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"Outcome ambiguity and Decision Aids: The Effect of a Decision Aid on Ambiguity Aversion in Managerial Capital Investment Decisions"

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OUTCOME AMBIGUITY AND DECISION AIDS: THE EFFECT OF A DECISION AID ON AMBIGUITY AVERSION IN MANAGERIAL CAPITAL INVESTMENT DECISIONS

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ABSTRACT: This study examines the efficacy of a decision aid in reducing managers' outcome ambiguity aversion within a capital investment decision context. Further, this study examines (1) whether the individual personality characteristic of tolerance of ambiguity (TOA) is associated with an investment decision when the outcome of that decision is relatively more ambiguous, and (2) whether TOA influences the efficacy of the decision aid. The results indicate that, overall, the decision aid was only effective in reducing outcome ambiguity aversion for low TOA subjects. When a decision aid was present, the level of ambiguity aversion exhibited by low TOA participants was significantly lower than that exhibited by high TOA participants. When a decision aid was not present, however, there was no difference in the level of outcome ambiguity aversion exhibited by participants irrespective of TOA level.

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I. Introduction

Uncertainty and ambiguity are present to some extent in nearly all capital investment decisions. Research has shown that ambiguity consistently influences choice across a variety of decision contexts (e.g., business, medicine, insurance, economics, taxes) (Camerer and Weber 1992). The expected outcomes of prospective capital investment options are rarely known with certainty, and outcome ambiguity[1], in particular, has been shown to negatively influence managers' resource allocation decisions (e.g. Ho et al. 2002, 2005; Ghosh and Ray 1997). In this study, I examine the effectiveness of a decision aid as a means of influencing managers' choice behavior in range estimate[2] (outcome ambiguous) decisions within a capital investment decision context.

In capital investment decisions managers are often faced with multiple options from which to choose on behalf of the firm. The uncertainty and ambiguity inherent in capital investment decisions can increase choice complexity and difficulty which, in turn, influences individual choice behavior (Sawers 2005). Prior research demonstrates that individuals have limited cognitive capacity. Consequently, they commonly rely on simplifying heuristics in complex decision environments (e.g. representative heuristic,

[1] "Outcome ambiguity" is defined (as in Curley and Yates, 1985, p. 274) as "uncertainty about the processes by which outcomes are determined". When estimating the return of a potential capital investment, the return could be estimated as an unambiguous 16% or could be presented as a range of outcomes (e.g. the return lies between 14 and 18%). In the latter case, ambiguity exists regarding which return will be realized.

[2] I use the term "range estimate decisions" throughout this paper to denote decisions with projected outcomes (e.g.. estimated ROI) that are ambiguous (e.g. presented as a range estimate of possible outcomes) as defined in footnote 1.

accessibility heuristic). Reliance on these heuristics has been shown to lead to both optimal and suboptimal behavior (Kahneman 2003).

Evidence indicates that, in a gain context, decision makers consistently exhibit ambiguity aversion in choice behaviors when projected outcomes are ambiguous or uncertain (see Camerer and Weber 1992 for a comprehensive review of the literature on ambiguity in decision making). This tendency towards ambiguity aversion can result in suboptimal judgments and decisions (Camerer and Weber 1992; Ghosh and Ray 1997; Ho et al. 2002; 2005) and can lead to seemingly irrational choices (e.g. the desire for additional information even when the additional information does not change the judgment or decision) (Camerer and Weber 1992).

Decision aids are often employed, both in practice and in research, as a means of guiding employee behavior and decisions in directions beneficial to the firm. (Bonner 2008). However, the effectiveness of decision aids in resolving the underlying causes of suboptimal decision making is not always clear (Bonner 2008). Although organizations may invest substantial resources in the development, implementation and utilization of decision aids, the potential benefits of decision aids are not always realized (Bonner 2008). A variety of individual and task variables can limit the effectiveness of decision aids (Bonner 2008; Glover et al. 1997). Moreover, if the underlying cause(s) of suboptimal judgments and decisions are not addressed by the aid and/or if users are resistant to relying on it, then the decision aid may not provide any benefits; thereby potentially wasting resources. (Bonner 2008).

