementary sheet containing a brief description of what each ratio indicates and how each ratio is calculated was provided. A primary purpose of the ratio analysis phase was to allow subjects the opportunity to encode into memory information about the firm, allowing tests of the influence of affective responses on memories and judgments.

At the end of the ten minutes, subjects returned the materials to envelope two and were instructed to open envelope three. Envelope three provided a place for subjects to enter their likelihood assessments and indicate their levels of confidence in their judgments.

Once all assessments had been recorded and returned to envelope three, subjects opened envelope four containing an explanation of the decision aid and the recommendation given by the aid. The aid is described as a regression model developed with ratio data from a large number of firms (some of which had experienced financial problems and some of which had not). Further, the aid is said to use a subset of the 14 ratios as its input. This is done to emulate a situation where the decision aid is just one of other cues to be used to arrive at a judgment. Manipulation of the type of decision aid recommendation (positive or negative), while holding the numerical data constant, allows examination and hypothesis testing of the effect that the recommendation has on users' memories and judgments. As such, the aid recommendation provided is not truly the output of a valid regression model. The form of the decision aid recommendation is an indication of the likelihood the firm will experience financial problems within the foreseeable future with three possibilities: a LOW, MEDIUM, or HIGH likelihood. Subjects in the positive aid recommendation treatments received a LOW likelihood probability, while subjects in the negative aid treatments received a HIGH likelihood probability. Historical prediction accuracy is provided to offer face validity to the aid.

Subjects returned the decision aid information to envelope four and opened envelope five. Envelope five provided a place for subjects to record their final likelihood assessments and indicate their levels of confidence in their assessments. The materials were returned to envelope five and subjects then opened and completed a series of demographic questions and manipulation checks contained in envelope six.

Upon returning the materials to envelope six, subjects completed a task designed to capture their working memory capacities. The operation-word span task (derived from LaPointe and Engle (1990)), used extensively in psychology research, is a well-accepted measure of an individual's working memory. Span tasks are designed to resemble the working memory demands during the performance of complex cognitive tasks by placing simultaneous demands on both processing and storage (Miyake and Shah 1999). Measures captured here are used to test hypothesis five. Designed for individual administration, the operation-word span task was adapted for administration to a large group. The group administration is discussed with deviations from single-person administration noted in parentheses. The task consists of a series of simple arithmetic operations with an answer followed by a one-syllable word, such as "(4x3)+1=14 sword." Each operation and accompanying word is presented simultaneously one operation-word pair at a time on an overhead projector for a short period of time (rather than on an individual's computer screen). Subjects indicate whether the answer following the operation is correct or incorrect in a booklet and then attempt to remember the word following the operation (rather than verbally expressing the correctness of the operation and saying the word out loud). After a brief interval, the experimenter moves on to the next operation-word pair. After varying sets of two to seven operations, a question mark appears on the screen prompting subjects to write down as many of the words from the previous set as they can remember. Three sequences of each set size are presented in random order. Approximately half the operations are correct; half are incorrect.

The task is scored to achieve two span scores: a set-size memory score and a total memory span. Set-size memory is the maximum set size where the subject correctly recalled all the words in two out of the three times that set size was presented. Total memory span is the sum of the number of correctly recalled words recalled in any order. Words are deemed correctly recalled only when the associated operation is correctly indicated as being correct or incorrect, keeping subjects from focusing entirely on remembering the words.

Klein and Fiss (1999) examined the reliability of the operation-word span task and found alpha coefficients greater than .75 in a series of test-retests. However, the types of subjects used in most psychology studies were of a different ability and general demeanor than the average accounting student. An initial pilot study deemed the task rather unsuccessful in discriminating subjects with above average mathematical ability. From observing subjects completing the task, it appeared that the simplicity of the mathematical operations and the amount of time allowed for each operation-word pair did not place significant demands on subjects' processing and storage functions. Therefore, the task was adapted to better reflect the abilities of accounting subjects. Three adaptations were made. First, the complexity of the operations was increased. For example, "[(4x3)-(3x2)]+1=8 sword." Second, the time given for viewing each operation-word pair was reduced by 33 percent. Last, the set sizes were changed to sets of three to eight with two of each set size. A second pilot study on Masters of Accounting students supported success in taxing the abilities of these more numerically skilled individuals. Observing subjects completing the task, it appeared that a significant burden on both processing and storage functions was achieved. Table 1 presents the operation-word combinations used.

Upon completion of the working memory task, subjects opened envelope seven, which contained a memory reconstruction task. The memory reconstruction task is adapted from Kida et al. (1998). It is designed to capture the extent to which memory is reconstructed to match the decision aid recommendation direction, either positive or negative, to allow testing of hypothesis one. The task consists of a series of statements with instructions directing subjects to indicate whether the statement was included in the original data set and their confidence in each determination. Statements are of six types. Four statements are new items that have an affective response consistent with the decision aid recommendation. Four statements are new items that have an affective response inconsistent with the decision aid recommendation. Two statements are items in the original data set that were originally inconsistent with the decision aid recommendation but whose values were changed to be consistent with the recommendation. Two statements are items in the original data set that were originally consistent with the decision aid recommendation but whose values were changed to be inconsistent with the recommendation. Three statements are items in the original data set exactly as they appeared and one probe statement is an item that was obviously not in the original data set. These last four statements were included as attention checks to test whether subjects paid adequate attention to the task. Reconstruction is exhibited when subjects believe that new items consistent with the decision aid recommendation and items originally inconsistent with the decision aid recommendation but changed to be consistent were included in the original data set.

Experiment Two

Experiment two is similar to experiment one with three exceptions. First, experiment two was administered via the Internet using an interactive web-based database application developed with Cold Fusion. Subjects completed the experiment in university computer labs under the supervision of the experimenter or an assistant. This facilitated both administration of the experiment and data collection. Data were automatically collected during the experiment in a relational database tied to the web application. This allowed the capturing of exact timing of individual subject behavior not possible with paper-based materials. The design also allowed the examination of search in a much more realistic and less obtrusive manner than would the use of information boards or other more primitive process-tracing techniques. Second, experiment two adds the ability to perform external information search during the task. Third, experiment two does not include the working memory capacity task. The addition of the search component extended the time necessary to complete the experiment to a level prohibiting the inclusion of the working memory capacity task as well.

The experimental procedures followed one of three sequences as depicted in Figure 4. Each timing of the aid, early, delayed, or late, was crossed with one of two types of decision aid recommendation, positive or negative, yielding a 3 x 2 between-subjects design. Additionally, there was a control group who received no aid. Subjects were randomly assigned to one of the seven experimental treatments. The experimental materials were identical to those of experiment one with the inclusion of additional information for each financial ratio from which the user could select a subset to view. Since only the ordering of materials varies, only the late introduction sequence is described.

Upon arriving in a university computer lab, subjects were given a slip of paper with a web address and were given a brief verbal description of the exercise they would be completing. Subjects were told to enter the web address into their web browsers and proceed as instructed on screen. As in experiment one, subjects were provided introductory instructions followed by the timed ratio analysis phase. To insure correct interpretation of the ratios given, the presentation of the financial ratios included functionality whereby subjects could view a brief description on the screen of what each ratio indicates and how each ratio is calculated. Likelihood assessments and confidence levels were then recorded.

Next, subjects were informed they had the ability to search for additional information. The financial ratios were provided once again, this time hyper-linked to provide access to some additional information. The additional information included further comparative data, either prior year or industry average ratios, depending on what was available previously. In addition, it also provided the firm's relative ranking of each ratio within its group of direct competitors reported as being in the top, middle, or bottom third. Subjects searched for additional information for six ratios. This limited ability to search is indicative of practice where time and cost constraints prohibit exhaustive external search (Hulland and Kleinmuntz 1994). The subjects then recorded revised likelihood assessments and indicated their levels of confidence in their judgments. The search portion of the task allows tests and comparisons to be made of search patterns to determine the influence of decision aids and affective responses on search.

Following the explanation of the decision aid and the aid recommendation, subjects provided final likelihood assessments and confidence levels. Further, they ranked the top six ratios they believed to be most important in making their judgments. This provides data to test hypotheses related to cue usage. This was followed by a series of demographic questions, manipulation checks, and miscellaneous questions. These questions served the dual purpose of capturing needed information and acting as a distracter task to clear subjects' short-term working memories. This portion of the task was timed and set at ten minutes. Subjects were not allowed to continue to the next section until the time expired. This was done to ensure everyone had the same amount of time between last viewing information and the memory task in an effort to insure equality in clearing subjects' working memory. Research on memory indicates only a few minutes are needed to completely clear working memory.

Last, subjects completed the memory reconstruction task. Subjects were then allowed to leave.

Independent Variables

The two independent variables manipulated are timing of the decision aid recommendation and the type of decision aid recommendation. For experiment one, the decision aid recommendation is provided at one of two possible timings: 1) early – before viewing the financial ratios; and 2) late – after viewing the financial ratios. For experiment two, the decision aid recommendation is provided at one of three possible timings: 1) early – before viewing the financial ratios or searching; 2) delayed – after viewing the financial ratios but before searching; and 3) late – after both viewing the financial ratios and searching. See Figures 5a and 5b for a graphical depiction of the timing manipulation for both experiments. The type of decision aid recommendation provided to subjects is one of two possible directions: 1) positive – a low likelihood the firm will experience financial problems in the foreseeable future, or 2) negative – a high likelihood the firm will experience financial problems in the foreseeable future.

In addition, working memory capacity is measured for each subject in experiment one. The operation-word span task provides a span measure related to the capacity of an individual's working memory. The total memory span, which is the sum of the number of correctly recalled words recalled in any order, is used for this measure.

Dependent Variables

To examine memory reconstruction, the dependent variable is the extent of reconstruction. Reconstruction is defined as the difference in the percentage of times users incorrectly identify new items consistent with the direction of the decision aid recommendation (New/Consistent) as being in the original data set and new items inconsistent with the direction of the decision aid recommendation (New/Inconsistent) as being in the original data set. For search patterns, the dependent variable is the direction of search. Direction of search captures the extent of the positive or negative valence of searched items. This yields an index on a scale of –6 to +6 as favorable cues receive a value of +1 and unfavorable cues a value of –1. This measure does not allow weighting of searched items. Items searched first may have more importance than those searched last. Therefore, a second measurement of search direction uses relative weights based on when during the six items searched each item was viewed in an attempt to capture the relative importance of searched items. Items searched first receive a weight of six, items searched second receive a weight of five, and so on. This yields a scale ranging from –21 to +21. For cue usage, the dependent variable is an index capturing the relative direction (positive or negative) of the cues deemed most important. Two measures of cue usage are determined, using the same scoring procedures as used for search. For judgments, the dependent variables are the final likelihood assessment and the assessment revision, calculated as the change from the initial assessment to the final assessment.

