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John Anderson and Damon Fleming

*Full Length Research Paper*

# Analytical procedures decision aids for generating explanations: Current state of theoretical development and implications of their use

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The use of decision aids could potentially improve auditor's decision making by assuring that the correct hypothesis is available for the auditor to consider when employing analytical procedures. Previous research has shown that auditors have limited ability to generate error explanations on their own. The purpose of this study is to synthesize the literature for the development of decision aids for generating explanations for analytical procedures, and validate an important finding of the literature, in light of criticism that a previously found effect may be due to a potential flaw in the experimental design. As predicted by interference theory and availability theory, the results confirm that the proportion of error vs. non-error explanations in the design of the decision aid can significantly impact the auditor's assessment of the likelihood that the cause of a ratio fluctuation is due to error or irregularity, with implications on audit effectiveness.

**Key words:** Analytical procedures, decision aid, audit judgment.

## INTRODUCTION

Auditing standards (Public Company Accounting Oversight Board (PCAOB), 2010; American Institute of Certified Public Accountants (AICPA), 1988) require that auditors apply analytical procedures in the conduct of an audit. The purpose of analytical procedures decision aids is to assist the auditor in determining the possible error explanations that may be associated with unusual fluctuations in relationships of account information with financial indicators, economic indicators, or operating indicators. Preliminary analytical procedures can assist the auditor in planning the audit to identify and direct unusual fluctuations in these relationships. Previous

research has utilized a diagnostic model to explain how auditors examine unusual fluctuations in analytical procedures (Libby, 1985; Libby and Frederick, 1990; Heiman, 1990; Koonce, 1993). In this diagnostic model, auditors' generate hypotheses to explain the unusual fluctuations. Auditors search for information is then guided by their available hypotheses. Previous research has examined factors affecting auditors' ability to self-generate analytical procedures explanations (e.g. Anderson et al., 1992). However, there has been limited research in the use of decision aids to assist auditors in the generation of analytical procedures

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explanations. Heiman (1990) found that experienced auditors as well as inexperienced auditors have difficulty retrieving frequently occurring error hypotheses without assistance. The use of decision aids could potentially improve auditor's decision making by assuring that the correct hypothesis is available for the auditor to consider when employing analytical procedures. However, research has shown that decision aids may have dysfunctional effects (Fischhoff et al., 1978; Purvis 1987; Pincus 1989; Kachelmeir and Messier 1990). Bamber et al. (1995, 75) noted that decision aids often lack a theoretical foundation.

Biggs et al. (1995) discuss the importance of considering interference and availability theory in analytical procedures judgement research. Anderson et al. (1997) built upon Anderson et al. (1992) by considering auditors' use of an analytical procedures decision aid in assessing the likelihood that the cause of a significant fluctuation in inventory turnover was due to error/irregularity or non-error. Anderson et al. (1997) found that auditors using a decision aid that was biased towards error explanations were more likely to assess that the probability of the cause of the inventory turnover ratio fluctuation was due to error. However, consistent with Anderson et al. (1992), the finding of availability was asymmetric, whereby an error biased decision aid raised the assessment of the probability of error as the cause for the fluctuation, whereas a non-error biased list did not lower the assessment of the probability of error as the cause for the fluctuation. This finding is consistent with the concern for audit effectiveness and avoiding potential lawsuits from failure to find an error/irregularity as the cause of a fluctuation which led to a material misstatement in the financial statements. However, Hermanson (1997) argues that the significant finding of the effect of availability from the use of a biased decision aid in Anderson et al. (1997) may be due to a demand effect created by the use of a repeated-measures design in the study. The purpose of this study is to examine the effects of interference and availability in the use of decision aids for early-stage auditors and validate the findings of Anderson et al (1997) by using a between-subjects research design to overcome the limitations in the research design noted by Hermanson (1997).

