Using Expert Knowledge Structures to Design Fraud Risk Assessment Decision Aids

Authors:

Jacob Rose, PhD
Southern Illinois University

Carolyn Strand Norman, PhD
Virginia Commonwealth University

February 2009

The Institute of Internal Auditors Research Foundation

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ISBN 978-0-89413-670-2
04/09 First Printing

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ACKNOWLEDGMENTS

We gratefully acknowledge research funding from The Institute of Internal Auditors Research Foundation. We also wish to recognize the helpful comments and suggestions from the participants of research workshops at the University of Central Florida, Southern Illinois University, Virginia Commonwealth University, Georgia Southern University, and Melbourne University. This research project would not have been possible without the professional support from the experienced internal auditors who participated in interviews, surveys, and the experiment. We also thank our students who enthusiastically participated in our research project. We owe each of them our heartfelt appreciation.

ABOUT THE AUTHORS

Jacob (Jake) Rose, PhD, is a professor of accountancy at Southern Illinois University Carbondale. He is the director of the PhD program in accounting, and his research focuses on issues related to judgment and decision-making in the contexts of information systems, auditing, and corporate governance. Professor Rose serves on the editorial boards of the *Journal of Information Systems*, the *International Journal of Accounting Information Systems*, and *Issues in Accounting Education*.

Carolyn Strand Norman, PhD, CPA, is an associate professor at Virginia Commonwealth University. She teaches accounting information systems classes at the graduate and undergraduate levels and also teaches a doctoral seminar in behavioral research. Professor Norman is an active member of the board of directors for the Central Virginia chapter of The Institute of Internal Auditors and regularly presents two-hour ethics seminars at chapter events. She is also an associate editor for *Issues in Accounting Education* and a special editor for *Behaviour & Information Technology*.

STUDY OBJECTIVE

The purpose of this research was to design and test a decision aid based on the knowledge structures of experienced auditors. We used Pathfinder Network Scaling (PNS) analysis to accurately measure the knowledge structures of fraud risk assessment experts and then embedded those knowledge structures within a decision aid to determine its effectiveness for promoting rapid development of expertise. That is, we investigated whether novice decision aid users acquired knowledge structures that were similar to those of experts, and whether novice users then made judgments similar to those of experts.

Both internal and external auditors are expected to prevent and detect fraud within an organization; however, due to their limited exposure to fraudulent reporting (i.e., ill-developed knowledge structures for fraud and indicators of fraud), auditors tend to focus on nonfraudulent explanations for errors (Zimbelman 1997). Given the complexity of fraud risk assessments, auditors' lack of fraud-related experience and auditors' limited capability for assessing fraud, these professionals commonly use fraud risk assessment decision aids (e.g., Allen et al. 2006; Shelton et al. 2001).

In general, decision aids are designed to increase accuracy, expedite the decision-making process, increase decision quality, decrease the effort required for effective performance, and train novice users to make judgments like experts (e.g., Arnold et al. 2004a; Barrick and Spilker 2003; Rose 2002; Kachelmeier and Messier 1990). For these reasons, auditors rely on decision aids to help novices acquire expert-like knowledge (e.g., Dowling and Leech 2006; Rose 2002; Rose and Wolfe 2000). However, studies on decision aids report conflicting results regarding their use. Decision aids have been found to both improve and harm judgment performance and can facilitate or hinder expertise development (e.g., Asare and Wright 2004; Rose and Wolfe 2000; Odom and Dorr 1995). In general, users of decision aids develop less expertise than nonusers, and decision aids typically hinder the acquisition of professional knowledge and skill (Rose 2002). Thus, decision aids are very effective for promoting decision accuracy and efficiency, but ineffective for promoting expertise development.

A common theme of decision aid research is that design features are key determinants of their effectiveness (e.g., Rose and Wolfe 2000; Rose 2002) and individuals are better able to achieve superior judgment and decision performance as they acquire more expert-like knowledge structures (e.g., Rose et al. 2007; Choo and Curtis 2000; Schvaneveldt 1990). Thus, experts' knowledge structures represent a valuable and currently unexplored tool for designing decision aids. Specifically, given that knowledge structures appear to be the key to expert performance, aids that promote the development of expert-like knowledge structures by novice users should significantly influence performance during and after use.