CHAPTER IV

RESULTS

Experiment One

Purpose

The purpose of experiment one is to examine the effect of decision aids on memory patterns and judgments without the influence of information search (hypotheses one and two). The effects of the type of decision aid recommendation (aid type) and the timing of the decision aid recommendation (aid timing) are both investigated. In addition, working memory capacity is measured to determine its moderating influence on memory patterns and judgments (hypothesis five).

Statistical Procedures

The experimental plan is a two-factor completely randomized fixed-effects model. Hypotheses are tested using paired t-tests, Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA), and correlation analysis procedures.

Hypothesis one posits that memory will be reconstructed to match a decision aid's recommendation, whether positive or negative. A paired t-test is employed to examine mean differences in memory patterns. Specifically, I test for differences between positive identification of New/Consistent items and positive identification of New/Inconsistent items.

Hypothesis four proposes that decision aid recommendations affect decision-makers' judgments. An ANOVA model is used to examine the effect of the type of decision aid recommendation and timing of the decision aid recommendation on final assessments. The dependent variable is the final assessment. The fixed factors in the model are the type of decision aid recommendation and timing of the decision aid recommendation, and working memory capacity is included as a covariate.

Finally, hypothesis five involves the effects of subjects' working memory capacities on the level of influence decision aids have on decision processes. I conduct correlation analysis to determine if there is a statistically significant relationship between subjects' working memory capacities and the influence a decision aid has on memory patterns and judgments. I then employ an ANOVA model with the difference between inaccurate New/Consistent identifications and inaccurate New/Inconsistent identifications as the dependent variable. Fixed factors are the type of aid recommendation and timing of the aid recommendation, and working memory capacity is included as a covariate.

Descriptive Statistics

A total of 64 subjects participated in experiment one. Table 2 provides descriptive statistics on the subjects for experiment one.[1] Several observations are noteworthy. Overall, incorrect identification of New/Consistent items is higher than for New/Inconsistent items for both types of decision aid recommendations. The type of aid recommendation appears to have an effect on the final assessment. The mean final

[1] Data were analyzed for normality and to identify outliers. Boxplots, histograms, and normal probability plots were examined. No extreme outliers were noted and the hypothesis of normality was not rejected.

assessment for subjects receiving a negative aid recommendation is 68.9, while only 35.7 for those receiving a positive aid recommendation. While these initial observations appear to support the hypotheses, formal statistical tests will provide empirical support.

Manipulation Checks

In order to draw reliable conclusions from the hypotheses tests, it is necessary to verify that subjects correctly interpreted the intended manipulations, exerted adequate effort and attention to the task, and paid attention to the decision aid. To insure the manipulation of the type of decision aid recommendation was correctly interpreted, a manipulation check was included in the instrument that required subjects to indicate whether the decision aid recommendation suggested the firm was likely to experience financial difficulty. Mean levels of agreement/disagreement confirm the intended manipulation was achieved. To determine whether subjects were paying adequate attention to the task, I included three items in the memory task that were in the original dataset and one new item that was obviously not in the original dataset. Error rates on incorrect identification of these items were low (8.6%), indicating that subjects were able to recall original data items and recognize new data items. Accurate recall indicates that subjects exerted effort during both the study and test phases. Finally, two questions addressing the perceived credibility of the decision aid were provided. Mean agreement levels for whether subjects believed that the decision aid was useful and reliable, based upon comparisons with the neutral position, indicate that the aid was perceived as being useful and credible. These manipulation and attention checks provide support that subjects understood the task, understood the information given them, and exerted effort during the task.

Effect of Decision Aid Recommendations on Memory

Hypothesis one predicts that decision-makers receiving a decision aid recommendation will reconstruct memory for financial data to match the affective response induced by the aid recommendation. To test the hypothesis, a paired t-test is used to compare percentage of times New/Consistent items were identified as being in the original dataset with percentage of times New/Inconsistent items were identified as being in the original dataset. A significantly greater identification of New/Consistent items (41.0%) as compared to New/Inconsistent items (7.4%) supports reconstruction of memory to match the decision aid recommendation. The result of the paired t-test is highly significant ($t = -9.514$, $n = 64$, $p<0.0001$). There are a significantly greater percentage of inaccurate New/Consistent identifications than inaccurate New/Inconsistent identifications. This provides evidence in support of hypothesis one.

Effect of Decision Aid Recommendations on Final Judgment

Hypothesis four predicts that decision aid recommendations will influence the judgments of their users. Specifically, it predicts that decision-makers using a decision aid will reach more positive (negative) final judgments when the aid's recommendation is positive (negative).

Results of an ANOVA model with assessment bias as the dependent variable and the type of the aid recommendation and the timing of the aid recommendation as fixed factors are presented in Table 3 Panel A. Assessment bias is calculated as the final assessment less a neutral assessment of fifty. This measure captures the amount and direction the final assessment deviates from a neutral assessment.[2] Aid type is statistically significant at p<.0001, while aid timing is not. Positive aid recommendations resulted in a mean final assessment of 35.7, while negative aid recommendations resulted in a mean final assessment of 68.9. The direction of aid recommendation does influence the final judgment, specifically in the direction of the aid recommendation. This provides evidence in support of hypothesis four.

Further insight is gained by looking at the revision made to assessments, comparing the initial assessment to the final assessment. Table 3 Panel B presents the results of the ANOVA model using assessment revision as the dependent measure (initial assessment minus final assessment) and the type of the aid recommendation and the timing of the aid recommendation as fixed factors. Neither aid type nor aid timing is statistically significant, but the interaction effect of aid type and aid timing is statistically significant at p<0.0001. Figures 6 and 7 present graphs of assessment revision and the change in assessments, respectively. Unsurprisingly, it is clear that receiving the aid recommendation early results in a major bias in judgment, but that this bias is somewhat "neutralized" (but not completely) as additional information is acquired. As would be expected, much reliance is placed on the decision aid in the absence of other information. Once other information is received, the decision-maker begins to rely on their own judgment as well, although not completely.

[2] This assumes that, on average, the final assessment resulting from examination of the data alone would be a neutral assessment. The objective of the experiment was to present an overall neutral dataset that would result in a neutral assessment. Pilot tests confirmed that the dataset resulted in neutral assessments.

Effect of Working Memory Capacity on Memory and Decision Processes

Hypothesis five predicts that decision-makers' working memory capacities will be a determinant of the amount of influence the decision aid has on their memory patterns and judgments. Specifically, it proposes that there will be a negative association between decision-makers' working memory capacity and both memory reconstruction effects and the influence of aid recommendations on judgments. I first test hypothesis five by correlating subjects' working memory span score with New/Consistent, New/Inconsistent, total number of items incorrect, and assessment bias. Table 4 provides the results of the analysis. There are significant negative correlations for all four combinations. Subjects with increased working memory capacities tend to have significantly fewer incorrect identifications of New/Consistent and New/Inconsistent items, make fewer incorrect identifications overall, and make final judgments that are less influenced by the aid recommendation. This provides preliminary support for hypotheses 5a and 5b.

To further investigate hypothesis 5a, subjects are classified into groups of high or low working memory capacity, partitioned by average span score. Table 5 Panel A provides a comparison of mean error rates for New/Consistent items, New/Inconsistent items, and all errors for subjects of high and low working memory capacity. Subjects with higher working memory capacities have lower error rates across all three categories. This suggests that working memory capacity is a determinant of overall memory, but not necessarily a determinant of the level of influence the aid recommendation will have on memory. As an additional test, Table 5 Panel B presents the results of an ANOVA model with the difference between inaccurate identification of New/Consistent items and New/Inconsistent items as the dependent variable. Fixed factors are type of aid recommendation and timing of aid recommendation and working memory capacity is included as a covariate. Working memory capacity is not statistically significant. Taken together, this suggests that while subjects with lower working memory capacities are more susceptible to reconstruction they are also more susceptible to all other errors, or memory errors in general. Therefore, hypothesis 5a is not supported.

Hypothesis 5b is investigated by comparing assessment bias and revision in assessment for high and low working memory capacity groups. Mean comparisons reveal that subjects with lower working memory capacities appear to have more bias in their assessments (mean of 4.78 compared to mean of –0.43) and tend to revise their assessments to a greater degree (mean of –8.37 compared to mean of 1.46). Even though both results are in the expected direction, an independent samples t-test indicates that assessment bias is not significantly different but revision in assessment is significantly different at $p = 0.063$. As an additional test, Panels A and B of Table 3 provide results of ANOVA models with assessment bias and revision in assessment, respectively, as dependent variables, and working memory capacity included as a covariate. Working memory capacity is statistically significant in both models. Working memory capacity is a statistically significant determinant of the amount of influence the aid recommendation has on final judgments. Therefore, hypothesis 5b is supported.

Experiment Two

Purpose

Experiment two examines the effect of decision aids on memory patterns, information search, cue usage, and judgment.

Statistical Procedures

The experimental plan is a two-factor completely randomized fixed-effects model. Hypotheses are tested with paired t-tests, Repeated Measures, Analysis of Variance (ANOVA), and Analysis of Covariance (ANCOVA) procedures.

Hypothesis one posits that memory will be reconstructed to match a decision aid's recommendation, whether positive or negative. As in experiment one, I test hypothesis one with a paired t-test to examine mean differences in memory patterns. Specifically, I test for differences between positive identification of New/Consistent items and positive identification of New/Inconsistent items. Additionally, I employ a Repeated Measures ANOVA model. This is a more powerful test as it allows for the additional examination that the effect the type of aid recommendation and timing of the aid recommendation have on memory. Fixed factors in the model are the type of decision aid recommendation and timing of the decision aid recommendation. Covariates for subjects' rating of the perceived usefulness of the aid and student type are included in the model.[3]

[3] Throughout the data analysis, covariates for subjects' rating of the perceived usefulness of the aid, subjects' perceived reliability of the aid, and student type were included during initial analyses. When any of these covariates were not statistically significant in the full model, they were removed in the final analyses.

Hypothesis two addresses the potential for the decision aid recommendation to influence the decision-maker's search strategy and cue usage. An ANOVA model is utilized to examine the effect of the decision aid recommendation on information search and cue usage. The dependent variables are search direction and direction of cue usage. Fixed factors in the model are type of decision aid recommendation and timing of the decision aid recommendation.

Hypothesis three examines the effect of the timing of decision aid recommendations on decision-making processes. A Repeated Measures model and an ANOVA model are used to examine differences in memory reconstruction and search and cue usage direction, respectively, due to the timing of the aid recommendation. Dependent variables are memory reconstruction, search direction index, and cue direction index. Fixed factors in the model are type of decision aid recommendation and timing of the decision aid recommendation.

Hypothesis four proposes that decision aid recommendations affect decision-makers' final judgments. An ANOVA model is employed to examine the effect of the type of decision aid recommendation and timing of the decision aid recommendation on final assessments. The dependent variable is the final assessment. Fixed factors in the model are type of decision aid recommendation and timing of the decision aid recommendation.

