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Joseph A. Russo Jr

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by

Joseph A. Russo, Jr., Ph.D.
Professor of Accounting
Lubin School of Business
Pace University

THE LUBIN SCHOOL OF BUSINESS

PACE UNIVERSITY

PROBLEM SOLVING BEHAVIOR DURING AUDITING TASKS IN THE FIELD: THE INTERACTION OF KNOWLEDGE AND ENVIRONMENT

by

Joseph A. Russo, Jr., Ph.D.

Joseph A. Russo is Professor of Accounting, Lubin School of Business, Pace University.

ABSTRACT

If we believe that observable problem solving behavior is the product of an auditor's unobservable processing of environmental stimuli, then problem solving behavior during an auditing task ought to be understandable in terms of the interaction between episodes during which environmental stimuli are processed and the succeeding observable behaviors by which the task solution is brought about. In light of this expectation, the research presented in this paper proposes that observed auditor perception and execution behaviors during audit tasks in field situations can be understood in terms of the crossbreak of two factors. The first of these is the state of an auditor's knowledge base, that is, the knowledge elements of which it is composed and the strengths of the linkages among them. The second factor is the presence of physical, technological, and social barriers in the task environment which thwart an auditor's habitual problem solving behaviors. Lack of knowledge gives rise to cognitions reflecting uncertainty and confusion while unavailable knowledge generates analysis and planning cognitions. Perception behaviors (1) reflect an auditor's belief that sought information exists and is available in the work environment, and (2) reveal an absence of barriers which interfere with an auditor's habitual response to a need for information. Execution behaviors reflect (1) an auditor's belief that sought information either does not exist or exists outside of the work environment and (2) an intention to transform the task environment.

Support for hypotheses based upon the preceding understanding is found in observations of the problem solving behavior of four first-year auditors performing an empirically intense task in simulated auditing environments. A significant interaction is demonstrated between the state of an auditor's knowledge base and the presence of barriers to habitual problem solving behavior. As expected of novices, significant associations were found between (1) perception behaviors and uncertainty cognitions, and (2) execution behaviors and analysis and planning cognitions. The findings bolster the previously stated belief in the genesis of problem solving behavior and confirm the value of the research paradigm it suggests. From a pragmatic perspective, the findings suggest that delays in these subjects' problem solving efforts are associated with a lack of knowledge which necessitates devoting time to constructing an adequate representation of the task situation, and an unavailability of knowledge which necessitates conscious deliberation in selecting appropriate execution procedures.

INTRODUCTION

In the field, auditing tasks[1] generally progress as evolving sequences of linked decisions and actions. During a task, behaviors appropriate to accomplishing objectives are chosen and implemented. Implementation takes the form of observable behaviors which transform an auditor's task environment and, in so doing, they alter the environmental stimuli upon which succeeding objectives and behavior choices are based. This iterative process continues until a task solution is reached. If we believe that observable problem solving behavior is the product of an auditor's unobservable processing of environmental stimuli, then problem solving behavior during an auditing task ought to be understandable in terms of the interaction between episodes during which environmental stimuli are processed and the succeeding observable behaviors by which the task solution is brought about.

Accordingly, this paper investigates two factors associated with accessing procedural knowledge.[2] The first of these is the state of an auditor's knowledge base, that is, the knowledge elements of which it is composed and the strengths of the linkages among them. The second factor is the presence of barriers in the task environment which thwart an auditor's habitual problem solving behaviors. Two multi-part hypotheses are proposed regarding the association of each factor with selection and initiation of perception and execution behaviors, the two categories of problem solving behaviors normally observable under field conditions. These hypotheses are supported by observations of the problem solving behaviors of four first-year auditors performing simulated review engagements. The findings bolster the previously stated belief in the genesis of problem solving behavior and confirm the value of the research paradigm it suggests.