RESEARCH QUESTIONS

This study examined three primary issues associated with fraud risk assessment decision aids. First, we designed a decision aid based upon experts' knowledge structures, embedded these knowledge structures into the organization of the decision aid, and investigated whether novice users acquired more expert-like knowledge structures than did novices who used a decision aid based upon the fraud triangle in Statement on Auditing Standard (SAS), No. 99, *Consideration of Fraud in a Financial Statement Audit* (AICPA 2003).

Second, we explored the value of outcome feedback. In particular, we examined whether outcome feedback would help novices make more expert-like judgments than novices. Finally, we investigated whether our decision aid, based on experts' knowledge structures, was equally valuable to experienced and novice auditors.

METHODOLOGY

Participants and Design of Experiment

We conducted two experiments; the first included 81 accounting students and the second included 86 experienced internal auditors. We selected internal auditors as our professional participants in this study for a number of reasons. First, internal auditors have a professional obligation to be alert to control weaknesses that could allow fraud, to evaluate the indicators that fraud may have occurred, and to notify appropriate authorities within the organization (DeHaven 1990; IIA 1985). Second, most frauds are uncovered by internal auditors and internal controls (e.g., KPMG 2006). Third, external auditors often rely on the risk assessments of internal auditors (e.g., PCAOB, AS No. 5 2007).

We used a between-participants design for each experiment where we manipulated the organization of the decision aid (*organization*) and outcome feedback (*feedback*). Organization was manipulated by altering the layout of the fraud cue checklist. Cues were organized according to the fraud triangle presented in Statement on Auditing Standards No. 99 (AICPA 2003) or according to an aggregate expert knowledge structure. Outcome feedback provided to participants was either an average of fraud risk assessments made by a group of experts or no outcome feedback.

Procedure and Task

We randomly assigned the participants in both experiments to one of four treatment conditions, and the participants completed the task at their place of employment (students completed the task during a normal classroom period). The task was completed on a PC and required approximately 40 minutes to complete. Each participant made three assessments of financial statement fraud risk with the help of a decision aid. After completing three risk assessments, the participants completed a concept-pair rating task where they evaluated the relatedness of all combinations of the 15 red flags included in the decision aids (see Table 1). Finally, participants completed a test case where they evaluated the risk of financial fraud without the use of a decision aid.

Dependent Variables

Our two dependent variables were knowledge structure acquisition and fraud assessment accuracy. Pathfinder Network Scaling (PNS) analysis is used to assess participants' knowledge structures and the similarity of the structures to an expert knowledge structure. PNS provides a direct measure of a decision maker's knowledge structure (Choo and Curtis 2000; Day et al. 2001; Goldsmith and Davenport 1990; Kraiger et al. 1993; Schvaneveldt 1990). PNS measures of knowledge structure can be assessed in decision environments where professionals make complex judgments and where traditional measures of declarative and procedural knowledge and decision outcome data are not available. PNS analyses allow for direct comparisons of novice and experts' knowledge structures that are independent of the complexity of the decision domain and these comparisons reveal the capability of novices to perform like experts.

PNS allows for comparison of expert and novice knowledge structures through the use of the measure "C," which is defined as "the closeness to expert knowledge structure" (e.g., Goldsmith and Davenport 1990; Schvaneveldt 1990). Recent research demonstrates that PNS effectively captures the effects of instruction, experience, and decision aid use on the development of knowledge structures in complex

accounting domains. Additionally, the "closeness" of novice knowledge structures to experts' knowledge structures mediates the relationship between the design of decisions aids and subsequent novice decision performance (Rose et al. 2007). Thus, measurement of the similarities between experts' knowledge structures and novice structures is valuable because similarities between knowledge structures are highly predictive of novice decision performance. The "C" score can range from 0 to 1, with 0 indicating that the two knowledge structures are completely dissimilar and 1 indicating that the two knowledge structures are identical.