Descriptive Statistics

A total of 198 subjects participated in experiment two. One subject was removed from the analyses because of a failure to complete the experiment, leaving a total sample size of 197. Minor technical difficulties arising during the experiment caused a loss of data for some subjects for various measurements, thus the sample size varies across different statistical tests. The technical problems encountered were spread evenly among treatments.

Table 6 provides descriptive statistics on the subjects for experiment two.[4] Several observations are worth noting. There appear to be significant differences between New/Consistent items and New/Inconsistent items overall for both types of aid recommendations. Direction of cue usage is more negative for negative aid recommendations than it is for positive aid recommendation. However, search direction appears essentially the same for both positive and negative aid recommendations. Final assessments are toward opposite ends of the scale, with positive recommendations eliciting more positive assessments and negative recommendations eliciting more negative assessments.

Manipulation Checks

The manipulation and attention checks described for experiment one are the same for experiment two. Those checks provide support that subjects understood the task, understood the information given them, exerted effort on the task, and believed that the decision aid was credible.

[4] Data were analyzed for normality and to identify outliers. Boxplots, histograms, and normal probability plots were examined. No extreme outliers were noted and the hypothesis of normality was not rejected. Due to some variety in the subject pool, variables were also cross-tabulated to ensure even spreads across treatments. For example, student type, whether graduate or undergraduate student, and undergraduate

Effect of Decision Aid Recommendations on Memory

Hypothesis one predicts that decision-makers receiving a decision aid recommendation will reconstruct memory for financial data to match the affective response induced by the aid recommendation. As in experiment one, I test hypothesis one with a paired t-test comparing percentage of times New/Consistent items were identified as being in the original dataset with percentage of times New/Inconsistent items were identified as being in the original dataset. The result of the paired t-test is highly significant ($t = 13.636$, $n = 195$, $p<0.0001$). There are a significantly greater percentage of inaccurate New/Consistent identifications than inaccurate New/Inconsistent identifications. This provides support for hypothesis one.

I further test hypothesis one with a Repeated Measures ANOVA model comparing the percentage of times New/Consistent items were identified as being in the original dataset with the percentage of times New/Inconsistent items were identified as being in the original dataset. This measure of reconstruction is essentially the difference between positive identification of New/Consistent items and positive identification of New/Inconsistent items. It captures the extent to which incorrect identification is consistent with, or in the direction of, the aid recommendation. A significantly greater percentage of identification of New/Consistent items as compared to New/Inconsistent items supports reconstruction of memory to match the decision aid recommendation.

Fixed factors in the model are the type of decision aid recommendation and timing of the decision aid recommendation, with perceived usefulness of the aid and

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GPA, were considered, among others. Chi-square tests were not statistically significant. Any variation was spread evenly across treatments.

student type included as covariates. Repeated Measures analysis is a more powerful test of hypothesis one as it allows for the examination of the effects of type of decision aid recommendation and timing of decision aid recommendation on memory reconstruction. It allows a comparison of inaccurate New/Consistent identifications with inaccurate New/Inconsistent identifications while controlling for the effect of between-subjects factors, type of aid recommendation and timing of aid recommendation. It also allows for the examination of the effect of the between-subjects effects on the repeated measure.

To provide a preliminary view of the analysis, Table 7 presents mean percentages for inaccurate New/Consistent identifications and inaccurate New/Inconsistent identifications split by both the type of aid recommendation and the timing of the aid recommendation. It is evident that there are higher percentages of inaccurate New/Consistent identifications than inaccurate New/Inconsistent identifications across all treatments. Table 8 Panel A presents the results of the within-subjects analysis of the Repeated Measures ANOVA model. As in experiment one, the item of primary interest is reconstruction. Reconstruction is highly significant at $p<.0001$. There are a significantly greater percentage of inaccurate New/Consistent identifications than inaccurate New/Inconsistent identifications. This provides evidence in support of hypothesis one. Taken with the results of experiment one, I conclude that memories are reconstructed to be consistent with the decision aid recommendation.[5]

[5] A group with no decision aid recommendation was included in the experimental design to allow for additional tests of the robustness of memory reconstruction results. The group without a decision aid recommendation was expected to exhibit approximately equal inaccurate identifications of New/Consistent ratios and inaccurate identifications of New/Inconsistent ratios. I am unable to perform reliable tests on the no-aid group, however. The graduate students in the no-aid group had much lower initial and final assessments than all other subjects, including those in early aid treatments who had not received a decision aid prior to making an initial assessment. Further, there was no such favorable bias in any of the pilot

Effect of Decision Aid Recommendations on Information Search and Cue Usage

Hypothesis two predicts that decision aid recommendations will influence users' search patterns and the cues they use. More specifically, hypothesis 2a predicts that decision-makers using a decision aid will search more positive (negative) information when the decision aid's recommendation is positive (negative). Hypothesis 2b predicts that decision-makers using a decision aid will rank positive (negative) information cues as more important than negative (positive) cues when the decision aid's recommendation is positive (negative).

Hypothesis 2a and 2b are both tested with an ANOVA model. For search, the dependent measure is the search direction index, a measure of the extent of the positive or negative valence of searched items. Table 9 Panel A provides the results of the ANOVA model for search direction. Neither aid type nor aid timing is statistically significant as a main effect, but the interaction is statistically significant at the .05 level. Only the early and delayed treatments are examined because in the late aid treatment the aid recommendation is given after search, and therefore it cannot affect search. Figure 8 presents a plot of the interaction. It reveals that those receiving early aid

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experiments. This favorable assessment bias, or deviation from a neutral assessment, is a significant predictor of memory reconstruction in the no-aid group. That is, these subjects formed favorable impressions from the neutral ratio set, and they exhibited reconstruction consistent with this positive bias. It appears that these subjects viewed the neutral data, formed an overall positive impression, and reconstructed memories to match the affective response to the data. This finding is consistent with the results of Kida et al. (1998). In addition, there are other anomalies in the no-aid group that cannot currently be explained. For example, the no-aid group made significantly more ratio identification errors for some ratios than any other treatment group. Based on the available data, it also appears that all extreme observations are congregated in the no-aid group. Further research will be needed to determine what occurred with this no-aid treatment group and why it differed from previous pilot groups. It is possible that some form of maturation effect occurred, because the subjects in question performed the task on the same day and most of the subjects knew each other well.

recommendations search in a direction consistent with the aid recommendation while those receiving the delayed aid recommendation tend to search for items that disconfirm the aid recommendation.

While there is no main effect for aid type as predicted by hypothesis two, the aid type does influence search patterns when the timing of the aid recommendation is considered. Aid recommendations influence search patterns and support is provided for hypothesis 2a. An examination of the overall mean search direction index yields additional insight. The mean search direction index is -4.56. On average, subjects tended to search more negative informational cues than positive informational cues. A one-sample t-test confirms this is significantly different from zero at $p<.0001$ ($t = -7.746$, $df = 126$). Subjects' search patterns are more directed toward negative items than positive items.[6]

These results are consistent with findings in both psychology and accounting literature. Psychology literature finds that people seek out evidence to confirm an initial hypothesis (Einhorn and Hogarth 1981). In accounting, although there are indications of this as well (Klayman and Ha 1987; Danos et al. 1989), in general, accountants are not as susceptible to confirmation bias (Kida 1984; Asare 1992), and are more prone to seek out disconfirming evidence due to a disposition toward professional skepticism (Ashton and Ashton 1988; Smith and Kida 1991; Bonner and Pennington 1991). It appears that receiving the aid recommendation early creates a strong initial affective response and initial hypothesis. This leads to a confirmation bias. When the aid recommendation is

[6] Two measures of search index were analyzed. Using the alternate measure of search direction, neither main effect nor the interaction was statistically significant, although the mean search difference was still

delayed, the data may become the basis for an initial hypothesis. However, due to the neutrality of the data, a strong response is not produced. When the aid recommendation is subsequently received, the aid recommendation's strong response causes subjects to take a disconfirming approach, due to professional skepticism. From this, it can be concluded that the aid does affect users' search patterns with a confirmation bias effect for early aid timing and a conservative bias when the aid is delayed.

Table 9 Panel B presents the results of the ANOVA model used to test whether cue usage is influenced by the decision aid. The dependent variable is the cue direction index, a measure of the extent of the positive or negative valence of cues subjects reported as most important. While aid timing is not statistically significant, aid type is statistically significant at $p<.01$.[7] Subjects receiving negative aid recommendations ranked a greater number of negative cues as being important than they ranked positive cues as being important. The aid influences the cues subjects deem to be important. Therefore, hypothesis 2b is supported.

Timing of the Decision Aid Recommendation

Hypothesis three predicts that the level of influence the decision aid recommendation has on the decision-maker's memory and cognitive processes will depend on when during the decision-making process the aid recommendation is received. In particular, those receiving the aid recommendation early in the process will exhibit less

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significantly different from zero at the .01 level. The measure of search reported in Table 9 attempts to capture the relative importance of cues examined and therefore provides more meaningful insight.

[7] Two measures of cue usage index were analyzed. Using the alternate measure of cue usage direction, results are essentially unchanged.

memory reconstruction and different search and cue usage patterns than those receiving the aid recommendation later in the process.

I test hypothesis 3a with a Repeated Measures ANOVA model with the rate of identification of the New/Consistent items as being in the original dataset and rate of identification of New/Inconsistent items as being in the original dataset as the dependent repeated measure. Timing of the aid recommendation and type of the aid recommendation are the fixed factors in the model. Two covariates are included in the model: perceived usefulness of the aid and student type. Panel B of Table 8 presents the between-subjects effects. Both covariates are statistically significant. Aid timing is statistically significant at $p<.01$. Figure 9 reveals that subjects receiving aid recommendations early and delayed have greater amounts of reconstruction than those receiving aid recommendations late do. This is in the opposite direction predicted by hypothesis 3a. A potential explanation for this result lies in the way reconstruction between-subjects effects are tested with the Repeated Measures model. For between-subjects effects, tests of significance are based on differences in the average of total New/Consistent errors plus total New/Inconsistent errors. Therefore, the repeated measures model fails to consider differences in New/Consistent errors relative to other errors. To further test for the effect of timing on reconstruction, I use an ANOVA model with inaccurate New/Consistent identifications minus inaccurate New/Inconsistent identifications as the dependent variable. Fixed factors are type of aid recommendation and timing of the aid recommendation. Table 10 presents results of the ANOVA model. Aid timing is not statistically significant and hypothesis 3a is not supported.

I test both hypotheses 3b and 3c with ANOVA models. For hypothesis 3b and 3c the dependent variables are search direction index and cue usage direction index, respectively. Aid timing and type of aid recommendation are the fixed factors. Panels A and B of Table 9 present the ANOVA models of the effect of aid timing on search and cue usage, respectively. Aid timing is not statistically significant in either model. However, for search direction, there is a statistically significant interaction between aid type and aid timing. Therefore, timing of the aid does affect search direction, but is dependent on the type of aid recommendation. Hypotheses 3b is supported while hypothesis 3c is not supported.

