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Problem Solving Behavior in Novice Auditors: An Iterative Model, Methodology, and Early Findings

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SUMMARY

This paper presents initial findings from a program of research concerning the problem solving behaviors of novice auditors. The study of novice problem solving behaviors can provide insights into the nature of expertise and how it is acquired. An iterative model of auditor problem solving behavior is presented which explicitly incorporates the context within which auditing tasks are performed. Four auditors with one year of professional auditing experience were video and audio taped as they carried out simulated review engagements in a domain of audit practice to which they had no previous exposure. The subjects' observable and cognitive behaviors were analyzed in terms of the model and compared with an *a priori* expectation of novice problem solving behavior.

The major conclusions drawn from the model are: (1) auditors follow predictable patterns of problem solving behavior; (2) behaviors following perceptions and executions are indicative of the levels of recognition and recall which reflect familiarity with the task and task environment. Empirically, the data generated from these experiments support the position that the participants behaved as novice auditors. These data, therefore, can serve as a basis for further exploration of auditors' problem solving behaviors and establish benchmarks for future expert/novice comparisons. Extensions of these findings and the direction of further research are discussed.

INTRODUCTION

This paper presents a model of auditor problem solving behavior and an observation methodology which explicitly take into account the context within which auditing tasks are performed. The model and methodology are applied to the creation of a database of problem solving behaviors of four novice auditors conducting simulated review engagements.

The Cognitive Emphasis of Behavioral Research in Auditing

Auditor judgment and expertise are the subjects of a considerable body of literature.[1] Almost by definition, judgment and expertise are concerned with how auditors solve problems. Bamber's (1993) recent examination of the auditing research in this area leads him to conclude that, while in non-auditing research the focus is on contextual variables, in auditing, the primary focus is on understanding auditors' cognitive processes. This cognitive emphasis generally reflects a data-processing orientation built upon Newell and Simon's (1972) model of the human information processing system (HIPS).

The cognitive/data-processing emphasis of the research outlined above virtually excludes consideration of auditors' problem solving behaviors which are observable in the field. Research by Bandura (1978), Watson (1985), Gibbins and Newton (1993), and others clearly point to a need to consider the effect of interaction among auditor problem solving behavior, task environment, and auditor cognitive processing. In the field, auditors are constrained by their task environment, react to it, and by their very own data acquisition and solution execution behaviors, alter it. Hogarth (1991), after reviewing cognitive research in auditing, concludes that, to date, this research has been too narrowly focused on specific tasks in isolation from the remainder of the context in which auditing tasks are performed. The present paper is an early attempt to address this oversight.

Organization of This Paper

The remainder of this paper is organized in six sections. Section 1 presents an iterative model of auditor problem solving behavior. This model was used to analyze the problem solving behaviors of four auditors as they pursued simulated engagements involving an unfamiliar domain of audit practice. Section 2 discusses a methodology for observing and capturing problem solving behaviors. Section 3 proposes a hypothesis which establishes the suitability of the data obtained from this experiment for future task and expert/novice comparisons. The experimental design and analytical methodology are discussed in Section 4 and findings are presented in Section 5, along with additional discussion. Finally, Section 6 presents a summary and indications for future research.