Fraud risk assessment accuracy is computed by comparing participants' fraud risk assessments to an aggregate of experts' fraud risk assessments. The absolute difference between a participant's fraud risk assessment on a test case and an aggregate of assessments by experts can range from 0.5 to 7.5 (based on an aggregate expert score of 7.5 on a risk rating scale of 0 to 10).

Development of Decision Aids

We developed two decision aids with a total of 15 fraud cues (see Table 1). We included the same 13 cues that Wilks and Zimbleman (2004) used and added two additional cues to represent all three sides of the fraud triangle (SAS No. 99, AICPA 2003). The first decision aid included a checklist of risk factors organized into the three categories commonly referred to as the fraud triangle: (1) incentive/pressure to perpetrate a fraud, (2) opportunity to carry out a fraud, and (3) attitude/ability to rationalize the fraudulent action.

Table 1. Fraud Cues Used in Both Decision Aids

	Selected SAS No. 99 Appendix Red Flag Financial Statement Fraud Cues	Abbreviated Version
Incentive	High degree of competition or market saturation accompanied by declining margins	High degree of competition
Incentive	High vulnerability to rapid changes, such as changes in technology, product obsolescence, or interest rates	Vulnerability to changes in interest rates
Incentive	Significant declines in customer demand and increasing business failures in either the industry or overall economy	Decreased customer demand
Incentive	Excessive pressure on management to meet requirements or third-party expectations due to profitability or trend level expectations	Excessive pressure on management to meet financial targets
Incentive	Need to obtain additional debt or equity financing to stay competitive — including financing of major research and development or capital expenditures	New financing needed to stay competitive
Incentive	Marginal ability to meet exchange listing requirements, debt repayment, or other debt covenant requirements	Difficulty meeting debt requirements
Incentive	Significant financial interests in the entity	Management has significant financial interests in the company
Incentive	Personal guarantees of debts of the entity	Management makes personal guarantees of company debts

Table 1. Fraud Cues Used in Both Decision Aids (Cont'd)

	Selected SAS No. 99 Appendix Red Flag Financial Statement Fraud Cues	Abbreviated Version
Opportunity	Assets, liabilities, revenues, or expenses based on significant estimates that involve subjective judgments or uncertainties that are difficult to corroborate	Many accounting estimates involve subjective judgments
Opportunity	Significant, unusual, or highly complex transactions, especially those close to period end that pose difficult "substance over form" questions	Many transactions pose substance over form questions
Opportunity	Significant related-party transactions not in the ordinary course of business or with related entities not audited or audited by another firm	Significant related-party transactions
Opportunity	Significant operations located or conducted across international borders in jurisdictions where differing business environments and cultures exist	Cross-border operations
Opportunity	Significant bank accounts, or subsidiary, or branch operations in tax-haven jurisdictions for which there appears to be no clear business justification	Foreign bank accounts with no justification for location
Attitude	Ineffective communication, implementation, support, or enforcement of the entity's values or ethical standards by management or the communication of inappropriate values or ethical standards	Management poorly communicates firm values
Attitude	Unreasonable demands on the auditor, such as unreasonable time constraints regarding the completion of the audit or the issuance of the auditor's report	Management places strong pressure on auditors

The second decision aid included the same 15 fraud cues but we organized the cues according to the knowledge structures of fraud experts. We obtained these knowledge structures by asking a group of fraud experts to complete a concept-pair rating task. These fraud experts included a certified fraud examiner (CFE) with 16 years of professional experience, a chief audit executive (CAE) with a CFE license, an auditing professor who teaches a course on fraud examination, and a second CAE with fraud detection experience. The experts rated the similarity of the 15 fraud cues using a program developed by the authors. Using PNS, we aggregated the experts' knowledge structures to create a single expert knowledge map.