When these underlying issues are addressed, decision aids are more likely to be effective at reducing bias in judgments and decisions (Bonner 2008). Further, in decision

contexts where outcome ambiguity may have higher salience to the decision maker, increasing the amount of structure and clarity through a decision aid may be an effective means of influencing employee choice behavior (Bonner 2008).

Individual characteristics, such as cognitive style, may also influence choice behavior (e.g. Ghosh and Ray 1992). One such individual characteristic is individual tolerance of ambiguity (TOA); which has been shown to be an important determinant of choice (e.g. Ghosh and Ray 1997; Sherman 1974). The tendency toward ambiguity aversion in range estimate decisions may be at least partially influenced by this individual characteristic (Ghosh and Ray 1997). Consequently, I also examine individual tolerance for ambiguity (TOA) to assess its association with ambiguity aversion in range estimate decisions and whether TOA influences the efficacy of the decision aid.

I conduct an experiment in which participants select between three capital investment proposals with varying levels of outcome ambiguity. All participants are provided with information about company goals (both long- and short-term) to assist in making the decision. Additionally, approximately half the participants received a decision aid used for assessing the contribution of each proposal toward achieving both the long- and short-term strategic goals of the organization. Participants then allocate points among the three capital investment proposals according to his or her relative degree of support for each project. Individual levels of tolerance of ambiguity are also measured using the MacDonald (1970) tolerance of ambiguity scale.

I predict that subjects provided with a decision aid will be less likely to exhibit ambiguity aversion in their choices; however, I find only partial support for this prediction. I also predict an association between individual levels of tolerance of ambiguity and the

selection of capital investment alternatives with higher or lower outcome ambiguity; however, I find no statistically significant association between these factors. While this could be unique to the current experiment, this may also indicate areas for further investigation. Prior research has found an association between these factors using alternative tolerance of ambiguity scales (Furnham and Ribchester 1995). Recent research assessing correlations between different TOA scales found the correlations among several scales to be somewhat low (Furnham and Ribchester 1995). This suggests that different scales may be capturing somewhat different constructs of TOA (Furnham and Ribchester 1995). Further exploration of these differences among scales may provide insight into the specific aspects of TOA, if any, that are associated with ambiguity aversion in range estimate decisions.

I also predict, and find, an interactive effect between the decision aid and individual tolerance of ambiguity levels. Specifically, the decision aid is more (less) likely to influence choice behavior when individuals measure low (high) in TOA. The results suggest that individuals low in TOA may be considerably more receptive to guidance from decision aids than are individuals measuring high in TOA.

The results of this study have implications for decision aid use and design in capital investment decisions and contribute to existing literature regarding the factors that influence decision aid effectiveness. As most accounting decisions involve some degree of uncertainty, the factors that influence these types of decisions are of particular interest to many accounting researchers (e.g., Bonner, 2008; Haka, 2007; Loewenstein, Rick, and Cohen 2008).

Prior research has established that individual choices are influenced by the presence of ambiguous information in the decision task and has identified many factors that may influence ambiguity aversion and choice behavior. I contribute to this literature by examining potential methods for reducing the influence of outcome ambiguity on resource allocation decisions.

The remainder of this paper is organized as follows: Section II provides the theoretical issues and develops the hypotheses for this study. The research methodology is described in section III, followed by the results in Section IV. Section V summarizes the results and discusses implications, limitations and directions for future research.

II. Theoretical Issues and Hypothesis Development

Decision Making Processes and Outcome Ambiguity

Prior research has demonstrated that individuals do not always behave rationally. The concept of bounded rationality encompasses the idea that individuals are rational, but that they do not always make rational decisions as a result of cognitive limitations (Kahneman 2003). Consequently, decision makers frequently rely on shortcuts or heuristics to assist them in making decisions. Though these heuristics can lead to normatively correct decisions, they have also been shown to lead to errors and biases in judgment. Errors and/or biases in judgments and decisions may result in managerial decisions that are inconsistent with the long-term interests of a firm (e.g., Ho and Vera-Munoz, 2001; Ghosh and Ray, 1992, 1997).