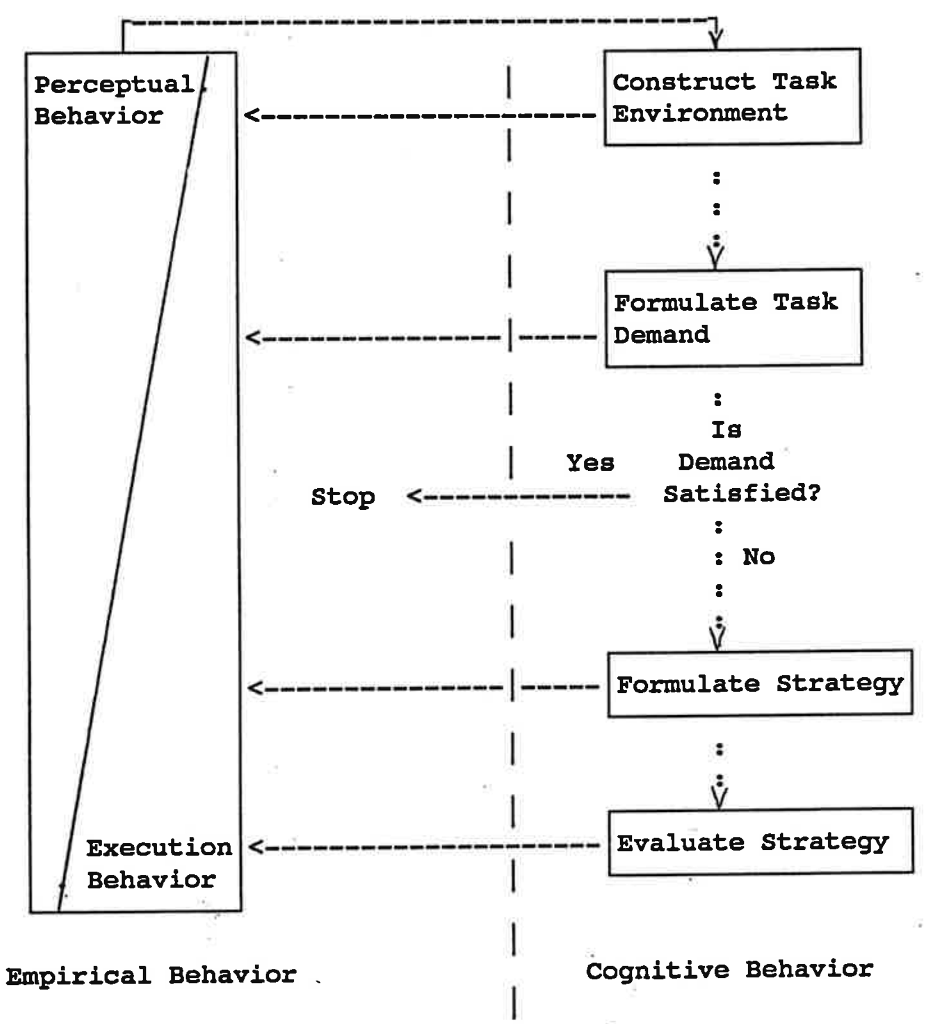
1. AN ITERATIVE MODEL OF AUDITOR PROBLEM SOLVING BEHAVIOR

Major Categories of Problem Solving Behavior

Figure 1 shows in schematic form an iterative model of the problem solving process of auditors in the field. The model posits that auditor problem solving behaviors are composed of empirical behaviors, which can be directly observed, and cognitive behaviors, which cannot normally be observed.

Figure 1

Iterative Model of Auditor's Problem Solving Behaviors



Empirical behaviors, in turn, can be categorized as perception and execution behaviors. Perception behaviors are activities through which an auditor acquires knowledge of the task environment,[2] and include, among others, such activities as reading documents and receiving information verbally, as over the telephone. Execution behaviors are activities by which an auditor alters the task environment in some purposeful way, and includes, among others, such activities as requesting documents, performing calculations, creating memos and workpapers, and organizing documents. Cognitive behaviors, which are not observable and not accompanied by any observable behavior, include the data processing and cognitive activities through which an auditor assimilates, evaluates, and otherwise processes perceptions and information in working memory.

Model Operation

Problem solving proceeds through a sequence of iterations consisting of periods of directly observable empirical (perception and execution) and unobservable cognitive behaviors. During any interval of time in which the behavior of an auditor is observed, we are very likely to see a mixture of the two observable behaviors mentioned as well as periods in which we observe no meaningful task related behavior at all. During the latter periods, an auditor may be engaged in cognitive activity, such as evaluating the outcome of a test or considering the implications of possible further testing. The only evidence of possible cognitive behaviors at these times is an apparent lull in empirically observable task related activity.