This paper reports basic research intended to add to the growing body of knowledge upon which to base efforts aimed at accomplishing a primary objective of behavioral auditing research, viz., the improved performance of practitioners in the field. Among the benefits to be gained from a better understanding of the interaction between knowledge and environment is greater efficiency in the performance of audit tasks. For example, in the experiment reported in this paper, episodes of cognition mediating observable problem solving behaviors accounted for approximately 28 percent of the time during which these auditors' efforts were observed and recorded. Measured against a standard of completely habitual performance of a vary familiar task, this finding provides a first-order estimate of the efficiency to be gained through training and experience which enhance the availability of procedural knowledge.

THEORETICAL DEVELOPMENT

By its nature, any discussion of access to procedural knowledge must involve consideration of phenomena on both sides of the cognitive-empirical[3] interaction during problem solving. In the laboratory, tasks used in auditing research have tended to lack the interactive nature of field tasks and to require solutions represented by intellectual commitments, i.e., judgments or decisions.

This cognitive emphasis in auditing research has been noted and commented upon by Bamber (1993) and Hogarth (1991). Unlike auditing tasks in the laboratory, those in the field tend to be empirically intense. Such tasks are characterized by (1) a requirement for significant amounts of information input from the task environment, (2) solutions which require significant interaction with and transformation of the task environment, and (3) application of a considerable body of domain and task knowledge. Solutions to empirically intense tasks are altered states of the task environment. In research taking this broader view of problem solving, Russo (1995) has proposed an observation methodology which directly addresses the cognitive-empirical interaction in auditing tasks performed under simulated field conditions. This methodology employs video taped observation of auditors' empirical problem solving behaviors together with synchronized concurrent think-aloud protocols (Ericsson & Simon 1993) to examine the relationships between behaviors and the cognitions immediately preceding them. Using this methodology, Russo has compiled a data base of the problem solving behaviors of four novice auditors during simulated review engagements. This data base forms the foundation for the findings reported in this paper.

Habit and Experience

Psychological research generally supports two conclusions regarding human behavior.[4] First, the circumstances in which habitual behaviors are most likely to be evoked are those in which the situational cues are most like the cues present when those behaviors were learned (e.g., see Godden & Baddeley 1975; Tulving 1983; Organ & Bateman 1991, Ch. 4). These circumstances define what is familiar to an auditor. In familiar circumstances, situational cues are sufficient, but not always necessary, to evoke behaviors that are normally undertaken habitually. Second, the greater the variety of circumstances providing cues for learning a particular behavior, the more generalized become the cues required to evoke that behavior (Mayer 1992, Ch. 4). As experience with situations in which a particular behavior proves successful increases, the specificity of that behavior to the particular circumstances of individual situations declines and a more abstract conceptualization of when that behavior is appropriate strengthens.

Cognitive Episodes

A cognitive episode consists of all cognitions mediating two successive empirical behaviors. The kinds of empirical behaviors and mediating cognitions captured in the data base are summarized in the Appendix. Cognitive episodes arise whenever links between microfeatures of knowledge in long-term memory are either lacking or weak.[5] Such situations arise when auditors confront new or unfamiliar tasks and task environments. If, during any cognitive episode, an uncertainty arises, it may be addressed by analytical cognitions, planning cognitions whose objectives are the acquisition of information from the task environment, or observable habitual reactions to uncertainty. On the other hand, relevant but not immediately retrievable knowledge present in long-term memory may be located by means of a series of cognitions, each cognition acting as a virtual link between microfeatures of knowledge in memory. Cognitive episodes of this kind are the conscious traces of "access paths" which terminate with evocation of the target knowledge.

The Meaning and Operationalization of "Availability"

"Availability" as applied to behavior is a term expressing the relative ease with which an auditor accesses required knowledge stored in long-term memory. Highly available knowledge can be accessed directly, as is the case with habitual behavior. Unavailable knowledge, on the other hand, must be accessed indirectly by, for example, a series of cognitions, as discussed above. Compared with direct access, indirect access is a slower process. Operationally, declarative knowledge is considered to have been accessed when it enters short-term (working) memory, where it can be verbalized as part of a concurrent, think-aloud protocol. Procedural knowledge is considered to have been accessed when the behavior commences. A broad measure of the relative availability of procedural knowledge is the frequency with which observed behaviors follow cognition. A sequence of cognition followed by empirical behavior is presumptive evidence[6] of non-habitual access to procedural knowledge.