Ambiguity is one factor that has consistently been shown to influence choice behavior (e.g. Ellsberg 1961; Einhorn and Hogarth 1986; Viscusi and Magat 1992; Ghosh

and Ray 1997; Ho et al. 2002). In a seminal study, Ellsberg (1961) examines choice behavior related to ambiguity. In a choice between two items that are identical except for the degree of ambiguity in the probabilities, he finds that people tend to choose the option with lower ambiguity. Later studies have also found ambiguity aversion (Einhorn and Hogarth 1986; Viscusi and Magat 1992) and even that people will pay a premium to avoid ambiguity (Camerer and Weber 1992; Becker and Brownson 1964).

The precise mechanisms through which ambiguity aversion influences decisions remains unclear (Loewenstein et al. 2008; Camerer and Weber 1992); however, most proposed explanations incorporate a difference in the salience of the ambiguous information to the decision maker (Loewenstein et al. 2008; Du and Budescu 2005). Alternative explanations include the application of heuristics such as "avoid betting when other people possess information you lack or when you lack information that will be helpful in decision making" (Loewenstein et al. 2008; Du and Budescu 2005).

This increased salience of ambiguous information can lead decision makers to selectively focus on a small subset of information in the decision task. Selective attention has been shown to influence framing, goal elicitation, evidence accumulation, and judgment and choice (Kahneman 2003). Ross (1989) finds that when ambiguity is higher, subjects take longer to make a decision and focus on less relevant aspects of the information. Further, he provides evidence that as ambiguity increases decision makers' attention increasingly shifts from good outcomes (gains) to bad outcomes (losses).

Selective attention influences the way that decisions are made and the options that are selected (Krantz and Kunreuther 2007; Weber and Johnson 2009). Several studies suggest that changing the salience of the information will alter the decision maker's

tendency to select ambiguity averse options (e.g. Du and Budescu 2005; Ho, Keller, and Keltya 2002). Ho et al. (2005) examine the influence of outcome ambiguity and irrelevant information on capital budgeting decisions and find that in a gain context, managers select investments that do not maximize firm value. To ensure that managers at various levels of the organization are focusing on the factors that the organization finds most relevant to capital investment decisions, Ho et al. (2005) suggest implementing systems that explicitly state the items to consider throughout the capital budgeting process. Together, these research findings suggest a decision aid designed to refocus attention on all salient aspects of the decision may be an effective means of reducing aversion to outcome ambiguity in managerial decision making.

Decision Aids

Decision aids are widely employed in practice and in research as a means overcoming biases in individual judgments and decision making (Bonner 2008; Sawers 2005; Larrick 2004). Decision aids can improve cognitive processes and create more structure in tasks leading to less complexity and higher quality judgments and decisions (Bonner 2008).

Companies may invest substantial resources in the development, implementation and utilization of decision aids. However, prior research has demonstrates that the potential benefits of decision aids are not always realized. A variety of individual and task variables can limit the effectiveness of decision aids (Bonner 2008; Glover et al. 1997). Moreover, if the underlying cause(s) of suboptimal judgments and decisions are not addressed by the aid and/or if users are resistant to relying on it, then the decision aid may not provide any benefits; thereby potentially wasting resources. (Bonner 2008).

Decision aids which have addressed these problematic issues have been shown to be effective. Specifically, evidence suggests that decision aids may reduce the effects of many biases that influence decisions under risk and uncertainty (Ghosh & Crain 1993; Mackay et al 1992). In a capital investment decision context, Sawers (2005) examines the effectiveness of a decision aid in overcoming decision avoidance in complex and uncertain decision environments. The decision tool utilized was designed to promote a problem-focused (versus emotion-focused) approach to decision making in order to overcome choice avoidance associated with negative affect. This aid was found to be effective in overcoming decision avoidance for tasks in which negative emotional responses to choice difficulty would normally lead to choice avoidance. However, this study did not evaluate whether or not the aid was effective in overcoming ambiguity-averse choice behavior or other biases in the actual decision.