The solution to an auditor's task is a transformation of the task environment. Iterations of the model continue until an auditor perceives that the task environment has been altered to such an extent that (1) the demand he/she perceives for professional performance has been extinguished, and (2) the solution achieved does not violate personal and professional standards, the engagement budget, or any other task constraints. The relative mix of perception, cognition, and execution behaviors which an auditor follows in achieving a solution to the task is his/her solution strategy.

Model Assumptions

The model of auditor problem solving behavior described above makes two assumptions, both of which are consistent with the generally accepted model of the HIPS. First, it assumes that all auditors employ effort minimization strategies within a cost/benefit context. The HIPS, for example, employs various techniques and structures in order to make the most efficient use of limited cognitive resources (Simon 1976, and others). Studies by Scribner (1984), Lave et al. (1984), and others show that experts also employ strategies which reduce physical effort. Compared with novices, experts are better able to employ cognitive and physical effort reduction strategies which are consistent with their objectives. Second, the model assumes that all auditors are purposeful problem solvers; that is, they choose actions which they perceive to be appropriate to the achievement of their objectives. To do so, all auditors possess a minimum level of general and domain knowledge so as to be capable of comprehending the task environment and the demand being made on them for professional performance. This assumed minimum is that body of knowledge which qualifies one to sit for the CPA examination.

Comparative Advantages of the Iterative Model

Compared with decision models of information economics, the iterative model remains within the capabilities of each individual HIPS in that it does not require evaluations to be made over complete sets of alternative possible outcomes, does not require specification of probability distributions applicable to the evaluations of expectations over these sets of alternatives, or the generation of forecasts. It is a satisficing rather than optimizing model and explicitly takes into account the fact that an auditor is personally an important part of the task environment, affecting it as it affects him/her. Because the model operates iteratively, it provides an explanation for the evolutionary manner in which auditors often solve problems.[3] Finally, the model is recursive. That is, the same model which explains the solution process for an auditor's task also explains the solution process for sub-problems that arise out of and in the course of dealing with that task.

2. BEHAVIOR OBSERVATION METHODOLOGY

A complete study of problem solving behaviors requires a methodology which captures both the normally observable behaviors of auditors in field situations as well as their cognitive processes. In the research described in this paper, the former are captured on video tape while the latter are captured on audio tape. Concurrent verbal protocols are the verbatim transcriptions of the verbalized thoughts of experimental subjects, captured on audio tape, as they go about a task. This methodology is well established in behavioral auditing research and, therefore, will not be discussed further here.[4] The use of video tape, on the other hand, is relatively rare in auditing research.[5] Consequently, the following paragraphs will discuss behavior observation and the specific adaptations of this methodology to auditing research.

Behavior Observation

The systematic observation of behavior is widely used in social science research. Arrington's (1943) review and evaluation of time sampling methodology appears to mark the start of modern approaches to behavior observation. Extensive reviews of current behavior observation methodology and its use in behavioral science research are provided by Kent and Foster (1977) and Cooper et al. (1987). The basic technique involves one or more researchers observing the behaviors of the subject(s) during fixed intervals of time, according to a predetermined sampling plan. The sampling plan specifies what behaviors are to be recorded, how the observation intervals are to be selected, their number, and duration. The objective of the sampling plan is to make a sufficient number of observations so that behaviors observed during the periods sampled are representative of behaviors which occur in general. Although historically, behavior observation has been conducted *in vivo*, with the introduction of modern video technology, video recordings of behavior have become common in some areas because they are free from individual observer effects, can be viewed at convenient times and in convenient time segments, and can be reviewed numerous times to properly classify difficult to code time segments.

The following conditions require that protocols of cognitive processes be augmented by the systematic observation of empirical behavior:

1. The task has a high degree of empirical intensity. An empirically tense task is one in which the solution strategy requires significant interaction with or transformation of a subject's task environment.

2. The solution is represented by a transformation of a subject's physical or social environment. Purely cognitive information fails to give evidence on the transformations which take place.

3. There is a need for the subject to interact with his/her environment. In many cases, interaction is non-verbal and habitual.

4. Constraints and potential resource limitations are present to a significant extent. Information regarding normal behavior where constraints are not challenged or resources are not binding is generally not available in the verbal protocol.