Effect of Decision Aid Recommendations on Judgment

Hypothesis four predicts that decision aid recommendations will influence the final judgments of users. Specifically, it predicts that decision-makers using a decision aid will reach more positive (negative) final judgments when the aid's recommendation is positive (negative).

Results of an ANOVA model with the final assessment as the dependent variable and the type of the aid recommendation and the timing of the aid recommendation as fixed factors are presented in Panel A of Table 11. Aid type is statistically significant at $p<.0001$, while aid timing is not statistically significant. Subjects receiving a positive aid recommendation had a mean final assessment of 43.41 and subjects receiving a negative aid recommendation had a mean final assessment of 69.47. The direction of aid recommendation does influence final judgment. Therefore, hypothesis four is supported.

Further insight is gained by looking at the revision made to assessments, comparing the change from the initial assessment to the final assessment. Using the assessment revision as the dependent variable, and the type of the aid recommendation and the timing of the aid recommendation as fixed factors, Panel B of Table 11 presents the results of the ANOVA model. Neither aid type nor aid timing is statistically significant at the .05 level. The interaction effect of aid type and aid timing is statistically significant at $p<0.0001$. Graphs of assessment revision in figures 10a and 10b reveal that early aid recommendations differ from delayed and late aids, but delayed and late aids follow similar patterns. Just as in experiment one, it is no surprise that receiving the aid recommendation early results in a major bias in judgment which is "neutralized" somewhat (but not completely) as additional information is acquired. As expected, much reliance is placed on the decision aid in the absence of other information. Once other information is received, the decision-maker begins to rely on their own judgment, although not completely.

Figure 11 presents a plot of the three assessments made split by aid timing and aid type. Taken with the other results, this suggests that while timing does not matter for the final assessment it does have an effect on judgments prior to the final assessment. As long as the aid recommendation is received at some point prior to final judgment, all information is considered received and final judgments do not differ due to timing effects.

CHAPTER V

SUMMARY

Discussion and Conclusions

Decision aids have been recommended to support decision-makers in tasks where human information-processing limitations and individual differences limit performance. In high load environments individuals' processing capacities are heavily taxed and decision aids may be of great value in helping users cope with increased cognitive demands. Numerous studies support positive outcomes of decision aid use in a variety of settings. The focus of most research tends to be on the outcomes of the decision-making process. While the potential effects of decision aid use on decision processes are acknowledged, there is little evidence to explain how decision aid use affects the user. The effects of aids on decision processes may lead to detrimental effects that, had they been previously considered, could have been mitigated through user training, task structure, decision aid design, or some combination of these. This study examines the use of decision aids and the influence they exert, both positive and negative, on all phases of the decision-making process.

There are six key findings from this research: (1) decision aid recommendations create strong affective responses that are encoded in memory and cause users to reconstruct memories of financial data to be consistent with the affective response, (2) receiving a decision aid recommendation at the start of a task creates a strong initial response that acts as an initial hypothesis wherein users' subsequent information search patterns exhibit a confirming bias, (3) receiving a decision aid recommendation later in the task creates a strong response that initiates professional skepticism and causes users' subsequent information search patterns to exhibit a disconfirming bias, (4) decision aid recommendations influence the choice of information cues users believe to be important, (5) decision aid recommendations exert influence on users' judgments, with the amount of influence diminishing as additional information is received, and (6) working memory capacity is a determinant in the ability to recall financial information but does not determine the extent of influence decision aid recommendations have on users. These findings, when considered together, validate the need for a more complete examination of how decision aids impact the entire decision-making process to identify potential negative consequences in addition to proposed benefits. Understanding the effects decision aids have on inputs to the decision process and the decision processes employed is as essential as understanding the impact they have on the outputs of the decision process. Results indicate that unintended consequences do arise from decision aid use that significantly affect decision-making. In addition, the results indicate that to minimize the detrimental effects of aid use, task structure must be considered when incorporating decision aids into deterministic tasks.

The first finding extends the literature on affective responses to financial information. Both data and peripheral cues have been found to elicit affective responses that persist in memory, causing users to reconstruct memories of financial data to match the affective response (Kida et al. 1998, 2001; Rose 2001). Decision aid recommendations have a similar effect on memory. As evidenced in several of the findings, in addition to causing users to reconstruct memories, the affective response generated by the decision aid recommendation influences subsequent decision processes.

Particularly, information search patterns exhibit either a confirming or a disconfirming bias, depending on when the aid recommendation is received. Decision aid recommendations also influence what cues users believe to be most important, directing users to consider cues consistent with the affective response of the aid recommendation as more important than cues inconsistent with the affective response. This has implications for both task efficiency and task effectiveness. While disconfirming a hypothesis tends to be the most efficient method of hypothesis testing, there is a tendency to do otherwise (Harris 1981). The structure of the task can be organized so as to promote a more efficient disconfirming strategy. To promote the investigation of conflicting evidence, decision aid recommendations could be provided later in the decision-making process. The additional information provided by the decision aid can both provide support for or against the hypothesis and be a catalyst for further inquiry. In turn, a more complete search and consideration of information should lead to greater effectiveness (Solomon and Shields 1995; Cloyd 1995).

The fifth finding is also noteworthy. The influence of decision aid recommendations on judgments tends to decrease as additional information is acquired. Because decision aid recommendations have a strong influence on judgments, particularly in the absence of other information, care must be taken to structure the task or provide an environment that promotes complete consideration of all relevant information so task effectiveness is not compromised. If time pressure or other environmental factors interrupt or otherwise cut short the decision-making process, aid recommendations previously received have the potential to exert undue influence. While this may be beneficial in cases where the decision aid is known to be more accurate than individuals but there is a tendency to ignore the aid, the potential also exists for adverse consequences in situations where the input of the individual is a crucial and necessary aspect of the decision. Consideration of the nature of the task, the nature of the decision-maker, and the environment need to be considered in structuring the task.

The finding that working memory capacity determines the ability to recall financial information is not surprising. Sufficient working memory capacity is necessary to manipulate and encode information successfully. Limitations in working memory capacity would be expected to lead to a lower ability to recall detailed information. What is surprising is that I failed to find results that working memory capacity is a determinant of the extent of influence decision aid recommendations have on users. To cope with greater restrictions of working memory capacity, individuals must rely more on chunking of data. Decision aid recommendations are a form of data chunking, as they incorporate multiple pieces of information into a single chunk. Therefore, it was expected that individuals with more limited working memory capacities would rely on the automatic chunking provided by the decision aid to a greater extent than individuals with greater working memory capacities. One possibility for the failure to find results may lie in the type of subjects participating in the study. It is possible that none of the subjects participating in this study were truly of "low" working memory capacity such that effects would be evident. The subject pools in many psychology studies that find working memory capacity effects are likely characterized as having much variation in memory-related abilities. The accounting and business students in this study possessed very similar working memory capacities, and it is possible that the working memory capacity task employed did not truly distinguish between high and low subjects.

The findings should also be valuable to decision aid reliance researchers. The decision aid reliance literature suggests that users rely or do not rely on decision aids based primarily upon a comparison of the user's decision and the aid's recommendation. However, this measure is problematic because it fails to consider how the decision aid is incorporated into the user's decision-making process, especially when outputs and recommendations do not agree. An improved measure of reliance would consider how decision aids influence other phases of the decision-making process (Rose 2002; Kachelmeier and Messier 1990; Whitecotten and Butler 1998). My results suggest that subjects do incorporate decision aid recommendations into their decision-making process, and many of these effects are not revealed by examining only outputs. I find that a decision aid affects judgment, but I also find that memories, search patterns, and cue usage are significantly influenced by decision aids. The study provides some rationale for examining memory patterns and information search as unobtrusive means to more appropriately measure reliance. Decision aids influence the entire decision-making process, and this study offers several new variables that could be employed to determine the effects of decision aids on judgment, decision-making, and reliance.

Limitations and Future Research

The intended experimental setting was novice use of a decision aid in a deterministic task. Whether these results would extend to other task types or settings is unknown. The effect of varying levels of experience on the effects of decision aid use is warranted. Prior research finds that "experts" often ignore or fail to rely on decision aids, while novices tend to rely on aid advice. An extension of this research could examine if and how results differ for more expert subjects.

Measurement of search patterns was restricted. While subjects were given the opportunity to search for a maximum of six information items, six items was also the minimum requirement of the search component. Whether subjects would have searched for six items without these restrictions cannot be determined. Results could differ if totally unrestricted search was allowed. Future research could manipulate search time pressure to promote more importance-based sequential search. This would allow for an alternate measure of search importance to the measure employed in this study. Additionally, time-based measures may provide a valuable addition to the measure of search that could capture search importance to a greater degree. Time spent viewing information could provide additional information on the relative importance of cues. Similarly, measurement of cue usage required subjects to rank the six most important cues. Alternative measures of cue usage could provide more information on the relative importance of each cue.

The experiment was conducted over the Internet using a web browser interface. There exists the possibility that affinity (or repulsion) toward the Internet might have affected results. Additionally, the decision aid was a seemingly static decision aid. It may have lacked validity due to its lifeless nature. Future research could explore whether the form and nature of the decision aid alters results. Interactive decision aids may have more of an influence as they may be viewed more as an "electronic colleague" and given greater weight.

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APPENDIX

Table 1. Operation-Word Span Task.