In another study, Slovic and Tversky (1974) examine whether providing information about ambiguity aversion and alternate decision techniques is an effective aid to reducing ambiguity aversion in choice behavior. Despite receiving this information aid, the majority of subjects still selected the ambiguity-averse option. However, research has shown that instructions or warnings of this nature are generally ineffective at improving choice behavior (Fischhoff 1982; Arkes 1991). The reason for this may be that, while the decision maker becomes aware of the potential bias, the aid does not address the underlying cognitive error or bias (Bonner 2008).

The decision aid used in my study is directly linked to company strategic objectives as suggested in prior research (e.g. Ho et al. 2005; Kaplan and Norton 2004, 2006). In addition, the aid provides structure, yet is simple and user-friendly. Further, the aid assists

the user in decomposing the essential elements of each investment option according to the impact on the organizations strategic objectives. Each of these decision aid elements (e.g. ease of use, structure, decomposition, links to strategic objectives) have been shown to increase the usefulness and effectiveness of decision aids (Bonner 2008).

Decision aids that enhance the use of accounting information or that refocus the decision maker's attention on the most salient decision elements, while still allowing for flexibility and user input, may be an effective way to influence employee behavior in desired directions (Bonner, 2008; Glover et al. 1997). As mentioned previously, the decision bias induced by ambiguous outcomes may be particularly receptive to correction through the use of decision aids that alter the salience of important decision elements. Increasing the amount of structure and information clarity, particularly in decision contexts where outcome ambiguity may have higher salience, can be an effective means of reducing decision bias in complex or difficult decisions making environments (Bonner 2008).

Taken together, this research suggests that a decision aid may be an effective means of redirecting attention from an over-emphasis on ambiguous outcomes to a more complete focus on the organizations' long- and short-term strategic goals. This method may reduce task complexity, a factor associated with ambiguity in choice options, and reduce the effort and uncertainty involved in the decision making process. Therefore, I expect that subjects provided with a decision aid will make decisions dominated more by company strategic objectives and less by aversion to outcome ambiguity. This leads to my first hypothesis:

H1: Subjects provided with a decision aid will exhibit less ambiguity aversion in range estimate decisions compared to subjects without a decision aid.

Tolerance of Ambiguity

In addition to task characteristics, individual decision maker characteristics, such as cognitive style, can influence choice behavior (e.g. Ghosh and Ray, 1992). Individual attitude toward ambiguity is one such factor that has been shown to be an important determinant of choice (e.g. Ghosh and Ray 1992, 1997). The general tendency toward ambiguity-averse choice behavior in range estimate decisions may be at least partially influenced by this factor of individual differences in tolerance of ambiguity (TOA).

TOA has been described as both a cognitive orientation and a stable personality trait (e.g. Furnham & Ribchester, 1995; Bonner, 2008) and defined as the degree to which individuals perceive ambiguous situations or stimuli as desirable. Ambiguous situations or stimuli involve unfamiliar, complex, or incongruent cues that are difficult to structure or categorize (Budner, 1962; Furnham & Ribchester, 1995). Individuals who are low in TOA tend to avoid ambiguous stimuli, tend to seek supportive rather than objective information, and have a greater need for clarity (Furnham & Ribchester, 1995). High TOA individuals, on the other hand, tend to see ambiguous situations as desirable, stimulating, and challenging (Furnham & Ribchester, 1995).

Sherman (1974) examines the relationship between individual TOA and ambiguity aversion in range estimate decisions (referred to as "decision-theoretic ambiguity aversion" in his study) and finds a modest correlation between the two. Ghosh and Ray (1997) also examine this relationship in a different context and find that individual levels of TOA determine choice behavior in range estimate decisions. Thus, I expect that individual TOA levels will influence ambiguity-averse choice behaviors in capital investment decisions. Specifically, I expect that individuals low in TOA will exhibit

greater ambiguity aversion in choice behavior in range estimate decisions relative to individuals high in TOA. This leads to my second hypothesis:

> **H2:** Individuals measuring relatively low in tolerance of ambiguity will be more likely to select ambiguity-averse choice options in a range estimate decision compared with individuals measuring relatively high in tolerance of ambiguity.