5. There is a need to disambiguate the verbal protocol.

6. The task is one which a subject performs automatically or habitually.

7. The research question is one which can only be answered by observing empirical behavior.

Adaptations for Observing Auditor Problem Solving Behavior

Behaviors recorded on audio and video tapes are coded in terms of the three major categories of problem solving behaviors specified by the iterative problem solving model, i.e., perception, execution, and cognitive behaviors. See **Appendix** for a description of behaviors included in each of these categories. In some cases, information obtained from the video or audio tape alone is sufficient to categorize a behavior. In other cases, information from both the audio and video tapes must be combined to determine the categorization. Because problem solving behavior over the course of an auditing task may not be consistent, the usual behavior observation procedures of time sampling must be replaced with continuous behavior observation. In this modification of procedure, the total solution time is divided into 3-second frames and behavior in each frame is observed and coded in terms of the 23 unit behaviors listed in Table 1. Only the first 2100 frames of each subject's behavior were used for the analyses reported in this paper.[6]

Table 1

Unit Behaviors

Ongoing behaviors:
inactive, waiting, requesting, reading, writing, footing, compare/tick, cross-reference/index, operating calculator

Single frame behaviors:
operate intercom, organize, search, underline, copy, affix/attach, erase, cut

Instantaneous behaviors:
grasp, discard, tick (one object), read/look intercom, flip, scan, place, read/scan timepiece (watch), point

The audio and video protocols were coded independently by the author and a first-year doctoral student trained by the author. Major differences in coding were discussed and resolved where possible. If resolution was not possible, the matter was submitted to a third party, an experienced auditor who had participated in coding some of the protocols from pilot experiments, for evaluation. If, after this appeal, agreement still could not be reached, the difference in coding was allowed to remain. Following this procedure, the intercoder agreement for all subjects, measured by the ratio of the number of frames in which both coders agreed to the total number of frames coded, for all subjects, ranged from 81.93 percent to 85.39 percent. The kappa coefficients for the coded data (Cohen, 1960) ranged from .7477 to .7871, all significant at $p < .0000$. These levels of agreement are within the range of those found in verbal protocol studies in accounting.[7]

3. THEORETICAL DEVELOPMENT AND RESEARCH HYPOTHESIS

The iterative model of auditor problem solving behavior predicts the four basic sequences of two behaviors each, which are summarized in Table 2. This section discusses how these sequences were derived. The sequences are then used as a basis for the research hypothesis.

Table 2

Summary of Behavior Sequences

Sequence type	Behavior pattern	Task characteristics	Environment characteristic
A	p——>c——>	Unfamiliar	Blocked perception
B	x——>p——>	See notes	Blocked perception
C	p——>x——>	Familiar	Blocked perception
D	x——>c——>	Unfamiliar	No perception barrier

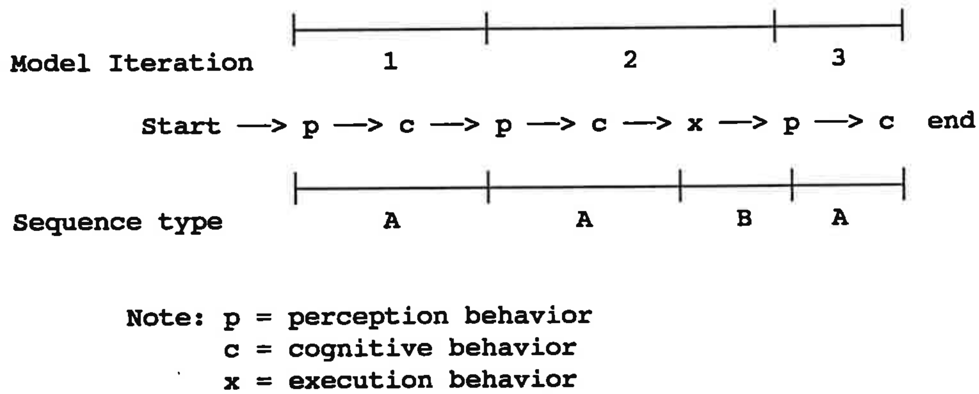
Notes: p = perception, c = cognition, x = execution. Type B behavior sequences are not informative with respect to task unfamiliarity/familiarity since this task characteristic is indicated by the presence or absence of a cognitive behavior following an explicit (types A or C) or automatic (type D) perception.