RESEARCH HYPOTHESES

Research Paradigm

The number and qualities of factors present and potentially affecting an outcome in a simulated auditing environment are so numerous and varied that their complete specification is not possible. For this reason, although the usual paradigm in experimental research is to specify the conditions under which a particular outcome will be observed, in this paper, an alternative approach is used. This alternative assumes that all factors affecting an outcome, although unidentified, have been captured in the simulated environment, and focuses only on identifying those factors and qualities which prevent the outcome of interest from taking place. Accordingly, in developing the research hypotheses, I begin with the assumption that the observed problem solving processes of expert auditors in the field are habitual[7] and then seek to identify (1) what factors in the task situation interfere with habitual behaviors (i.e., convert them from habitual to conscious behaviors), and (2) what effects these factors have on observed problem solving procedures. Having accomplished the foregoing, I then seek to infer possible underlying mechanisms accounting for the observed behaviors.

Implementing the preceding paradigm, in this section it is argued that (1) the physical, technological, and social circumstances of task environments interact with an auditor's knowledge base to produce the behavior choices observed, and (2) the association between a non-habitual empirical behavior and the cognition which immediately preceded it is an indicator of the state of an auditor's knowledge base leading up to that behavior choice. The possible interactions between knowledge and environment are summarized in Table 1. These interactions lead to four hypotheses which can be grouped into two broad categories based on observed behavior. Each hypothesis is developed in the following paragraphs.

TABLE 1

Crossbreak of Factors Affecting Problem Solving Behavior During Audit Tasks in the Field

State of Knowledge Base	Environmental Barriers: None Present	Environmental Barriers: Physical/ Technological/ Social	Cognitive Behavior	Behavioral Functionality
Knowledge Lacking	H1a	H2a	Uncertainty	See Note
Unavailable Knowledge & Schematic Lacunae	H1b	H2b	Analysis & Planning	Memory Search & Knowledge Retrieval
Observed Behavior	Perception	Execution		
Behavioral Intent (Objective)	Information Acquisition	Environmental Transformation		

Hypotheses

H1a: Perception behaviors will be preceded by uncertainty cognitions to the extent that knowledge is lacking.

H1b: Perception behaviors will be preceded by analysis and planning cognitions to the extent that knowledge is unavailable or information needs are consciously anticipated.

H2a: Execution behaviors will be preceded by uncertainty cognitions to the extent that knowledge is lacking and automatic responses to uncertainties are not thwarted.

H2b: Execution behaviors will be preceded by analysis and planning cognitions to the extent that knowledge is unavailable or information needs are consciously anticipated.

Note: The functionality of uncertainty and confusion is not discussed in this paper.

Hypothesis 1 - Interactions with Perception Behavior

Since auditors are assumed to be purposeful decision makers, perception behavior is sufficient evidence of a need for information from the work environment. In this experiment, reading is the only perception behavior. It is a well-learned response to an information need and practiced under a variety of circumstances. Therefore, in a familiar task situation, an auditor's habitual response to a need for information will be to read a document in the work environment which he/she believes has the required information. It also follows that reading behavior will not take place if an auditor believes that required information does not exist, that it exists outside the work environment, or that it must be created.[8]

In any observed sequence of problem solving behaviors, perception behaviors will have been preceded by cognitions to the extent that cognitive barriers, which reflect the state of an auditor's knowledge base, were present and interfered with an auditor's habitual response to a need for information. There are three kinds of cognitive barriers: (1) lack of knowledge, (2) unavailable knowledge, and (3) schematic lacunae (i.e., generically specified task-specific information required by available schemata). Expressions of uncertainties, such as what is present and available in the work environment and where and how to obtain documents and needed information, as well as expressions indicating confusion and an inability to integrate new information into a coherent representation of the task situation, are sufficient indicators of cognitive barriers of the first kind. To the extent that an auditor encounters cognitive barriers of this type, we can expect that perception behaviors will be preceded by cognitions expressing uncertainty or confusion.[9] These considerations lead to the following hypothesis regarding observed problem solving behaviors:

H1a: Perception behaviors will be preceded by uncertainty cognitions to the extent that knowledge is lacking.