Tolerance of Ambiguity and Decision Aid Interaction

Individual TOA can influence how investment options are framed (Ghosh and Ray, 1992). A decision aid can guide the decision maker in more appropriately framing the decision; thereby reducing uncertainty and adding clarity to the decision evaluation process (Bonner, 2008). However, a decision aid may differentially affect low and high TOA individuals.

Individuals low in TOA have a tendency to "resort to black-and-white solutions" (Frenkel-Brunswik, 1949) and tend to have a greater need for clarity (Furnham and Ribchester, 1995). In addition, low TOA individuals tend to see ambiguous situations as threatening (e.g. Budner, 1962; Furnham and Ribchester, 1995; Liedtka et al. 2008). Consequently, these individuals may be more receptive to elements in the task environment, such as a decision aid, that assist in the minimization or elimination of the perceived threat. Therefore, I expect that low TOA individuals will be more likely to be influenced by a decision aid in range estimate decisions.

Ghosh and Ray (1997) find that individuals who are less risk averse and have more TOA tend to have greater confidence in their choices. Greater confidence in choices is associated with less willingness to rely on a decision aid (Bonner, 2008). In a study within an investment decision context, Nelson et al. (2003) find that confidence is negatively

related to reliance on a decision aid. Therefore, to the extent that high TOA individuals have more confidence in decisions, I expect high TOA individuals to be less likely to be influenced by a decision aid in range estimate decisions. This leads to my third hypothesis:

> **H3:** A decision aid will be more likely to mitigate the effect of outcome ambiguity aversion in subjects measuring low in individual tolerance of ambiguity relative to those measuring high in individual tolerance of ambiguity.

III. Research Design and Experimental Method

Participants

Participants in this study were 80 MBA students enrolled in evening courses at a major university in the United States. Descriptive statistics for the sample are included in Table 1. Approximately 75% percent of the participants in this experiment were male. The average ages of participants were 31 years and 29 years for males and females, respectively. Subjects came from a variety of backgrounds: engineering, information systems / technology, management, finance and other fields.

[Insert Table 1 here.]

Task

Participants assumed the role of a member of the Investment Committee of a publicly held corporation. The committee had responsibility for selecting which of several investment proposals would receive funding. Information about company goals was provided as criteria for evaluating each investment proposal. The main criterion was the long-term corporate goal of increased shareholder value. Participants were told that

the company has implemented a Balanced-Scorecard (BSC) Management philosophy and recognizes simultaneous advancement in each of four operational categories (Learning & Development, Internal Processes, Customer Value, and Financial Performance) as essential for achieving and sustaining the long-term goal of increased shareholder value.

Following this narrative description of the evaluation guidelines, subjects were provided with a table summarizing the corporate long- and short-term goals, as follows:

Long-Term Goal:	Increased Shareholder Value
Short-Term Goals:	Learning & Development (HR) Internal Processes (Operations) Customer Value (Marketing) Financial Performance

Participants were instructed to consider contributions to all categories in selecting which investment proposal most merits funding. In addition, participants were provided with the corporate strategy map of company goals and antecedents. The strategy map further emphasized visually the causal linkage between each of the four short-term operational goals and the creation of long-term shareholder value.

After the description of company goals and strategy, detailed information was provided for each of three investment proposals. Each proposal was described in narrative form, including information regarding how elements of each proposal would contribute to any of the BSC strategic goal categories. Each proposal required an equal amount of funding from the firm.

Each proposal description was followed by a table showing return on investment (ROI) projections for each year of the project for the first 5 years after project

implementation. The yearly ROI projection for each proposal was presented as a range (i.e. 6 – 8 %).

Each proposal had the same projected return on *average* for each of the five years; however, there was increasingly greater variation in the range of projected returns between project proposals. Additionally, return variation increased from year to year with more variation in later years and the greatest variation in proposal three. Proposal three was also designed to have the greatest alignment with and contribution toward the multiple strategic goals of the company. In other words, proposal three was designed to have the greatest merit in terms of the overall strategic goals of the company in the long-term, but potentially be unappealing in the range or ambiguity of short-term financial outcomes. Pilot tests were conducted to confirm that this manipulation functioned as planned.