We conducted an experiment in which 107 graduate accounting students (as proxies for early-stage auditors) evaluated the financial statements and other information for a fictitious company that had a significant decrease in its inventory turnover ratio. Participants were either provided an error-biased decision aid, a nonerror-biased decision aid, or no decision aid in the study materials. The task was to assess the probability that the change in inventory turnover was associated with (1) accounting errors or irregularities or (2) nonerrors. We employed the same case materials that were used in Anderson et al. (1997) to isolate the judgment effects associated with our

sample and research design. Results show that early-stage auditors provided with an error-biased decision aid reported a significantly higher probability of an error for the change in inventory turnover than when no decision aid was provided. Additionally, auditors provided with a nonerror-biased decision aid did not report a significantly higher probability of a nonerror for the change in inventory turnover than when no decision aid was provided. This study contributes to the auditor judgment literature in several ways. First, we provide current evidence on the influence of the design of decision aids on the application of preliminary analytical procedures. Secondly, we show the effects of error-biased decision aids for early-stage auditors, providing further research evidence on the importance of gaining a more comprehensive understanding of judgment and decision making concerning analytical procedures. Finally, our results using a between subjects research design are consistent with Anderson et al. (1997), thereby addressing the concerns raised by Hermanson (1997) and providing clarity to the extant literature on the effects of error-biased decision aids on auditor judgment. The rest of this paper is organized into four sections. The first section presents the literature review and hypothesis development. The second section describes the data and research methods. The third section reports the results, and the final section provides a conclusion and suggestions for future research.

## Hypothesis development

### Availability theory and interference theory

Availability theory predicts that the more easily a subject can recall classes of instances or associations, the higher the estimate of frequency or probability for that class (Tversky and Kahneman, 1973). In the context of analytical procedures judgments, explanations can be due to either error or non-error, as illustrated by the analytical procedures decision aid answers (Blocher and Willingham, 1988). Availability theory would predict that the easier the class of error explanations can be recalled, the higher the auditors' estimate of the frequency of error as the cause for an unusual fluctuation in financial relationships. Interference theory predicts that output interference occurs when an individual is so preoccupied with one class of explanations that the generation of other types of explanations is impaired (Smith, 1971). The preoccupation with one class of explanations may occur as a result of studying items on a list or retrieving them from memory (Nickerson 1984, 541). Frederick (1991) found that output interference inhibited auditors' ability to recall experimenter-provided internal controls after a five minute delay, within and across taxonomic categories of internal control (e.g. segregation of duties,

authorization, etc.). Moser (1989) also found interference across the two categories “pro” and “con” for an investment decision related to whether earnings for Apple Computer, Inc. would be at least five percent higher than the previous year. Likewise, Anderson et al. (1992) found output interference across the two categories of error and non-error explanations for an unusual fluctuation in a financial ratio (inventory turnover) in the application of analytical procedures.

Anderson et al. (1992) found asymmetric output interference, whereby being preoccupied with non-error explanations inhibited the ability of auditors to generate error explanations, but being preoccupied with error explanations did not inhibit the ability of auditors to generate nonerror explanations. Hoch (1984) found a similar pattern of asymmetric output interference. Kaplan et al. (1992) argue that there are more potential non-error explanations than error explanations. Anderson et al. (1992) note that this preponderance of nonerror explanations may explain the asymmetric nature of their findings on output interference. Kinney and Haynes (1990) show concern about the implications of output interference theory and availability theory for auditing, whereby auditors may focus on non-error explanations and subsequently underestimate the probability of the cause of a ratio fluctuation to be an error, with implications on impaired audit effectiveness. However, Anderson et al. (1992) did not find the existence of the availability phenomenon, contrary to the findings of Hoch (1984) and Moser (1989). Even though preoccupation with non-error explanations inhibited the ability of auditors to generate error explanations, it did not lessen the auditors’ assessment of the likelihood that the reason for the financial statement fluctuation was due to error. Anderson et al. (1992) note that their failure to find a link with interference theory and the availability heuristic may be due to the fact that (1) their subjects were experienced audit managers, and (2) experience may mitigate the effects of heuristics and biases in audit judgment (Anderson and Wright 1988). Also, several authors have argued that auditors use a conservatism principle (Ashton and Ashton 1988; Smith and Kida 1991) such that auditors are more sensitive to negative evidence, since they are primarily concerned with finding potential error or irregularity causes of financial ratio fluctuations, in order to minimize audit risk. This conservatism may influence auditors in such a way that they are reluctant to lower their assessment of the probability that error is the cause of the ratio fluctuation, even with the influence of output interference from nonerror explanations.