Analysis and planning cognitions which arise as long-term memory is consciously searched for require environmental and strategic knowledge. Consequently, they are sufficient indicators of cognitive barriers of the second kind. Analysis and planning cognitions also evidence cognitive barriers of the third kind. However, rather than cuing procedural knowledge, the content of these cognitions is the planned acquisition of specific items of information from the work environment. To the extent an auditor's knowledge is unavailable, and to the extent that information requirements of schematic lacunae are consciously anticipated, then to that extent we can expect that perception behaviors will be preceded by analysis and planning cognitions. Based on the foregoing, we hypothesize, regarding observed problem solving behaviors:

H1b: Perception behaviors will be preceded by analysis and planning cognitions to the extent that knowledge is unavailable or information needs are consciously anticipated.

The more information made available in a single access to memory (i.e., the larger the "chunk"), the more integrated are knowledge schemata (Bedard & Chi 1993). As a result, fewer accesses are required to locate needed knowledge. Very frequent and numerous accesses to memory, on the other hand, are indicative of the small chunk size expected of task novices (Chase & Simon 1973; Simon 1976; Fisk et al. 1983). Consequently, the novice auditors in this experiment can be expected to lack task schemata and for those schemata that are present not to be comprehensive. These hypotheses, therefore, will enable the evaluation of the extent to which task relevant knowledge is lacking or unavailable in these subjects.

Hypothesis 2 - Interactions with Execution Behaviors

Since auditors are assumed to be purposeful decision makers, execution behavior is sufficient evidence of an intent to transform a task environment. Auditors employ many different execution procedures for this purpose and the objectives of these procedures differ. Some execution behaviors are like perception behavior in that they are intended to acquire information, except that they are taken in circumstances in which an auditor believes that required information or data exists outside the work environment. Other execution behaviors are intended to create, modify, or dispose of entities and relationships in the task environment. However, regardless of the overarching objective, an auditor's proximal objective in performing execution behaviors is always to bring about specific environmental transformations. By their nature, such transformations are always made in the face of physical, technological, or social barriers (hereafter referred to as "environmental barriers"), the surmounting of which became sub-tasks whose solutions must precede further progress in the main task.

Execution behaviors are habitually chosen whenever the situational cues in an auditor's current task circumstances sufficiently match those in which execution behavior habits were formed. The perceived physical, technological, and social circumstances in a particular task environment may be a source of sufficient variation in situational cues so as to interfere with habitual pursuit of a transformation objective.[10] In such cases, any cognitions associated with execution behaviors signal the presence of cognitive barriers which reflect the state of an auditor's knowledge base. Let us first consider lack of knowledge as a cognitive barrier. As discussed under hypothesis 1, uncertainty cognitions are sufficient evidence of a lack of knowledge. Since execution behaviors are always taken in the face of barriers, if an auditor has developed a habitual execution response to uncertainty which is not otherwise thwarted by a barrier, then task-specific execution behaviors will be immediately preceded by uncertainty cognitions. Additionally, if an auditor lacks knowledge about execution procedures appropriate in any given circumstances, then automatically chosen execution behaviors of a general (i.e., non-task-specific) nature[11] will be immediately preceded by uncertainty cognitions. Thus, with respect to observed problem solving behaviors:

H2a: Execution behaviors will be preceded by uncertainty cognitions to the extent that knowledge is lacking and automatic responses to uncertainties are not thwarted.