After reviewing each of the investment proposals, participants were instructed to allocate 100 points among the three investment proposals to indicate the degree to which they believe each proposal merits funding. A higher number of points allocated to a proposal indicates greater relative support for funding the proposal.

Decision Aid

Approximately half (38) of the participants were provided with a decision aid as part of the case materials. Before allocating points among the three investment proposals, participants provided with a decision aid were asked to assess the contribution of each investment proposal to the organization's short- and long-term strategic goals and then rank each proposal on each of the four balance scorecard criteria.

TOA Scale

Subjects also completed the MacDonald (1970) tolerance of ambiguity (TOA) scale. The scale consists of 16 statements designed to measure the degree to which an individual is tolerant of ambiguity. Participants responded to questions on a 7-point scale with 1 indicating strong agreement with the statement and 7 indicating strong disagreement with the statement. Participant responses were coded and combined to create a TOA score, which was split at the mean to create a dichotomous variable indicative of relative levels of tolerance of ambiguity (high or low).

Independent Variables and Covariate

I include one independent variable (decision aid use) and one measured variable (tolerance of ambiguity) in this study. Decision aid use was manipulated at two levels (decision aid, no decision aid). Tolerance of ambiguity was measured as described above and included in the model as a dichotomous variable (low, high).

Dependent Variable

The dependent variable in this study is participant capital investment proposal recommendations. Participants were asked to allocate points between three investment proposals according to the relative degree to which they believe each project warrants funding. The question of interest in this study is whether subjects will be more likely to indicate relatively greater support for the more ambiguous investment option when a decision aid was provided. Therefore, the dependent variable was operationalized as the percentage of total points participants allocated to proposal three.

IV. Analysis and Results

To test the hypotheses I use a 2x2 ANOVA design. Table 2, panel A, reports the ANOVA results using the percentage of points allocated to Project 3 as the dependent variable. Recall that Project 3 was the capital investment proposal with the widest range estimate/highest outcome ambiguity. The independent variables are decision aid use (decision aid, no decision aid) and tolerance of ambiguity (low, high).

[Insert Table 2 here]

H1 and H2 predicted a main effect for decision aid use and tolerance of ambiguity, respectively, on ambiguity-averse investment selection in range estimate decisions. As shown in Table 2, no statistically significant main effect is found for decision aid use ($F=2.079$, $p = 0.153$) or for tolerance of ambiguity ($F = 1.151$, $p=0.287$). Thus, H1 and H2 are not supported.

Hypothesis 3 predicted an interactive effect for TOA and decision aid use on ambiguity aversion in range estimate decisions. Specifically, I expect that subjects low in TOA would be more likely to be influenced by the decision aid and this would be reflected in the relative support given to each project. As shown in Table 2, panel A, the ANOVA results indicate a significant interaction between TOA and decision aid use ($F = 5.045$, $p = .028$). Panel B of Table 2 presents the least-squares means of points.

As expected, the decision aid significantly influences low TOA subjects to choose the more desirable, albeit ambiguous, capital investment project. High TOA subjects, in contrast, are not significantly affected by the decision aid. The relationship between the

estimated means is depicted in Figure 1. The mean points allocated to Project 3 for low TOA subjects without a decision aid was 28.826, while the mean points allocated for low TOA subjects with a decision aid was 42.941. The difference between these means is statistically significant ($F = 5.688$, $p=.022$). For subjects high in TOA, the mean points allocated were 33.316 and 30.238, respectively, for subjects with a decision aid and subjects without a decision aid. The difference between these is not statistically significant ($F = 0.4$, $p = .531$).

A comparison of means between high and low TOA subjects further illustrates the difference in the influence of the decision aid. Examining the means for subjects without a decision aid, the mean points allocated for low TOA subjects was 28.826 and for high TOA subjects was 33.316. The difference between these was not statistically significant ($F = 0.851$, $p = .362$). For subjects with a decision aid, the mean points allocated by low TOA subjects was 42.941 and for high TOA subjects was 30.238. The difference between these means is statistically significant ($F = 4.501$, $p=.041$).

Taken together, these results provide support for H3: not only is choice behavior for subjects low in TOA significantly influenced by the decision aid, but these subjects appear to be influenced by the decision aid to a greater degree compared to subjects high in TOA.