### **Analytical procedures decision aids for generating explanations for ratio fluctuations**

Decision aids have been proposed as possible solutions

to problems that have been identified in audit research (Messier 1995). Decision aids have the potential to expand the set of plausible hypotheses that auditors consider when conducting analytical procedures. Heiman (1990) found that 11 of 35 experienced auditors failed to generate more than two alternative error explanations for a set of fluctuating ratios. Anderson et al. (1992) found that experienced audit managers could only generate six error explanations if they generated them before non-error explanations, and only five explanations if they generated them after non-error explanations.

Following the findings of dysfunctional effects on audit judgment from decision aids reported by Pincus (1989) and Kachelmeier and Messier (1990), Bamber et al. (1995) issued a call for research that addresses the development and implementation issues surrounding decision aids. Several studies have indicated that performance with decision aids can be worse than unaided performance due to overreliance on the decision aid (Pincus, 1989; Glover et al. 1997; Kowalczyk and Wolfe 1998; Anderson et al., 2003). In Anderson et al. (2003), auditors rated explanations as more sufficient when provided by a decision aid than when provided by a client, when the explanations were in fact insufficient to account for a substantial portion of the fluctuation. The implications of Anderson et al. (2003) is that users of analytical procedures decision aids should be warned to be skeptical of nonerror explanations, even when provided by a highly objective source such as a decision aid.

### **The biasing effect of output interference in the use of analytical procedures decision aids**

Anderson et al. (1997) found that auditors using a decision aid that was biased towards error explanations were more likely to assess that the probability of the cause of the inventory turnover ratio fluctuation was due to error. The finding of availability was asymmetric, similar to the asymmetric finding of interference in Anderson et al. (1992), whereby an error biased decision aid raised the assessment of the probability of error as the cause for the fluctuation, whereas a non-error biased list did not lower the assessment of the probability of error as the cause for the fluctuation. The asymmetric finding of availability in Anderson et al. (1997) may be due to the conservatism displayed by auditors, whereby they are more sensitive to error as the explanation, due to a concern for audit effectiveness. The asymmetric finding of availability by Anderson et al. (1997) is consistent with the concern for audit effectiveness, to avoid potential lawsuits from failure to find an error/irregularity as the cause of a fluctuation which led to a material misstatement in the financial statements.



**Table 1.** Participant demographics.

<b>Panel A: Continuous measures</b>				
<b>Variable</b>	<b>n</b>	<b>Scale</b>	<b>Mean</b>	<b>S.D.</b>
Age	107	Years	27.5	4.6
Accounting credit hours	104	Count	22.9	13.4
General business experience	107	Months	38.7	42.4
Auditing experience	107	Months	2.4	9.5
<b>Panel B: Discrete Measures</b>				
<b>Attribute</b>	<b>Count<sup>c</sup></b>	<b>Percent</b>		
Gender				
Male	48	44.9		
Female	59	55.1		

### Validation of the effects of availability upon decision aid use

In a commentary on Anderson et al. (1997), Hermanson (1997) argues that the significant finding of the effect of availability from the use of a biased decision aid may be due to a demand effect created by the repeated-measures design of the study. Anderson et al. (1997) utilized a within-subjects design, whereby subjects were asked for an initial assessment of the probability that the cause of the ratio fluctuation was due to error, then presented with a decision aid (biased as either error or non-error as to the cause of the fluctuation), and then asked to re-assess the probability that the cause of the ratio fluctuation was due to error. Anderson et al. (1997) assert that the repeated measures design lends better support for their significant finding, since subjects might tend to anchor on their initial assessment, and therefore be reluctant to increase their assessment of the probability of error as the cause of the ratio fluctuation. Hermanson (1997) argues that the effect may be demand driven because subjects could have simply thought they should increase their probability of the assessment of error since they were provided with more information regarding error explanations. To address the issue of the possibility of a demand driven effect, the present study uses a between subjects design with a control group, whereby subjects in the treatment condition only make one assessment of the probability that the cause of the ratio fluctuation is due to error, and that assessment occurs after receiving the decision aid. The treatment groups are compared to the control group, which makes a similar assessment of the probability that the cause of the ratio fluctuation is due to error, but without a decision aid. Based on the results of Anderson et al. (1997), the hypotheses are stated as follows, predicting the asymmetric effect of availability:

**H1:** Auditors using a decision aid biased with error

explanations will assess a higher probability that the cause of the significant ratio fluctuation is due to error, compared to auditors not using a decision aid.