Basic Behavior Sequences

A literal tracing of the iterative process diagrammed in Figure 1 suggests that the following basic sequences of behaviors are possible: perception followed by cognition (type A), and execution followed by perception (type B). Types A and B sequences combine in various ways to produce an auditor's solution. The three model iterations diagrammed in Figure 2 illustrate one possible solution sequence.

Figure 2

An Example of a Complete Solution Strategy



To the extent that any behavior is automatic or habitual, we will not observe any activity indicative of cognitive processing. For example, reading is an automatic behavior for most people. Therefore, we do not observe people in the process of acquiring each letter, sequencing letters into words, then searching long-term memory for the word and its meaning. Rather, although some form of recognition and recall process is taking place, we only observe a smooth, ongoing reading behavior. The interruptions signaling cognitive behavior become evident, however, when an unfamiliar word or an unusual context is encountered. Hence, we see that cognitive behavior is a sign that something in the perceived task environment is unfamiliar.

The general principle enunciated above has several implications. First, to the extent that perceptions obtained from the environment are very familiar, knowledge is highly available. In such cases, no cognitive effort must be expended bringing that knowledge into short-term memory or applying it. Thus, the —>c fragment in any sequence of behaviors will be absent and any empirical behavior will be immediately followed by another empirical behavior. If that behavior is of the same type, then it is considered as a continuation of the previous behavior, but for a longer duration. Second, if there are no barriers to the reception and physiological encoding of physical stimuli emanating from the task environment, then the p—> fragment in any sequence of behaviors will be absent and any execution behavior will be followed either by cognition or, following the preceding convention regarding successor behaviors of the same type, a continuation of execution behavior for a longer duration. Barriers to stimulus acquisition are a consequence of the technological and physical circumstances of the task and task environment. These are parameters in a given task situation. In this paper, we will focus only on the interaction between empirical behaviors and knowledge availability, leaving the effect of the task and task environment parameters for a future paper.

Quantifying Task Unfamiliarity

Now let us observe for identical periods of time the problem solving behaviors of two auditors confronting the same initial task environment. Assume that the first auditor is very familiar and the second very unfamiliar with the task and task environment. The complete sequence of each auditor's problem solving behaviors observed during this period will be referred to as his/her solution sequence. We can describe each auditor's solution sequence in terms of A, B, C, and D behavior sequences. From the preceding discussion, familiarity reduces the incidence of —>c behavior fragments in a solution sequence. Consequently, we can expect that, compared with that of the second auditor, the solution sequence of the first auditor will reflect a relative absence of types A and D behavior sequences. The presence of a cognition following any explicit or automatic perception, as in types A and D behavior sequences, respectively, is a sufficient condition for concluding that an event has occurred in which knowledge was unavailable. On the other hand, the absence of a cognition following a perception behavior, as in a type C behavior sequence, is a necessary condition for concluding that knowledge was available;[8] if an auditor's solution behavior did not halt, then some schema must have been invoked.

Because A and D sequences unambiguously mark occasions of unavailable knowledge, and C behavior sequences provide strong evidence of knowledge availability, we may define a measure of task unfamiliarity, U_c, as the ratio of the number of information acquisition behaviors which were followed by cognitive behavior to the total of all information acquisition behaviors in the solution sequence. Let α, Γ, and δ represent, respectively, the frequencies with which A, C, and D behavior sequences occur in any given auditor's solution sequence. Then we may write:

$$U_c \equiv \frac{\alpha + \delta}{\alpha + \Gamma + \delta} \qquad [1]$$

U_c ranges from zero, indicating a complete absence of task and task environment challenges,[9] to a maximum which is a function of the number of barriers to sensory acquisition encountered in the task environment, but in no event can U_c be greater than 1. U_c is an ordinal level measure of the unavailability of an auditor's knowledge in a given task and task environment, permitting relative ranking of auditors along this dimension.