Operation	Word	Operation	Word
[(5/1)-(3X2)]+4=3	need	[(7/1)-(2X1)]+6=12	dress
[(2/1)+(7X7)]-2=51	set	[(9/3)+(6X4)]-3=24	tall
[(4X2)-(10/2)]+1=4	pair	[(6X1)+(9/1)]-6=8	bible
[(4/2)+(9X2)]-1=21	dust	[(4/2)+(8X1)]-2=10	snake
[(5/1)+(6X1)]-1=12	lock	[(9/3)-(2X1)]+1=2	hard
[(3/1)-(3X2)]+3=0	rock	[(4/1)+(7X2)]-4=15	tool
[(9X7)+(9/3)]-1=68	wire	[(10/1)-(3X2)]+3=7	skill
[(6/2)-(4X2)]+8=3	close	[(10X2)-(4/2)]+3=21	near
[(6X2)-(5/1)]+2=9	break	[(2X1)-(4/2)]+1=1	desk
[(3/1)+(6X2)]-2=15	beach	[(8/1)+(9X1)]-5=10	bird
[(10/1)+(6X3)]-1=29	hall	[(8X4)-(8/1)]+2=26	dance
[(4/2)+(10X2)]-1=22	green	[(5/5)-(3X1)]+4=2	send
[(6X3)+(6/3)]-2=20	camp	[(9/1)-(4X2)]+8=8	key
[(3/1)+(10X5)]-1=54	cut	[(10/2)-(8X1)]+6=5	wait
[(6X4)-(10/1)]+1=15	help	[(2/2)+(4X2)]-2=8	moon
[(9/1)+(6X4)]-7=27	stay	[(8/1)+(8X4)]-6=36	tree
[(10/2)-(3X1)]+4=6	aim	[(10/1)-(6X2)]+7=5	gas
[(8X1)-(3/3)]+5=12	forth	[(3/3)-(2X1)]+1=0	door
[(4X2)-(5/1)]+1=4	roll	[(5/1)-(3X2)]+4=3	fight
[(6X4)-(4/1)]+1=21	jump	[(3/1)-(6X1)]+9=6	trade
[(10X2)-(8/1)]+3=15	cause	[(8/4)+(6X3)]-2=18	head
[(3X2)-(5/5)]+1=2	arm	[(4X2)+(3/1)]-2=7	guest
[(9/1)-(4X2)]+6=8	blue	[(10/1)+(6X4)]-9=24	back
[(3X1)+(10/1)]-2=13	knife	[(4/2)+(9X2)]-1=17	shall
[(3/1)-(4X1)]+1=0	mouth	[(7X2)+(6/2)]-1=19	dream
[(10/2)+(7X3)]-4=2	score	[(7X7)+(2/1)]-1=52	curve
[(7X7)-(6/2)]+1=47	knee	[(9/1)-(5X2)]+5=4	buy
[(10X6)-(10/2)]+1=56	sum	[(7X1)+(3/3)]-6=4	far
[(3X2)+(9/3)]-1=9	heat	[(10/1)-(4X2)]+3=5	rain
[(7X2)-(2/2)]+3=16	add	[(10/2)-(4X1)]+4=5	taste
[(7X1)-(3/1)]+6=10	guy	[(10/1)-(3X4)]+9=7	brain
[(8X1)-(9/3)]+8=13	own	[(10/1)+(3X3)]-5=12	town
[(6/2)-(2X1)]+1=2	file	[(10/2)-(3X2)]+6=6	meal

Table 2. Descriptive Statistics – Experiment One.

Variable	N	Mean	Deviation	Minimum	Maximum
Positive Aid Recommendation[1]:					
New/Consistent	33	32.6%	24.6%	0.0%	75.0%
New/Inconsistent	33	6.1%	15.3%	0.0%	50.0%
Final assessment	33	35.7	21.1	0.0	75.0
Revision of assessment	33	-4.0	21.7	-62.0	57.0
Working memory span	33	50.1	8.0	34.0	65.0
Self-perceived usefulness of the aid	33	56.2	33.5	0.0	100.0
Self-perceived reliability of the aid	33	54.9	29.6	0.0	100.0
Negative Aid Recommendation[1]:					
New/Consistent	31	50.0%	28.1%	0.0%	100.0%
New/Inconsistent	31	8.9%	18.9%	0.0%	75.0%
Final assessment	31	68.9	21.1	10.0	90.0
Revision of assessment	31	-1.3	20.3	-50.0	60.0
Working memory span	31	48.9	9.2	25.0	63.0
Self-perceived usefulness of the aid	31	61.0	37.3	0.0	100.0
Self-perceived reliability of the aid	31	65.4	24.6	10.0	100.0

[1] Averaged across aid timing.

Table 3. Assessments – Experiment One.

Panel A: ANOVA on Assessment Bias

Source	Sum of Squares	df	Mean Square	F	Sig.
Aid Timing	1.686	1	1.686	0.004	0.950
Aid Type	16622.991	1	16622.991	38.743	0.000
Aid Type * Aid Timing	72.520	1	72.520	0.169	0.682
Working Memory Capacity[1]	2192.984	1	2192.984	5.111	0.027
Error	25314.728	59	429.063		
Total	45365.000	64			

R square = .440

Panel B: ANOVA on Assessment Revision

Source	Sum of Squares	df	Mean Square	F	Sig.
Aid Timing	22.408	1	22.408	0.077	0.783
Aid Type	182.727	1	182.727	0.624	0.433
Aid Type * Aid Timing	8021.298	1	8021.298	27.407	0.000
Working Memory Capacity[1]	1278.421	1	1278.421	4.368	0.041
Error	17267.789	59	292.674		
Total	27984.000	64			

R square = .373

[1] Working memory capacity was also included in the model as a categorical variable with subjects split into groups of high and low working memory capacities. Results using this variable are unchanged for the two main effects and interaction. Working memory capacity is not statistically significant for the assessment bias model but is statistically significant in the assessment revision model at $p = 0.074$. This is most likely an artifact due to a lack of adequate variation and small sample sizes.

Table 4. Correlation Analysis – Experiment One.

	New/Inconsistent	Number Incorrect	Assessment Bias	Span Score
New/Consistent	0.270 * 0.031 n = 64	0.748 ** 0.000 n = 64	0.214 0.089 n = 64	-0.248 * 0.048 n = 64
New/Inconsistent	 . .	0.507 ** 0.000 n = 64	-0.033 0.798 n = 64	-0.274 * 0.029 n = 64
Number Incorrect			0.137 0.281 n = 64	-0.363 ** 0.003 n = 64
Assessment Bias		 . .		-0.263 * 0.036 n = 64

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Table 5. Memory Reconstruction – Experiment One.

Panel A: Mean comparisons

	New/Consistent	New/Inconsistent	All errors
High working memory capacity	36.5%	3.4%	22.6%
Low working memory capacity	47.2%	13.0%	30.1%

Panel B: ANOVA on New/Consistent minus New/Inconsistent

Source	Sum of Squares	df	Mean Square	F	Sig.
Aid Timing	0.015	1	0.015	0.195	0.661
Aid Type	0.322	1	0.322	4.090	0.048
Aid Type * Aid Timing	0.001	1	0.001	0.014	0.908
Working Memory Capacity[1]	0.023	1	0.023	0.286	0.595
Error	4.652	59	0.079		
Total	12.250	64			

R square = .075

[1] Working memory capacity was also included in the model as a categorical variable indicating high and low working memory capacities. Results using this variable are unchanged from those shown here.

Table 6. Descriptive Statistics – Experiment Two.

Variable	N	Mean	Deviation	Minimum	Maximum
Positive Aid Recommendation[1]:					
New/Consistent	97	38.4%	29.8%	0.0%	100.0%
New/Inconsistent	97	11.3%	21.0%	0.0%	100.0%
Cue direction index 1	98	-0.5	1.9	-6.0	4.0
Cue direction index 2	98	-3.0	7.9	-21.0	13.0
Search direction index 1	96	-0.8	1.8	-6.0	4.0
Search direction index 2	96	-5.4	6.6	-21.0	13.0
Final assessment	98	43.4	23.1	0.0	93.0
Revision of assessment	98	-0.6	29.7	-77.0	64.0
Self-perceived usefulness of the aid	98	54.3	29.2	0.0	100.0
Self-perceived reliability of the aid	98	52.7	24.2	0.0	93.0
Negative Aid Recommendation[1]:					
New/Consistent	98	41.8%	28.2%	0.0%	100.0%
New/Inconsistent	98	13.0%	19.7%	0.0%	100.0%
Cue direction index 1	99	-1.2	2.0	-6.0	2.0
Cue direction index 2	99	-6.5	7.7	-21.0	11.0
Search direction index 1	95	-0.5	1.7	-4.0	4.0
Search direction index 2	95	-5.1	6.8	-20.0	11.0
Final assessment	99	69.5	21.4	13.0	100.0
Revision of assessment	99	3.4	23.1	-50.0	64.0
Self-perceived usefulness of the aid	98	61.4	25.7	0.0	100.0
Self-perceived reliability of the aid	98	59.3	24.9	0.0	100.0

[1] Averaged across aid timing.

Table 7. Memory Error Mean Comparisons – Experiment Two.

		Aid Timing			
		Early	Delayed	Late	Total
Aid Type	Positive	35.8%[a] 14.2%[b]	45.0% 12.1%	33.6% 7.8%	38.4% 11.3%
	Negative	46.6% 13.5%	46.7% 17.5%	31.5% 8.1%	41.8% 13.0%
	Total	41.8% 13.8%	45.8% 14.6%	32.5% 7.9%	

[a]Mean inaccurate New/Consistent identifications.

[b]Mean inaccurate New/Inconsistent identifications.

Table 8. Repeated Measures ANOVA Model: Reconstruction[a] – Experiment Two.

Panel A: Within-subjects contrasts

Source	Sum of Squares	df	Mean Square	F	Sig.
Reconstruction	0.570	1	0.570	13.649	0.000
Reconstruction * Aid Timing	0.070	2	0.035	0.835	0.435
Reconstruction * Aid Type	0.007	1	0.007	0.158	0.691
Reconstruction * Perceived Usefulness of Aid	0.007	1	0.007	0.172	0.678
Reconstruction * Student Type	0.005	1	0.005	0.123	0.727

Panel B: Between-subjects effects

Source	Sum of Squares	df	Mean Square	F	Sig.
Aid Timing	0.910	2	0.455	5.949	0.003
Aid Type	0.010	1	0.010	0.127	0.722
Perceived Usefulness of Aid	0.664	1	0.664	8.687	0.004
Student Type	0.320	1	0.320	4.180	0.042

[a] The difference between percentage of New/Consistent items incorrectly identified as being in the original dataset and percentage of New/Inconsistent items incorrectly identified as being in the original dataset.

Table 9. Search and Cue Usage – Experiment Two.

Panel A: ANOVA for Search Direction Index

Source	Sum of Squares	df	Mean Square	F	Sig.
Aid Timing	1.081	1	1.081	0.025	0.875
Aid Type	2.744	1	2.744	0.063	0.802
Aid Type * Aid Timing	176.741	1	176.741	4.053	0.046
Error	5364.114	123	43.611		
Total	8183.000	127			

R square = .032

Panel B: ANOVA for Cue Usage Direction Index

Source	Sum of Squares	df	Mean Square	F	Sig.
Aid Timing	41.998	2	20.999	0.344	0.710
Aid Type	623.317	1	623.317	10.198	0.002
Aid Type * Aid Timing	166.235	2	83.117	1.360	0.259
Error	11613.458	190	61.123		
Total	16848.000	196			

R square = .066

Table 10. Memory Reconstruction – Experiment Two.

Panel A: ANOVA of New/Consistent minus New/Inconsistent

Source	Sum of Squares	df	Mean Square	F	Sig.
Aid Timing	0.133	2	0.067	0.800	0.451
Aid Type	0.012	1	0.012	0.144	0.705
Aid Type * Aid Timing	0.227	2	0.114	1.363	0.258
Perceived Usefulness of Aid	0.008	1	0.008	0.100	0.752
Student Type	0.012	1	0.012	0.149	0.700
Error	15.488	186	0.083		
Total	31.063	194			

R square = .025

Table 11. Assessments – Experiment Two.