Now let us consider cognitive barriers other than lack of knowledge. Auditors may be knowledgeable about the performance of various execution behaviors, as well as about the nature of the transformations produced by each. However, in an unfamiliar task situation, situational cues alone will not be sufficient to evoke an appropriate execution behavior. Rather, an auditor must become aware, by means of an internal cue such as an analysis or planning cognition, of the immediate targets and objectives of any prospective actions before appropriate execution behaviors can be evoked. Hence, where knowledge is unavailable and the information requirements of schematic lacunae are consciously anticipated, cognitions immediately preceding execution behaviors will concern analysis and planning, regardless of the nature of any overarching objectives. Therefore, regarding observed problem solving behavior, we state:

> **H2b: Execution behaviors will be preceded by analysis and planning cognitions to the extent that knowledge is unavailable or information needs are consciously anticipated.**

Novice auditors are unfamiliar with a task situation and have not developed complex production systems for execution behaviors. Consequently, they employ simpler, more elemental productions, with the sequence of behaviors closely monitored by mediating cognitions. For these reasons, we expect that there will be a significant association between analysis and planning cognitions and execution behaviors.

Hypotheses 2a and 2b address a subtle but important difference in the mechanisms associated with execution behaviors. An auditor behaving as specified by hypothesis 2a knows how to obtain information which is lacking, *even if what is lacking is task-relevant strategic knowledge*. In the latter case, non-task-specific execution behaviors are employed. Further, that knowledge of execution behaviors which is used is so well learned and the surrounding circumstances so familiar, that the behavior is evoked automatically. Hypothesis 2b, on the other hand, addresses the unavailability of knowledge already present in long-term memory. However, because analysis and planning cognitions constitute the internal cues necessary to access that knowledge, the level of familiarity with the circumstances in which the execution behaviors are taken is much lower than those surrounding the automatic behaviors covered by hypothesis 2a.

DATA, FINDINGS, AND DISCUSSION

Data

Russo's data base of problem solving behaviors[12] was examined in light of the preceding hypothesized relationships. Data used were based on frequency counts of the number of times a behavior of a given type was followed by a behavior of a different type. The behavior sequences were those specified by the respective hypotheses. Table 2 shows the frequencies of behavior sequences for all four subjects as a group. These sequences are grouped into empirical behaviors

associated with preceding analysis and planning cognitions, and those associated with preceding uncertainty cognitions.

TABLE 2

Empirical Behaviors and Associated Preceding Cognitions

	Frequencies			Percentages		
	Percep-tion	Execu-tion	Total	Percep-tion	Execu-tion	Total
Uncert-ainty (See note)	99	49	148	44.2%	22.6%	33.6%
Analysis & Planning	125	168	293	55.8%	77.4%	66.4%
Total	224	217	441	100.0%	100.0%	100.0%

Chi-square for this table rejects the null hypothesis that non-habitual perception and execution behaviors are accessed in the same way ($X^2 = 22.138$, df = 1, $p < .0000$). Rejection of the null supports the alternative hypothesis that there are significant differences in the access to perception and execution behaviors. The data support the position that uncertainty cognitions are more associated with non-habitual perception behaviors than with execution behaviors and that analysis and planning cognitions are more associated with non-habitual execution behaviors than with perception behaviors.

Note: Expressions of confusion are not separately coded in the data base. They are included with uncertainties and self-assessments. The frequency of self-assessment cognitions is insignificant in this experiment and not included in this analysis.

Findings

The data show that among non-habitual behaviors, perceptions were preceded by uncertainty cognitions 44 percent of the time compared with only 23 percent of the time for executions. Seventy-seven percent of non-habitual execution behaviors were preceded by analysis and planning cognitions compared with 56 percent of non-habitual perception behaviors. A chi-square test of these data rejects the null hypothesis that non-habitual perception and execution behaviors are accessed in the same way ($X^2 = 22.1$, $p < .0000$); procedural knowledge of perception and execution behaviors may be unavailable, but for different reasons. These findings show a significant interaction between the presence of environmental barriers to selecting and carrying out problem solving procedures and the state of an auditor's knowledge base. For example, environmental barriers to information acquisition may force use of less familiar execution rather than more familiar perception behaviors. They thereby create intervening sub-tasks focused on overcoming these barriers, and in doing so, they place a different demand on the knowledge base than that placed by the original information acquisition objective.