**H2:** Auditors using a decision aid biased with non-error explanations will not assess a higher probability that the cause of the significant ratio fluctuation is due to error, compared to auditors not using a decision aid.

## RESEARCH METHOD

### Sample

One hundred and twenty graduate accounting students from a large public AACSB accredited university in the U.S. participated in the study. All participants were obtained through coordination with faculty teaching graduate accounting courses and study materials were completed during class time. Thirteen participants were excluded from the sample because of missing data and instrument internal validity checks. The 107 valid responses represent an 89 percent completed response rate.

Graduate accounting students are the subjects in this study and are sufficient proxies for entry-level auditors for at least two reasons. First, accounting curricula include the understanding, calculation, and analysis of common financial statement ratios used in analytical procedures analysis. Therefore, accounting students should be knowledgeable about possible error and non-error reasons for changes in financial ratios (e.g., inventory turnover ratio). Second, accounting students with audit experience have been exposed to practical aspects of analyzing financial statement ratios. On average, participants in the study had completed 22.9 semester units of accounting coursework and 2.79 units of audit coursework. They also had an average of 38.7 months of general business experience and 2.4 months of audit experience. Prior to this, research has used accounting students to proxy for entry-level accountants (e.g., Massey and Thorne 2006; Fleming et al., 2009), and the demographic characteristics of this sample suggest that the participants are reasonable proxies for entry-level auditors. Table 1 presents demographic data for the sample.

### Study materials and procedure

The participants were randomly assigned a packet of study

**Table 2.** Anova results for perr.

<b>Panel A: Mean and standard deviation for perra</b>				
<b>Variable<sup>b</sup></b>	<b>n</b>	<b>Mean</b>	<b>S.D.</b>	
ERROR AID	37	47.70	21.67	
NONERROR AID	35	37.37	16.45	
NO AID	35	39.00	19.51	

  

<b>Panel B: Error aid vs. no aid anova<sup>c</sup></b>				
<b>Hypothesis 1</b>	<b>df</b>	<b>MSE</b>	<b>F-Ratio</b>	<b>p-value(one-tailed)</b>
ERROR AID > NO AID	1	1362.22	3.192	0.039

  

<b>Panel C: Nonerror aid vs. no aid anova</b>				
<b>Hypothesis 2</b>	<b>df</b>	<b>MSE</b>	<b>F-Ratio</b>	<b>p-value(one-tailed)</b>
NONERROR AID > NO AID	1	46.41	0.143	0.354

materials that included summarized financial statements and other information about a fictitious publicly traded business. Participants were then presented the inventory turnover ratio for current and prior year as well as the year-over-year change (that is, a 5% decrease). Participants were told the change in the ratio could be the result of either (1) error or irregularity explanations, and/or (2) non-error explanations, and were given an example of error and non-error explanations using a different ratio (that is, payroll expense per day). The task was to assess the probability the decrease in the inventory turnover ratio was associated with (1) error or irregularity explanations or (2) non-error explanations. The sum of these two probabilities was 100%. The study materials were originally developed in Anderson et al. (1992, 1997) and adapted for this study. Participants completed the study materials in one sitting that lasted approximately 25 min.