Panel A: ANOVA of Final Assessment

Source	Sum of Squares	df	Mean Square	F	Sig.
Aid Timing	424.549	2	212.275	0.429	0.652
Aid Type	33360.269	1	33360.269	67.373	0.000
Aid Type * Aid Timing	1749.140	2	874.570	1.766	0.174
Error	94575.794	191	495.161		
Total	759174.000	197			

R square = .273

Panel B: ANOVA of Assessment Revision

Source	Sum of Squares	df	Mean Square	F	Sig.
Aid Timing	3076.898	2	1538.449	2.977	0.053
Aid Type	836.345	1	836.345	1.619	0.205
Aid Type * Aid Timing	36773.234	2	18386.617	35.583	0.000
Error	98693.721	191	516.721		
Total	139165.000	197			

R square = .289

Table 12. Table of Findings.

Hypothesis	Outcome
H1: Decision-makers using a decision aid will reconstruct memory for financial data to match the affective response induced by the aid recommendation.	Supported
H2a: Decision-makers using a decision aid will search more positive (negative) information when the decision aid's recommendation is positive (negative).	Supported
H2b: Decision-makers using a decision aid will rank positive (negative) information cues as more important than negative (positive) cues when the aid's recommendation is positive (negative).	Supported
H3a: Decision-makers receiving the decision aid's recommendation early in the decision-making process will exhibit less memory reconstruction effects than those receiving the aid's recommendation late in the decision-making process.	Not supported
H3b: Decision-makers receiving the decision aid's recommendation early in the decision-making process will exhibit search patterns different from those receiving the aid's recommendation late in the decision-making process.	Supported
H3c: Decision-makers receiving the decision aid's recommendation early in the decision-making process will exhibit cue usage patterns different from those receiving the aid's recommendation late in the decision-making process.	Not supported
H4: Decision-makers using a decision aid will reach more positive (negative) final judgments when the aid's recommendation is positive (negative).	Supported
H5a: There will be a negative association between decision-makers' working memory capacity and memory reconstruction effects.	Not supported
H5b: There will be a negative association between decision-makers' working memory capacity and the influence of aid recommendations on judgments.	Supported

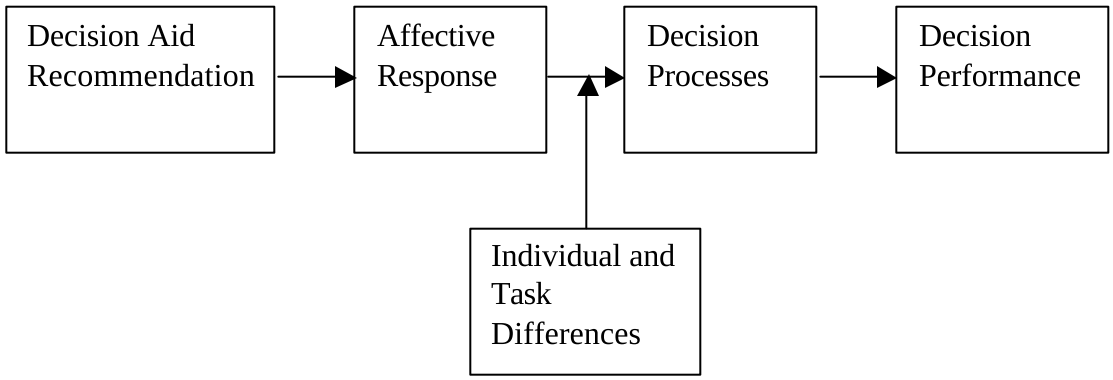
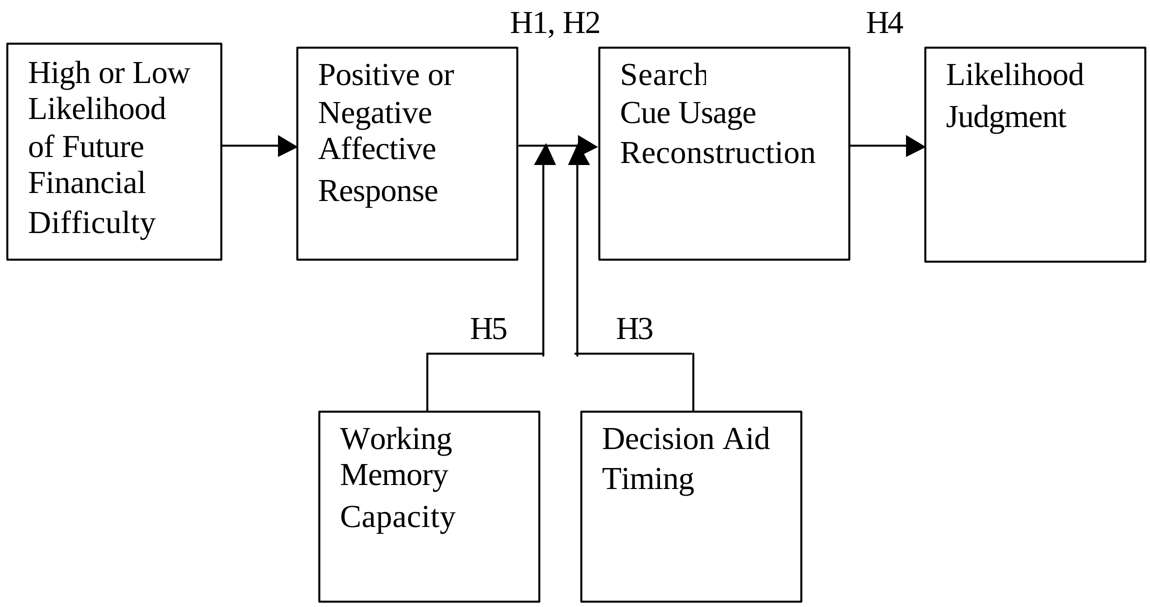


Figure 1. Construct Model.



Hypotheses

H1 Decision-makers using a decision aid will reconstruct memory for financial data to match the affective response induced by the aid recommendation.

H2 Decision-makers using a decision aid will exhibit search patterns and cue usage patterns influenced by the decision aid recommendation.

H3 The time at which the decision aid's recommendation is introduced will affect the level of influence the decision aid recommendation has on the decision-maker’s memory and cognitive processes.

H4 Decision-makers using a decision aid will reach more positive (negative) final judgments when the aid's recommendation is positive (negative).

H5 Decision-makers’ working memory capacities will be negatively associated with the amount of influence the decision aid has on their decision-making processes.

Figure 2. Operational Model and Hypotheses.

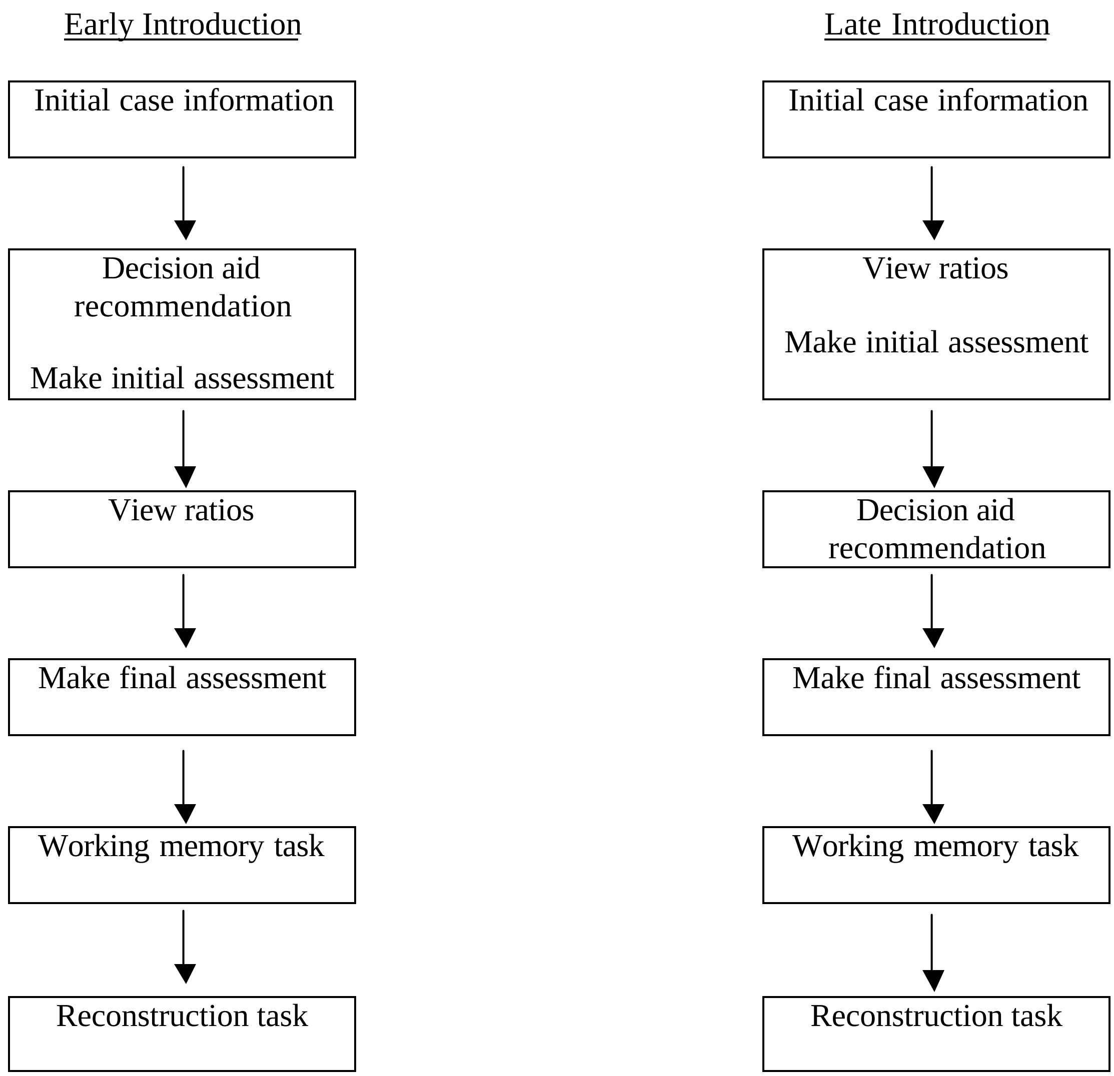


Figure 3. Sequence of Procedures – Experiment One.