Interpreting these results in light of hypotheses 1 and 2, the data are consistent with the positions that, for these auditors, (a) their use of non-habitual perception behaviors is more strongly associated with a lack of knowledge than is their use of execution behaviors, and (b) unlinked or weakly linked knowledge is the major factor associated with their use of non-habitual execution procedures. Both of these conditions contribute to the amount of time required to complete an auditing task. The findings suggest that delays in these subjects' problem solving efforts are associated with a lack of knowledge which necessitates devoting more time to constructing an adequate representation of the task situation, and an unavailability of knowledge which necessitates conscious deliberation in selecting appropriate execution procedures.

Discussion

Consistent with the research paradigm discussed earlier, the findings and interpretation presented derive from data selected for analysis based on empirical behavior. Inferences regarding the state of the knowledge base were then made based on the preceding cognition. This method of data selection is sufficient to establish association but not causality. Because additional theoretical development is required, analysis of causality has been deferred to a future paper. Further, the findings assume that the environment in which these experiments took place is a reasonable simulation of an actual auditing environment.

Because the subjects in this experiment were not randomly selected, the use of statistical tests of significance in this paper is valid only if it is assumed that the observations tested represent independently chosen random samples from the ongoing and constant problem solving processes of this group of auditors. Under this assumption, inferences may be made as to the behavior of these auditors in similar task situations or over different observation periods during the same task. That the underlying problem solving process observed is constant over time is an arguable assumption.[13] Therefore, the outcomes of reported statistical tests of significance should be

interpreted and used with caution. The conclusions drawn should be taken as being only suggestive of what may be the case in the larger population of novice auditors and in future replications of this experiment. However, descriptive statistics presented in this study are facts as applied to these particular subjects, and in that use, statistical tests of significance are unnecessary.

SUMMARY AND INDICATIONS FOR FURTHER RESEARCH

Summary

This paper has examined access to procedural knowledge, one aspect of the problem solving processes of auditors under field conditions. It is basic research intended to add to the growing body of knowledge upon which to base efforts aimed at improving practitioner performance. The major theoretical conclusion drawn is that an auditor's access to procedural knowledge in field situations is associated with the interaction of two major factors. The first of these factors is the state of an auditor's knowledge base. The second factor is the presence of barriers in the task environment which thwart an auditor's habitual problem solving behaviors.

Observed auditor problem solving behaviors are understandable in terms of the crossbreak of the two factors mentioned. Lack of knowledge gives rise to cognitions reflecting uncertainty and confusion while unavailable knowledge generates analysis and planning cognitions. Perception behaviors (1) reflect an auditor's belief that sought information exists and is available in the work environment, and (2) reveal an absence of barriers which interfere with an auditor's habitual response to a need for information. Execution behaviors reflect (1) the belief that sought information either does not exist or exists outside the work environment and (2) an intention to transform the task environment. Hypotheses based upon the preceding understanding were supported by observations of the problem solving behavior of four first-year auditors performing an empirically intense task in simulated auditing environments. A significant interaction was found between the presence of environmental barriers to problem solving behaviors and the state of an auditor's knowledge base. As expected of novices, significant associations were demonstrated between (1) perception behaviors and uncertainty cognitions, and (2) execution behaviors and analysis and planning cognitions. From a performance perspective, the findings suggest that delays in these subjects' problem solving efforts are associated with a lack of knowledge which necessitates devoting more time to constructing an adequate representation of the task situation, and an unavailability of knowledge which necessitates conscious deliberation in selecting appropriate execution procedures.