Additional Analysis

Because it is possible that points allocated to each project may not fully capture differences in relative support for each project, I conduct supplementary analysis. The points allocated to each project indicate each person's relative support for each of the three capital investment decisions. However, the same number of points allocated to a project

by two different subjects might indicate relatively different levels of support. For example, one subject could allocate 40 points to Project 3, 50 points to Project 2, and 10 points to Project 1. This would indicate relatively greater support for Project 2. Another subject might allocate the same 40 points to Project 3, but allocate 30 points to Project 2 and 30 points to Project 1. The second scenario would indicate relatively greater support for Project 3.

To capture whether decision aid use is associated with a greater likelihood that Project 3 was rated the highest, I use logistic regression with *OPTION CHOICE* (high ambiguity Project 3 vs. lower ambiguity Projects 1 and 2) as the dependent variable and decision aid (no decision aid vs. decision aid) as the independent variable. Both the logistic regression ($\chi^2(1) = 3.111$, $p = .078$) and the coefficient for decision aid ($p = 0.082$) were marginally significant (results not tabulated). Similar tests were conducted for TOA, but no significant results were found.

V. Discussion and Conclusion

This analysis was conducted to learn how decision aids can influence ambiguity-averse choice behavior in range estimate decisions within a capital investment context. The results of this analysis show that, as a method for overcoming ambiguity-averse choice behavior in capital investment decisions, a decision aid was only effective for a subset of participants. Specifically, participants measuring low in TOA appear to be significantly more receptive to decision aid guidance, compared to subjects high in TOA. No statistically significant association was found between the TOA personality trait measure and ambiguity-averse choice behavior in range estimate decisions. In other words, while both groups (high TOA, low TOA) seemed equally

prone to ambiguity-averse choice behavior in the no decision aid condition, only the low TOA subjects appear receptive to choice correction in the decision aid condition.

This finding highlights potential areas for future research regarding effective decision guidance methods, particularly for people who measure high in TOA. Although some studies have found an association between the TOA personality trait and ambiguity-averse choice behaviors when making range estimate decisions, other studies (including this one) have not. Several reasons for these different findings may exist, such as omitted correlated variables in the analysis or the use of different psychometric scales for measuring TOA. However, recent research suggests that even when observed choice behaviors are similar in high- and low-TOA individuals (as was the case in the no decision aid condition of this study), different cognitive processes may underlie that choice behavior for each group. Pushkarskaya et al. 2010 examine brain activation patterns related to different types of ambiguity and uncertainty in decision tasks and test whether those brain activation patterns are consistent with current theories of decision making. They find that the patterns are consistent only in subjects who are low in tolerance of ambiguity.

These differences in cognitive processing, even when actual choice behaviors are similar, may indicate a need for different decision guidance in tasks involving ambiguity and uncertainty. Future research could examine these issues and whether more sophisticated decision support systems can accommodate these differences effectively.

This study contributes to the literature on the influence of individual differences in capital investment decision making and decision aid effectiveness. The results highlight the importance of some personality traits in designing effective aids to judgment and decisions. The current study also contributes to the growing accounting literature

examining the influence of outcome ambiguity in capital investment decisions and the factors that influence ambiguity-averse choice behaviors in this setting. Additional research is needed to more completely understand the relationship between outcome ambiguity, ambiguity aversion, and decision aid effectiveness.

While this study provides additional insights into decision aid effectiveness, there are several limitations. First, this study was conducted using MBA students as surrogates for managers. In decentralized firms, managers at various levels of the organization are involved in the capital budgeting process; however, more experienced managers may have different incentives and may incorporate organizational strategy more fully into their decisions.

Second, this study was conducted in an experimental setting and tasks elements were necessarily simplified to accommodate the experimental setting, time constraints, and the need to isolate specific variables of interest. Real-world capital budgeting decisions are much more complex and involve greater quantities of information.