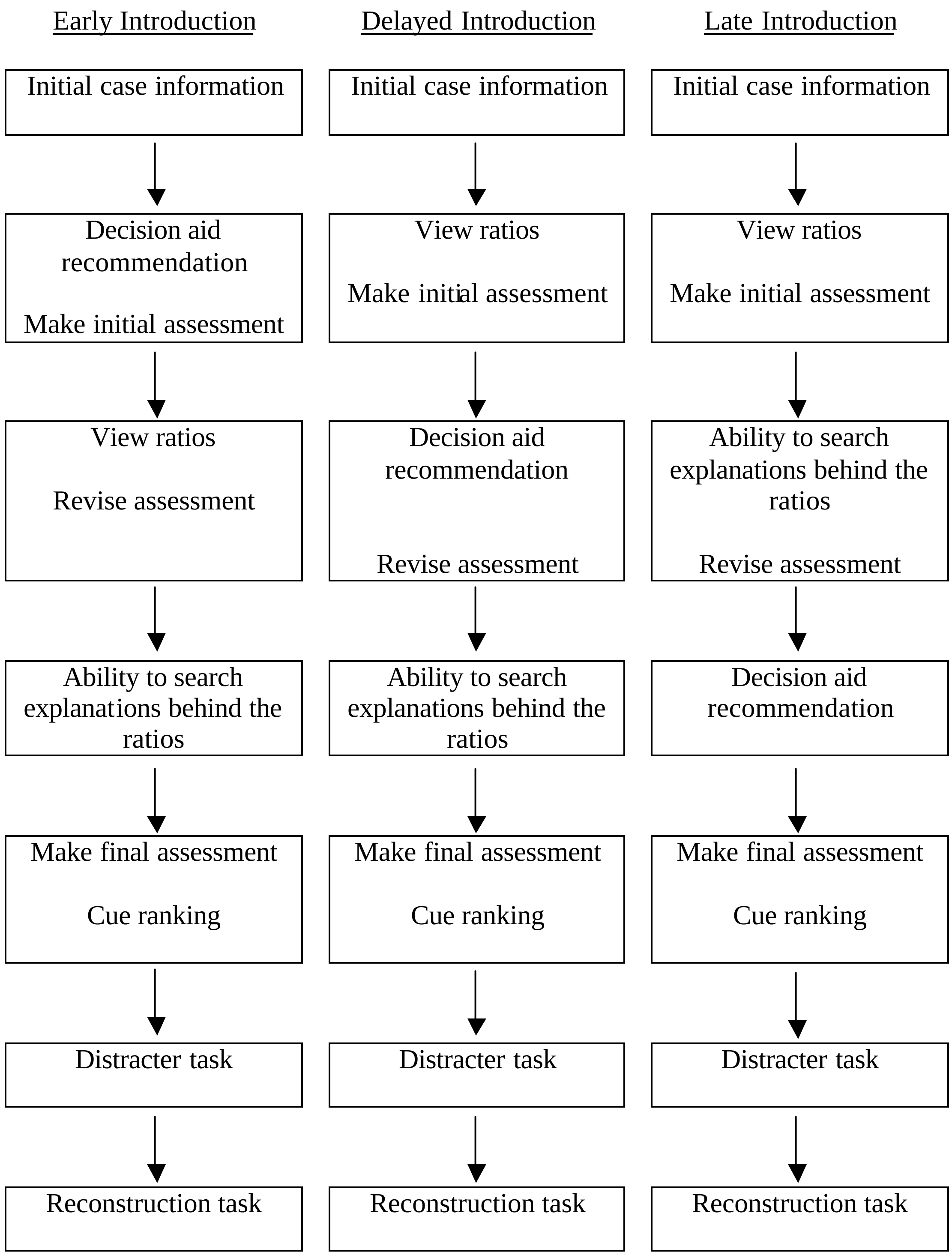
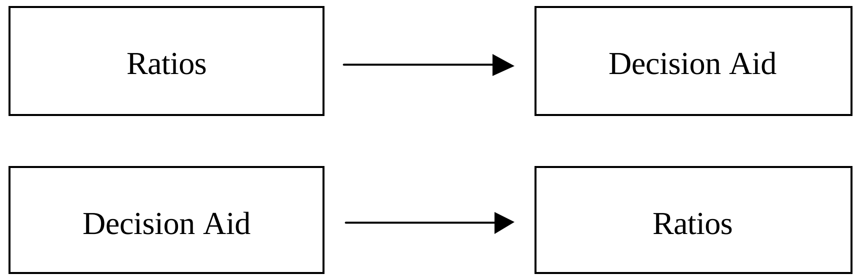
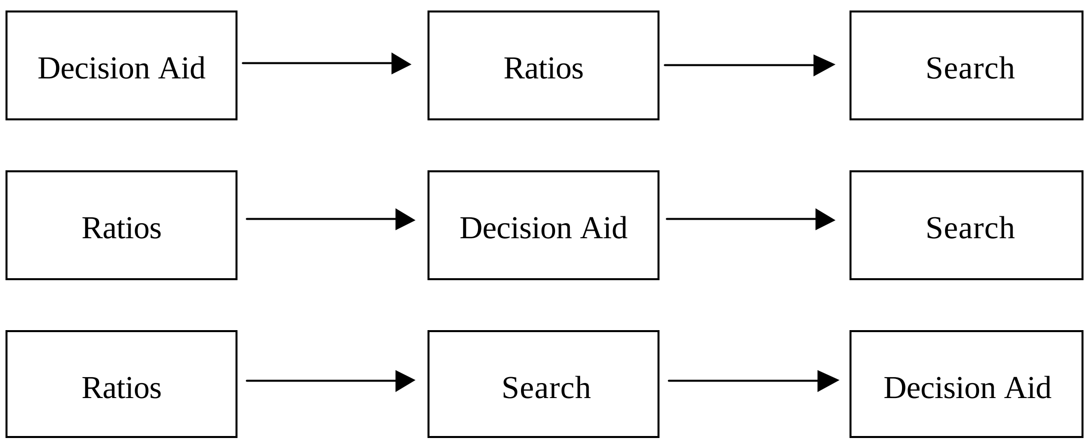


Figure 4. Sequence of Procedures – Experiment Two.



a – Experiment One.



b – Experiment Two.

Figure 5. Timing of Aid Recommendation Manipulation.

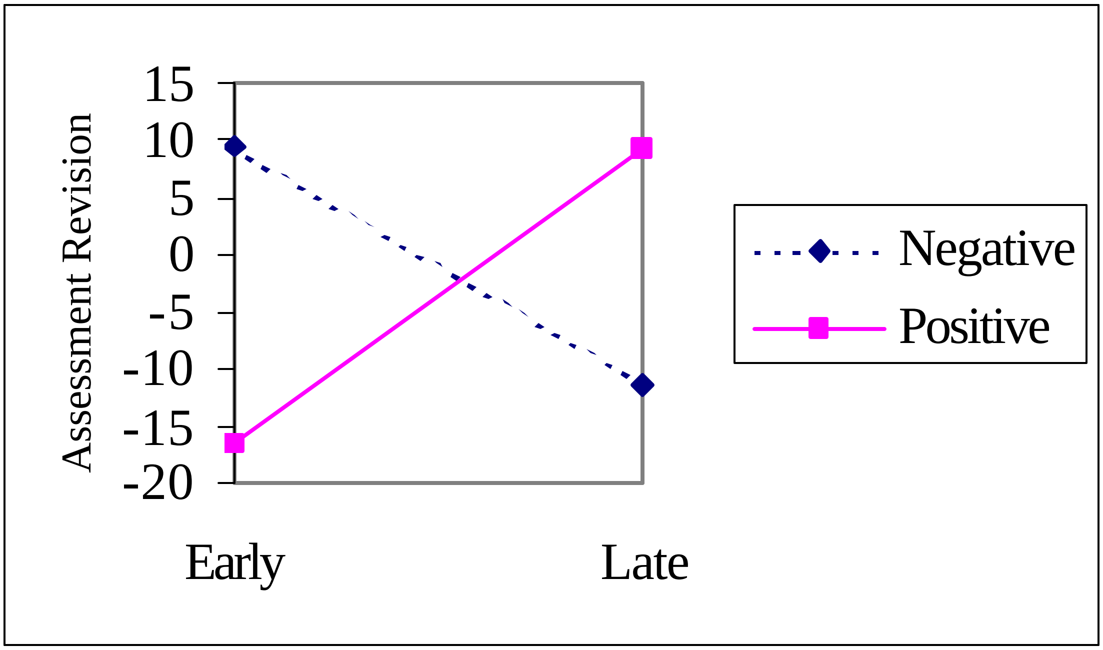


Figure 6. Effect of Aid on Assessment Revision – Experiment One.

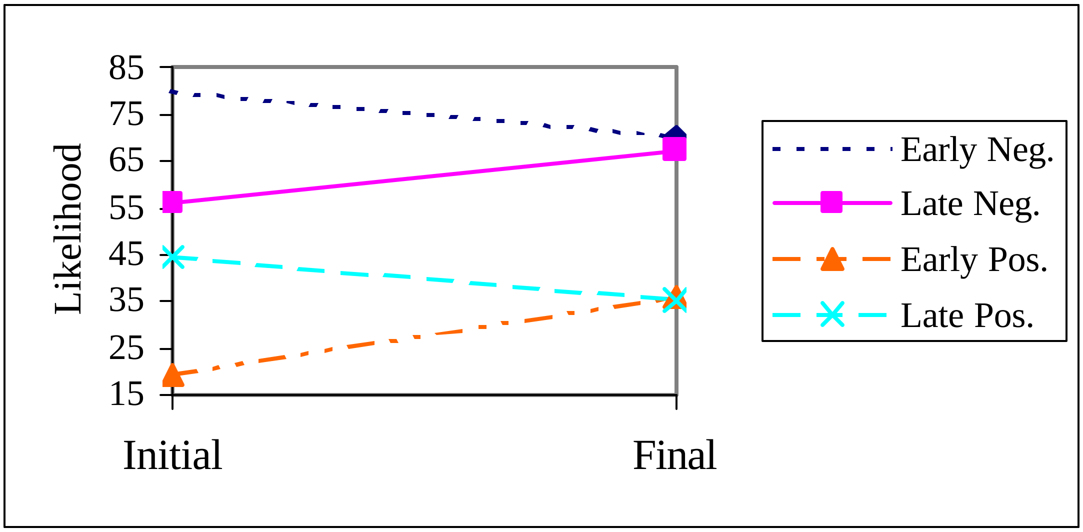
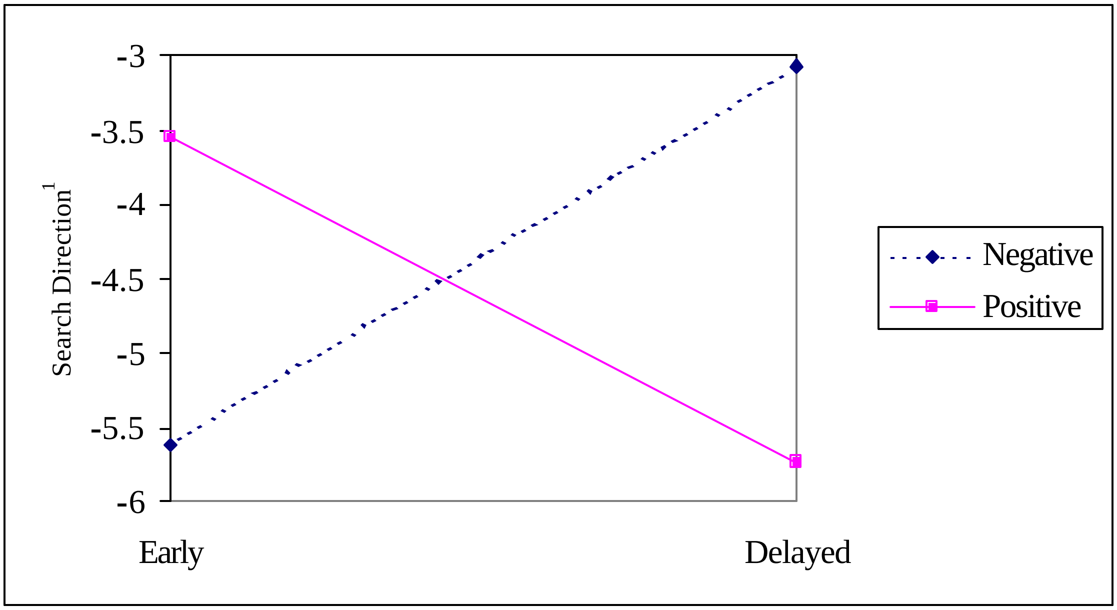


Figure 7. Likelihood Assessments – Experiment One.