ANALYSIS

Our first research question examined the effects of decision aid design on knowledge structure development and judgment performance. Preliminary results reported in Panel A of Table 1 indicate that the mean C score of users of the decision aid organized according to experts' knowledge structures was 0.180, while the mean C score of users of the SAS No. 99 organized aid was 0.125. This suggests that participants who used the aid that was organized according to an aggregate of experts' knowledge structures acquired a knowledge structure more like the aggregate expert knowledge structure than participants using the decision aid organized according to the SAS No. 99 checklist.

Our second research question explored the impact of outcome feedback. A comparison of means presented in Panel B of Table 2 indicates that participants using the expert-structure aid, who were provided with outcome feedback, had better judgment performance (i.e., a lower mean absolute difference score) than users of the expert-structure aid who received no feedback (difference score = 0.55 and 1.13 respectively).

The third research question investigated whether aids organized according to an expert knowledge structure will be equally effective for experts (greater than four years of experience) and novices (less than four years of experience). Descriptive analyses of knowledge structure acquisition and risk assessment performance by more and less experienced internal auditors are displayed in Table 3. Our results suggest that aid organization has no significant effects on knowledge structure acquisition by the more experienced aid users. However, less experienced users do develop expert-like knowledge structures when they use aids that are organized according to an expert knowledge structure.

Table 2. Means of Knowledge Structure Acquisition and Performance

Panel A: Knowledge Structure Acquisition

(participants' calculated C-Scores) – Mean (standard deviation) {sample size} responses across treatment conditions

Feedback	**Organization**		*Main Effect:*
	Expert	SAS No. 99	*Feedback*
Present	0.187 (0.041) {21}	0.122 (0.035) {19}	*0.156* *(0.05)* *{40}*
Not Present	0.171 (0.05) {19}	0.128 (0.035) {20}	*0.149* *(0.048)* *{39}*
Main Effect: *Organization*	0.180 (0.046) {40}	0.125 (0.034) {39}	*0.153* *(0.049)* *{70}*

Panel B: Performance

(absolute value of difference between expert fraud assessments and participants' assessments) – Mean (standard deviation) {sample size} responses across treatment conditions

Feedback	**Organization**		*Main Effect:*
	Expert	SAS No. 99	*Feedback*
Present	0.55 (0.22) {21}	1.45 (1.08) {19}	*0.975* *(0.88)* *{40}*
Not Present	1.13 (0.68) {19}	1.05 (0.83) {20}	*1.09* *(0.75)* *{39}*
Main Effect: *Organization*	0.825 (0.57) 40	1.24 (0.96) 39	*1.03* *(0.81)* *79*

C-Score: Measure (i.e., index of similarity) of the closeness of an individual's knowledge structure compared to that of an expert aggregate knowledge structure, using Pathfinder Network Scaling analysis. The "C" score can range from 0 to 1, with 0 indicating that the two knowledge structures are completely dissimilar and 1 indicating that the two knowledge structures are identical.

Organization: The checklist aid was organized using either the SAS No. 99 organization or the expert knowledge structure organization.

Feedback: Outcome feedback was either provided or not provided to participants.

Table 3. Descriptive Results for Knowledge Structure Acquisition

(participants' calculated C-Scores) – Mean; (standard deviation); and {sample size} across treatment conditions

Panel A: Less Experienced Users

Feedback	**Organization**		*Main Effect:*
	Expert	SAS No. 99	*Feedback*
Present	0.199 (0.076) {13}	0.129 (0.041) {10}	*0.168* *(0.071)* *{23}*
Not Present	0.190 (0.048) {8}	0.130 (0.049) {11}	*0.155* *(0.056)* *{19}*
Main Effect: *Organization*	0.195 (0.065) {21}	0.129 (0.044) {21}	*0.162* *(0.064)* *{42}*