Third, the use of a different psychometric scale for measuring TOA in this study compared to some prior research studies makes it difficult to compare results across studies. Some prior research has found an association between the TOA personality trait and ambiguity-averse choice behaviors using TOA scales different from the one employed in this study (Furnham and Ribchester 1985). Although an absence of this finding (i.e. an association between TOA and ambiguity-averse choice behaviors) in the current study could be due to differences in task and environmental variables, it may also be due to the TOA scale utilized. Research assessing correlations between the different scales suggests that somewhat different constructs may be captured by each. Further exploration of

differences in constructs captured with these alternative scales could provide more insight into possible associations between TOA and ambiguity-averse choice behaviors.

The results of this study have implications for decision aid use and design in capital investment decisions and contribute to existing literature regarding the factors that influence decision aid effectiveness. Most accounting decisions involve some degree of uncertainty and an understanding of the factors that influence these types of decisions is important for improving judgment and decision making quality (Bonner, 2008; Haka, 2007; Loewenstein et al. 2008). Prior research has established that individual choices are influenced by the presence of ambiguous information in the decision task and has identified many factors that may influence ambiguity aversion and choice behavior. I contribute to this literature by examining a potential method for reducing the influence of outcome ambiguity on choice behavior in resource allocation decisions.

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TABLES

Table 1
Descriptive Statistics

	Males	Females
Number	59	21
Mean Age	31 years	29 years
Background:		
Engineering	14	
Info Systems/Technology	12	
Management	12	
Finance	13	
Other	29	

Table 2

Panel A: ANOVA on Points[a]

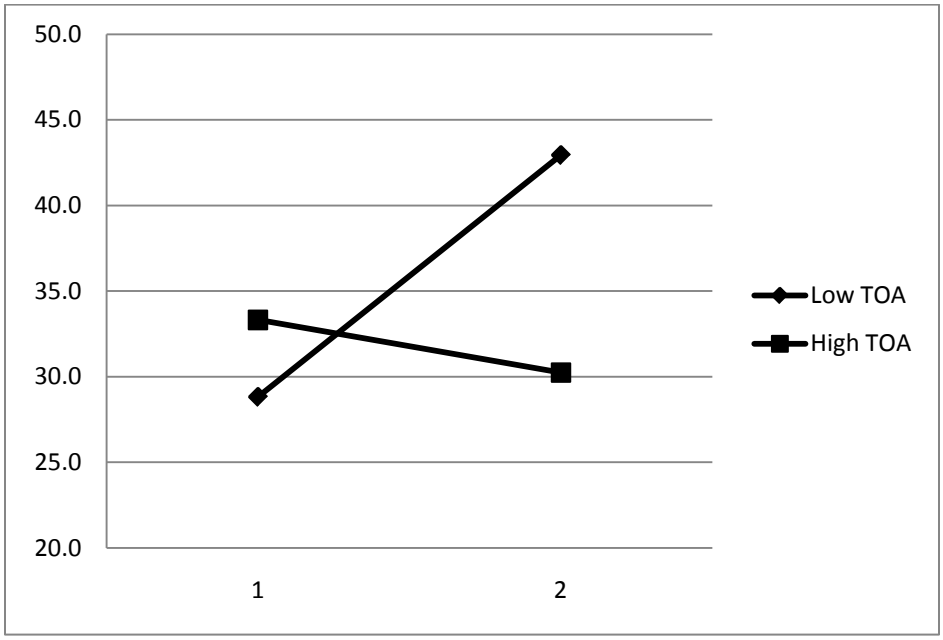
Source of Variation	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2237.327	3	745.776	2.578	.060
Intercept	90405.306	1	90405.306	312.534	.000
DECAID	601.445	1	601.445	2.079	.153
TOASplit	333.048	1	333.048	1.151	.287
DECAID * TOASplit	1459.335	1	1459.335	5.045	.028
Error	21984.160	76	289.265		
Total	112733.000	80			
Corrected Total	24221.488	79			

Panel B: Least Squares Means: Points

	Decision Aid		
	No	**Yes**	
TOA	**n = 42**	**n = 38**	
Low	28.826	42.941	35.884
High	33.316	30.238	31.777
	31.071	36.590	

[a] Percentage of points allocated to Project 3 (high ambiguity project).

Figure 1: Estimated Marginal Means of Points



1 = No Decision Aid
2 = Decision Aid