Indications for Further Research

The investigations described in this paper are necessarily broad and carried out at a very general level. They clearly represent an early stage of study, laying a foundation for further investigation. For this reason, the hypotheses proposed in this paper have been stated in positive rather than in the more traditional null form. This form reflects their intended use as investigative

probes in future research. The "to the extent that..." formulation used indicates the potential role of these hypotheses in anticipating ordinal measures of the effects of the factors mentioned. For example, the subjects in this experiment had no previous exposure to the task and task environment used in the simulations. Hence, both were very unfamiliar to them (Russo 1995) and the reported findings conform to expectations under such circumstances. However, application of the hypotheses to more familiar tasks and different task environments should produce different but predictable ordinal expectations. This is a matter for future research. Finally, because the subjects in this experiment were not randomly selected, findings reported in this paper are only suggestive of what may be true of the novice auditor population in general. Replications are needed to provide a greater level of comfort in the findings than that provided by the evidence presented here.

ENDNOTES

1. The term "task" will be used to refer to the demand which an auditor perceives being made for professional performance within constraints of personal and professional standards, resource availabilities, and other limitations. The term "task environment" will be used to refer to an auditor's cognitive representation of physical and social surroundings and circumstances within which a task must be performed. Thus, neither "task" nor "task environment" are terms that are to be understood in the sense of an objective reality. The term "work environment" is a subset of the task environment and consists of all documents and resources immediately available to an auditor's sensory perception without overt alteration of the task environment. The term "task situation" will be used to refer to the totality of the task and task environment.

2. Knowledge may be classified as to content and form. For purposes of this research, it is most suitable to classify the content of an auditor's knowledge into three categories: existence, process, and strategic. Existence knowledge consists of knowledge of relevant entities and relationships among entities in a domain. Process knowledge consists of knowledge of the dynamic processes accounting for the behaviors of entities. In this paper, existence and process knowledge will be referred to as schematic knowledge. Finally, strategic knowledge consists of knowledge of the behaviors by which an auditor can affect entities, relationships, and processes so as to achieve objectives. When used without qualification, the term "knowledge" will refer to knowledge of any kind.

Anderson (1983) differentiates knowledge as being either declarative or procedural in form. Declarative knowledge consists of knowledge which can be expressed as symbols and relationships among symbols. Procedural knowledge is a form of strategic knowledge. Although it can be in declarative form, to an extent increasing with experience, most strategic knowledge is compiled into productions which are carried out automatically, that is, without cognitive involvement. In this paper, strategic knowledge which exists in memory as productions will be referred to as procedural knowledge.

3. "Empirical" is used as a collective term for all perception and execution behaviors which are normally observable of auditors in the field. In this respect, cognitive behaviors are not empirical since cognitions are not observable under field conditions. Cognitions are assumed to be related to the empirical behaviors which follow them. The term "cognitive-empirical interaction" is used to represent the influence of cognition on immediately following empirical behaviors.

4. See Mayer (1992) for an extensive review. The following discussion draws heavily on research described by Mayer.

5. The discussion which follows is most easily interpreted in terms of a connectionist model of memory structure (see Rumelhart 1989 for a review). In such models, knowledge is represented in the pattern of activated knowledge microfeatures (nodes) which are linked in

memory. Unlinked microfeatures cannot be accessed directly. The potential knowledge they may represent, therefore, is unavailable. Dennett (1991) has proposed that cognition, along with speech, writing, and other conscious forms of behavior, is one means which has evolved for indirectly activating microfeatures of knowledge which are not directly (neurologically) linked in memory. The discussion in the text uses the term "virtual link" to represent this form of indirect knowledge activation.

6. All non-habitual empirical behavior is necessarily preceded by cognition. However, a finding that an empirical behavior was preceded by cognition does not necessarily imply any association between them. For example, in order to establish a causal relationship, the strongest form of association, it must be shown that a cognition was on the access path terminating with evocation of an observed procedure. However, habitual behavior may also be evoked by covert perceptions which occur during a cognitive episode (e.g., a sharp unexpected loud noise which evokes a learned or instinctive defensive response). In such instances, there would be no association whatever between the observed behavior (e.g., the defensive response in the preceding example) and the immediately preceding cognition. However, in the absence of evidence to the contrary, the presumption of an association between an observed behavior and the immediately preceding cognition is a reasonable one to make.