### Experiment design and variables

The study employed a 3 X 1 between-subjects design that varied the availability of a set of possible explanations for the change in the inventory turnover ratio (DECISION AID) before assessing the cause of the decrease in the inventory turnover ratio. The ERROR AID condition contained a set of 15 possible explanations for the change in inventory turnover, with 11 items that described possible accounting errors and 4 items that described possible non-errors. The NONERROR AID condition contained a set of 15 possible explanations for the change in inventory turnover, with 11 items that described possible non-errors and 4 items that described possible accounting errors. The NO AID condition did not contain a set of possible explanations for the change in inventory and was included as a control. See the appendix for ERROR AID condition explanation items. The dependent variable is the probability that the decrease in the inventory turnover ratio was caused primarily by error(s) or irregularities (PERR). The value is reported as a percentage with a closed-end which ranges from 0 to 100%.

## RESULTS

### Instrument analysis

Three attributes of company information presented in the

study materials were analyzed, to ensure that both errors and non-errors were reasonable possible explanations for the change in the inventory turnover ratio. Participants evaluated on 11 point scales the case company's stability of operations (-5 = very low stability, 5 = very high stability), stability of the economic environment for the industry (-5 = very low stability, 5 = very high stability), and strength of the company's internal controls (-5 = very weak internal controls, 5 = very strong internal controls). Results indicate the case company was viewed having moderately stable operations (mean = 0.03, s.d. = 2.09), moderately stable industry economic environment (mean = 0.29, s.d. = 1.97), and moderately strong internal controls (mean = -0.65, s.d. = 2.04). The response means for these variables are not significantly different across treatment conditions (all p-values > 0.20).

### Error-biased decision aid

H1 predicts auditors using an error-biased decision aid, which will assess a higher probability that the cause of the significant ratio fluctuation is due to error, compared to auditors not using a decision aid. Results shown in Table 2, Panel B, support H1 and indicate that auditors provided with an error-biased decision aid reported a significantly higher probability of an error for the inventory change (PERR mean = 47.70, S.D. = 21.67) than when no decision aid was provided (PERR mean = 39.00, S.D. = 19.51, F = 3.19, p = 0.039, one-tailed).

### Nonerror-biased decision aid

H2 predicts auditors using a decision aid biased with non-error explanations will not assess a higher probability that the cause of the significant ratio fluctuation is due to non-

error, compared to auditors not using a decision aid. Results shown in Table 2, Panel C, support H2 and indicate that auditors provided with a non-error-biased decision aid did not report a significantly higher probability of a non-error for the inventory change, that is, did not report a significantly lower probability of an error for the inventory change (PERR mean = 37.37, S.D. = 16.45) than when no decision aid was provided (PERR mean = 39.00, S.D. = 19.51,  $F = 0.143$ ,  $p = 0.354$ , one-tailed).

## DISCUSSION AND CONCLUSION

Decision aids may be lengthy, such as the list of 15 explanations used in the analytical procedures decision aid in Anderson et al. (1995, 1997). Circumstances of budgetary constraints and limited cognitive load may inhibit an auditor from fully using a lengthy list of explanations in a subsequent search of information during the audit. Mueller and Anderson (2002), explored the way in which auditors would trim a lengthy list of 20 explanations for a significant decrease in the inventory turnover ratio. In their study, auditors were asked to mark the explanations that they considered either "likely" (if in the *inclusion* treatment) or "not likely" (if in the *exclusion* treatment). As predicted by goal-framing theory, auditors experiencing an *inclusion* goal frame were found to derive a significantly smaller reduced set of alternatives (about 8 explanations) compared to auditors experiencing an *exclusion* goal frame (about 13 explanations). The goal-framing bias found in Mueller and Anderson (2002) resulted in the *inclusion* auditors starting with 5 fewer plausible explanations when beginning their information search. The implications are that it would be better for auditors to reduce the list of explanations by marking them "not likely" for the *excluded* explanations, in order to consider a larger number of explanations.