[1] Search direction is the extent of the positive or negative valence of searched items accounting for the order of search in an attempt to capture the relative importance of searched items. Items searched first receive a weight of 6, items searched second a weight of 5, and so on. This yields a scale ranging from –21 to +21.

Figure 8. Effect of Aid on Search Direction Index – Experiment Two.

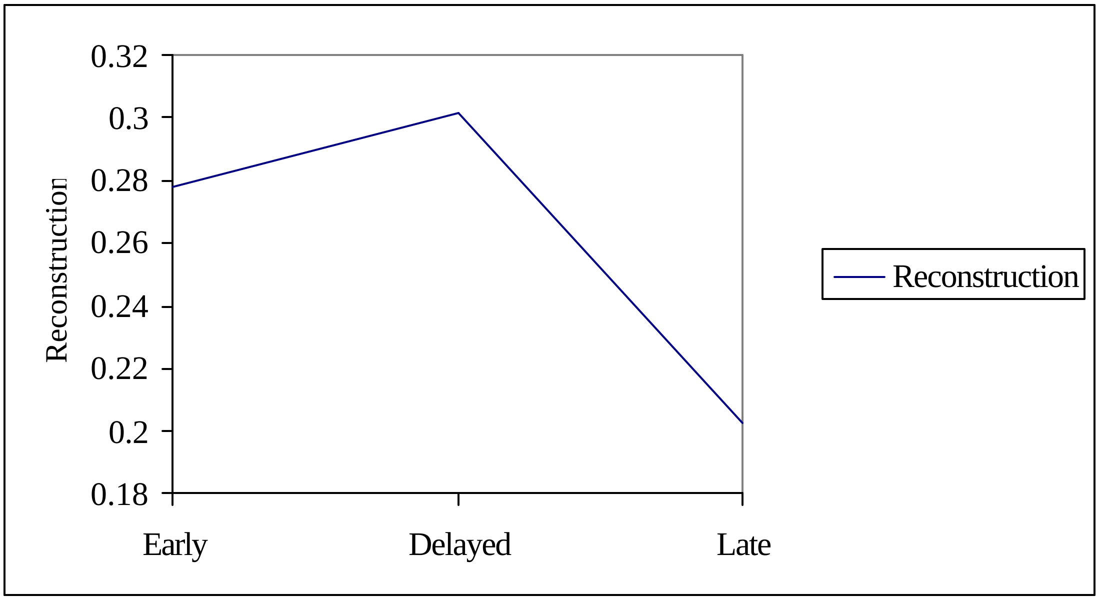
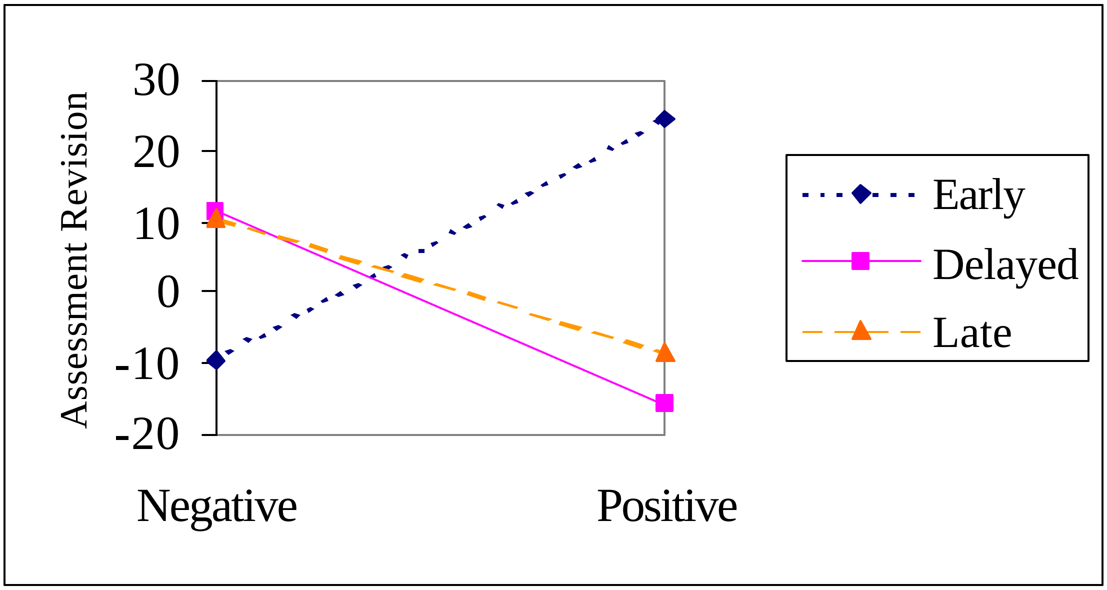
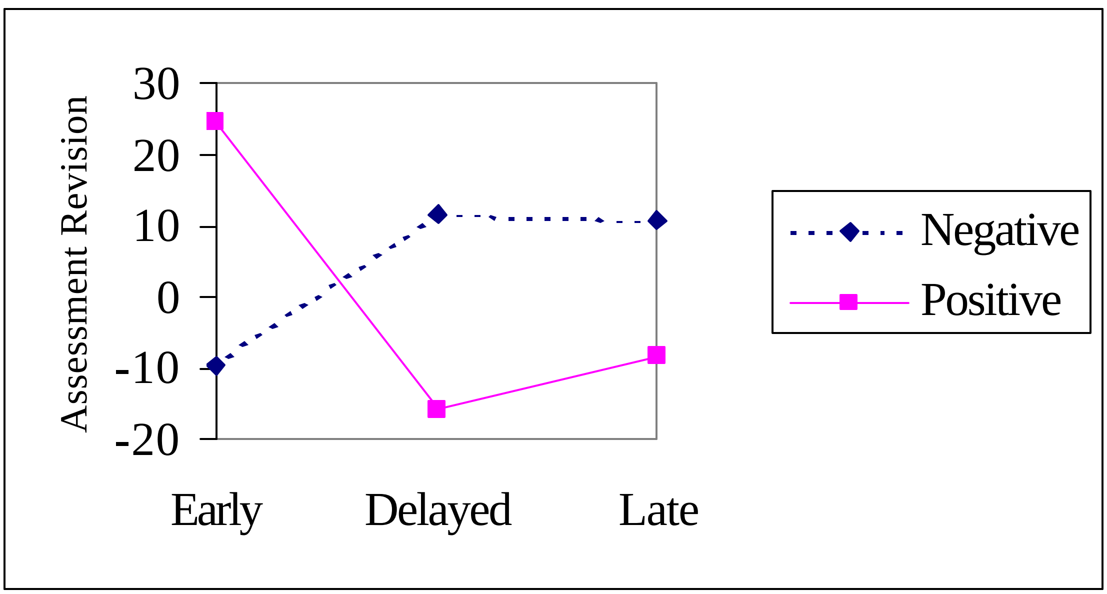


Figure 9. Effect of Aid Timing on Reconstruction – Experiment Two.



a



b

Figure 10. Effect of Aid on Assessment Revision – Experiment Two.

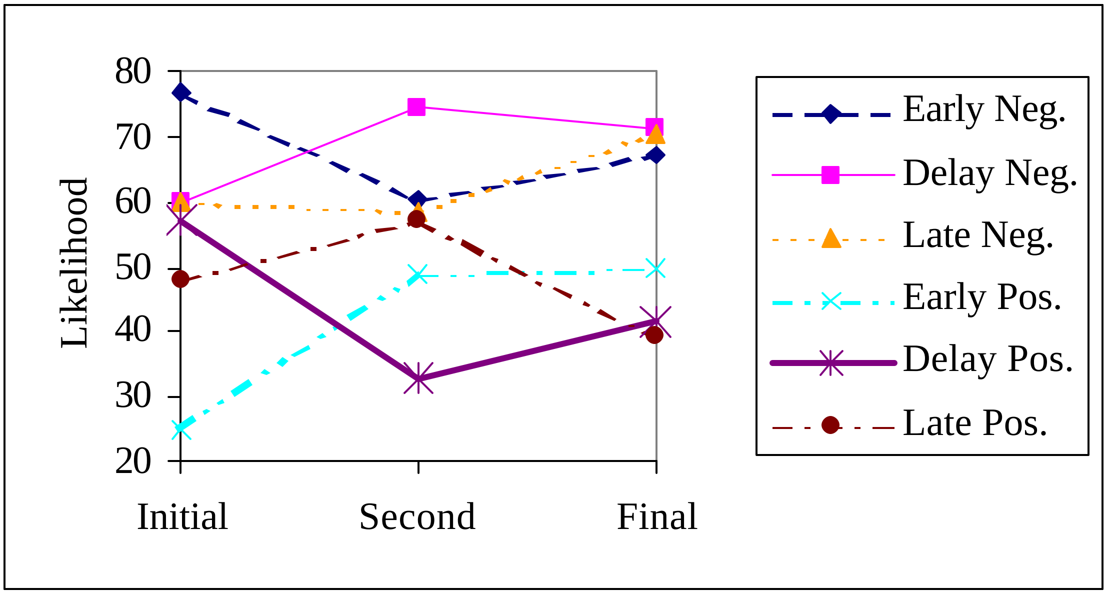


Figure 11. Likelihood Assessments – Experiment Two.

Vita

Forrest Douglas Roberts was born in Kansas City, MO and raised in Magnolia, AR, where he attended grade school through high school. He graduated from Southern Arkansas University in 1993 with a Bachelor of Business Administration in Accounting. He practiced in public accounting for two years before completing a Masters in Business Administration at the University of Arkansas at Fayetteville in 1996. Following two years with American Airlines, he attended the University of Tennessee, Knoxville and received a Ph.D. in Business Administration in 2002. Forrest will join the faculty at Appalachian State University in Boone, NC for the Fall 2002 semester as an assistant professor of Accounting.