7. Specifically, it is assumed that expert auditors are so familiar with a task environment and so practiced with a task that their problem solving processes consist of an uninterrupted sequence of habitually chosen perception and execution behaviors. This assumption functions as an ideal standard for analytical purposes rather than as a realizable standard of expert performance.

8. An auditor's belief regarding any aspect of a task situation is his/her knowledge of that aspect at the moment the belief is expressed. Beliefs may be expressed directly in words or thought or indirectly by their effects on behavior. An auditor will be unable to carry out a habitual reading behavior if he/she does not believe that the information sought exists and is available in the work environment.

9. For brevity, unless otherwise stated, the term "uncertainty" will be understood to include "confusion."

10. Environmental barriers may also arise from an absence of perceived challenge to an auditor's erroneously held beliefs.

11. A task-specific behavior is one intended to directly further attainment of a solution state. Research cited by Bedard & Chi (1993) shows that where auditors lack task-specific strategies, they revert to more general problem solving behaviors. It is suggested in the present paper that in an auditing environment where they are not thwarted, these behaviors are intended to address a sub-task whose objective is to acquire strategic knowledge, e.g., how to acquire needed information, rather than to directly further the attainment of a solution state. Acquisition of task-specific information required by an auditor's situation schemata (a type 3 cognitive barrier

in the text) is not a deficiency in an auditor's knowledge base.

12. For details of the model, experimental design, data collection, and analysis, see Russo (1995). At the level of data aggregation used in this paper (see the Appendix), kappa (Cohen 1960), a measure of agreement between independent coders, ranged from .7158 to .7478, all significant at $p < .0000$.

13. For example, learning may take place during pursuit of the task and, because of evolution of the task environment resulting from an auditor's previous problem solving behaviors, later observation periods may present a task situation quite different from that present during earlier observation periods.

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APPENDIX

PROBLEM SOLVING BEHAVIOR CATEGORIES

PERCEPTION: Behavior intended to acquire information present in the work environment.

Code	Assigned when the subject:
p1	is reading.

COGNITION: Conscious mental activity.

Code	Assigned when the subject:
c1	is planning - Subject states an objective or an action he/she considers taking.
c2	is analyzing - Subject states an assumption or draws a conclusion about the state of the task environment, or summarizes for himself/herself personal knowledge of some aspect of the task environment.
c3	expresses uncertainty about the task environment - Subject states a question or expresses uncertainty about specific entities, relationships, or processes in the task environment.
c4	expresses uncertainty about the task - Subject expresses uncertainty about strategy, objectives, or how to proceed in the task.
c5	makes a self-assessment - Subject makes a statement about the difficulty or complexity of the task, an aspect of the task or task environment; an assessment of his/her state of mind, feelings.
c6	monitors his/her performance - Subject makes a statement expressing his/her progress toward a solution; a statement about his/her performance in the task or about the quality of his/her work; a statement showing concern about how others may evaluate him/her, his/her work or performance in the task; expresses concern for violating a budget constraint, role behavior, or a norm.

EXECUTION: Behaviors intended to transform the task environment.

Code	Assigned when the subject is:
x1	requesting - Subject is requesting information or a document from someone in the task environment.

x2 calculating - Subject is verifying a calculation or performing an original calculation

x3 writing - Subject is writing a memo or workpaper (other than p1 or x4), cross-referencing, indexing, or comparing documents.

x4 preparing his/her report - Subject is writing the draft of his/her report or organizing his/her engagement folder.

x5 engaged in other execution behaviors - Subject organizes his/her work area or searches the work area for a document, discards a document.

UNCLASSIFIED BEHAVIORS

b Time spent performing behaviors other than those captured in the above categories.

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