A related question is the extent to which auditors may be liable if they do not exhaustively investigate every explanation that is generated by a decision aid. Using experienced U.S. judges, Anderson et al. (1995) designed a between subjects study whereby judges assessed the liability of auditors when they either fully used or partially used a decision aid. In the fully used decision aid treatment, judges read a case whereby auditors investigated all 10 explanations generated by a decision aid, which did not list the error explanation revealed to the judges as the actual cause for the significant ratio fluctuation. In the partially used decision aid treatment, the auditors examined the same 10 explanations in a decision aid that contained 15 explanations, and the error explanation revealed to the judges as the actual cause for the significant ratio fluctuation was included in the 5 explanations listed in the decision aid that were not investigated by the auditor. Auditors in the partially utilized decision aid treatment

were found significantly more liable by the judges. Given that decision aids may need to be exhaustively used, in order to avoid increased liability, it is important to design decision aids with the assumption that auditors may be expected to exhaustively investigate each explanation on a lengthy list. A lengthy list would presumably include both error and nonerror explanations. Given that Kaplan et al. (1992) argue that there are more potential non-error explanations than error explanations, the design of analytical procedures decision aids may potentially contain more non-error than error explanations.

Decision aids have been proposed as possible solutions to problems that have been identified in audit research (Messier 1995). Decision aids have the potential to expand the set of plausible hypotheses that auditors consider when conducting analytical procedures. Janvrin et al. (2008) noted that financial ratio tools are used and considered important, in a survey of 181 auditors. Although, Janvrin et al. (2008) describe tools for ratio analysis as useful by auditors, little is known about auditors' use of decision aids as a source of explanations for analytical procedures, due to a lack of field studies in this area since Hirst and Koonce (1996), where the use of such decision aids was rarely found. Janvrin et al. (2008) contend that audit researchers should examine analytical procedures in a decision aid context. Ultimately, there is potential for development of decision support systems for auditing that would utilize expert systems or artificial intelligence methods, whereby the expertise of experienced auditors is used to populate a knowledge based system with plausible explanations for significant unexpected fluctuations in financial statement accounts with financial, operating, and economic indicators (Hunton and Rose, 2010). The results of the present study provide additional theoretical guidance in the design of these analytical procedures decision aids for explaining unexpected fluctuations in financial statement accounts, validating Anderson et al. (1997) regarding the asymmetric effect of interference and availability theory upon the use of these decision aids, with implications on the proportion of nonerror explanations constructed in the list. This study also reviews and synthesizes the related literature regarding caution on auditors' use of nonerror explanations in the list (Anderson et al., 2003).

Literature is cited on current recommendations regarding the theoretical basis for trimming the list of explanations in a decision aid down to a manageable size (Mueller and Anderson, 2002). Consistent with the need to trim the list to a manageable size, literature is cited regarding the expectations of U.S. judges that auditors will exhaustively search whatever explanations are finally included in a decision aid (Anderson et al., 1995). This study validates the results of Anderson et al. (1997), to provide evidence on the utility of a decision aid to assist auditors with audit effectiveness in the application of analytical procedures. Given these validated findings of

Anderson et al. (1997), where a decision aid with a higher balance of error explanations has an availability effect of an increased assessment of the probability of error, it could be that decision aids designed with more error explanations as opposed to non-error explanations will lead to more effective audits, as auditors will approach the audit with a higher assessment of the probability that the ratio fluctuation is due to error, and extend audit procedures appropriately. Additionally, as suggested by Anderson et al. (2003), it may be prudent to warn auditors to be skeptical of nonerror explanations that are provided by a decision aid.

### Conflict of interests

The authors have not declared any conflict of interest

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**APPENDIX:** Error biased decision aid items.

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Error biased decision aid items.

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Errors in pricing inventory, including transfer pricing errors\*

Incorrect test counts of inventory\*

Consigned goods incorrectly included in inventory\*

Unbooked physical adjustments to inventory, including obsolete or unsalable inventory\*

Unbooked physical adjustments to inventory, including unrecorded shrinkage\*

Increase in actual inventory costs

Higher overtime or payroll

Sales down due to technological changes

Change in accounting or costing method for inventory

Inventory account not credited for sale(s)\*

Error in cut-off of inventory, accounts payable, COGS, or sales including unrecorded finished goods, incorrect beginning inventory, improper revenue recognition or unrecorded sales\*

Incorrect cost allocation, calculation or recording of inventory, including error in computing average cost, nonrepresentative average cost, miscosted overhead, or misapplication of variances\*

Misclassified transactions\*

Clerical errors in posting or extending\*

Error in recording labor rates\*

\* Error item

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