Panel B: More Experienced Users

Feedback	**Organization**		*Main Effect:*
	Expert	SAS No. 99	*Feedback*
Present	0.142 (0.042) {8}	0.171 (0.058) {13}	*0.160* *(0.053)* *{21}*
Not Present	0.158 (0.042) {12}	0.140 (0.062) {11}	*0.149* *(0.052)* *{23}*
Main Effect: *Organization*	0.152 (0.041) {20}	0.157 (0.061) {24}	*0.155* *(0.052)* *{44}*

C-Score: Measure (i.e., index of similarity) of the closeness of an individual's knowledge structure compared to that of an expert aggregate knowledge structure using Pathfinder Network Scaling analysis. The "C" score can range from 0 to 1, with 0 indicating that the two knowledge structures are completely dissimilar and 1 indicating that the two knowledge structures are identical.

Organization: The checklist aid was organized using either the SAS No. 99 organization or the expert knowledge structure organization.

Feedback: Outcome feedback was either provided or not provided to participants.

Experience: Less experienced users have fewer than four years of professional internal audit experience and more experienced users have four or more years of experience.

SUMMARY AND CONCLUSIONS

Our purposes for this research study were to design a decision aid based upon the knowledge structures of experienced auditors and to test the ability of the decision aid to train users to "think like experts" and "make judgments like experts." To accomplish these purposes, we employed two experiments. Our results suggest that individuals who use decision aids that are organized to represent an expert's knowledge structure develop knowledge structures that are similar to those of experts. The individuals who benefit most from this type of decision aid organization are complete novices (i.e., students) and less experienced practitioners (i.e., internal auditors with less than four years of experience). That is, when checklist aids are organized to represent the knowledge structures of experts, both students and internal auditors with limited professional experience develop knowledge structures that are similar to the expert knowledge structure embedded in the aid. In addition, they make decisions similar to the experts whose knowledge structures are represented by the aid.

We believe these findings suggest significant potential for future design and use of decision aids. In particular, if decision aids are designed to impart expert-like knowledge structures to users, then organizations will be able to take advantage of the efficiency and effectiveness gains that decision aids provide, while also promoting the development of expertise. Our experiments indicate that simple adjustments to the organization of a checklist decision aid can have substantial effects on the development of expertise after only limited use of the aid.

We also suggest that using PNS to measure knowledge structures represents a significant advance in our ability to determine the effectiveness of intelligent decision aids. PNS measures of knowledge structure can be assessed in decision environments where professionals make complex judgments and traditional measures of declarative and procedural knowledge and decision outcome data are simply not available, which is frequently the case in accounting and auditing practices. PNS analyses allow researchers to directly compare novice and experts' knowledge structures (independent of the complexity of the decision domain), and these comparisons reveal the capability of novices to perform like experts.

Additional research will be necessary to address the long-term effects of using decision aids that incorporate experts' knowledge structures. Since our experiments were conducted in a short-term setting (less than one hour), we are unable to speculate about the effects of decision aid use over periods of months or years. However, we find it promising that brief use of a decision aid has the capacity to significantly alter knowledge structures. Existing theory suggests that longer-term use of decision aids that incorporate experts' knowledge structure will result in more acquisition of expertise relative to brief use of such aids.

We also found that aid use did not alter the knowledge structures of experienced users. Available theory suggests that experienced users possess complex knowledge structures prior to aid use, and these users are reluctant to alter their knowledge structures simply because a decision aid suggests an alternative. We do not, however, have direct measures of the experienced users' knowledge structures prior to aid use, and we cannot measure whether experienced users' knowledge structures were entirely static in response to aid use.

In summary, our research findings suggest a new method for decision aid design that might be used in applications other than fraud risk assessment. That is, knowledge structures can be readily assessed with PNS analysis in any field that involves judgment and decision-making. Because this approach does not

require that all relevant declarative and procedural knowledge be determined, even the most complex judgments can be modeled. Given that decision aids are readily available and commonly used in many fields that require judgment, organization of practice aids to mimic experts' knowledge structures appears to hold considerable potential for training novices and less experienced professionals to think like and make judgments like experts.

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ISBN 978-0-89413-670-2
Item #2020.dl
Free to IIA Members
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