Research Hypothesis

Based on the preceding discussion, we hypothesize, in positive form:

H1: In an unfamiliar task situation, each empirical behavior will be followed by cognitive behavior.

"Unfamiliar" in the sense used here means that the task is one with which the subject has some experience, but not sufficient experience to significantly automate pursuit of the task. Unfamiliarity is an essential prerequisite if one is to study the acquisition of expertise which is presumed to develop only after repeated encounters with a task renders the task a familiar one. Since task unfamiliarity is indicative of a novice auditor, a high value of U_c signals novice behavior.

The hypothesis is a prediction concerning individual perception or execution behaviors. However, during the pursuit of an empirically intense auditing task, some behaviors may be taken in circumstances which satisfy the conditions of unfamiliarity and some may not. Thus, aggregated over a task, the outcomes from testing the hypothesis will be in terms of a degree of support rather than in terms of a decision to reject or not reject as in classic hypothesis testing. Data supporting this hypothesis establish a benchmark for the degree to which this simulation represents an unfamiliar task situation for the subjects. On the other hand, data which fails to support the hypothesis is indicative of the habitual or automatic problem solving behavior often observed in experts performing empirically intense tasks, i.e., behavior which is characterized by a sequence of alternating perception and execution episodes.[10]

The preceding discussion argues that problem solving behavior sequences are not random. Rather, the model shows that there are predictable underlying relationships which link any given behavior with the immediately following behavior. The term "behavior governing process" (BGP) will be used to represent this unspecified set of relationships.[11] The significance of any findings of support for the hypothesis is left for future research. Further, no attempt is made in this paper to fully exploit the various forms of analysis or research issues which may be addressed using either the model, the methodology, or the data generated by the experiment. These are matters also left for future research.

4. EXPERIMENTAL DESIGN AND ANALYTICAL METHODOLOGY

The hypothesis proposed in Section 3 was tested by means of simulated review engagements in which the problem solving behaviors of auditor-subjects were recorded on video and audio tapes which were then analyzed for the behavior sequences derived from the model. The need to study auditor problem solving behavior in the most realistic setting permitted by time, facilities, and resources suggests using a task which is a simulation of an actual engagement. Such a setting allows for both the auditor-environment interaction of an actual engagement and for the use of the skills and extensive knowledge base which are characteristic of auditing as a profession.

Subjects

The costly and time consuming process of protocol analysis limits sample sizes, typically, to four subjects. The four subjects participating in this experiment, all women, were selected by a partner of a Big Six international auditing firm based on their availability and willingness to participate. All subjects were members of the audit staff in the same practice office. Each was unaware of the participation of the others in this experiment until the experiment was completed. The subjects were of approximately the same age (range 20 to 22 years), and had completed their first year with the firm. All had sat for and passed some, but not all, parts of the CPA examination. None of the subjects had any auditing experience prior to their current position or previous exposure to the subject matter of the simulation.[12] Because of the selection method used, these subjects cannot be considered as a random sample from a population to which inferences can be generalized. However, any findings from this sample are suggestive of what may be found in future studies of this kind.

Task

The task in this experiment is a simulated review engagement.[13] The subject of the review is the Statement of Operating Expenses of a new office building in which the client is a tenant. Each auditor-subject is assigned to perform the review and draft a report giving negative assurances concerning conformity of the Statement of Operating Expenses with the terms of the client's lease. The simulation materials consist of preliminary materials, the case, documents, and computer screens. Preliminary materials provide background information on operating expense escalations, two sample examination reports, and exercises for practicing thinking aloud. The case provides the engagement letter and background on the subject's firm and the client. Documents are those produced by and available from various parties in the simulated task environment. Finally, computer screens display the answers to information requests. Because the simulation materials are extensive, they are not included with this paper. They can be obtained from the author.

Laboratory Arrangement

The laboratory is set up to appear as much as possible like the landlord's business office. At her workplace, the subject has paper and other supplies, a calculator, a CRT display terminal, and an intercom which serves as a communication device. The researcher is stationed behind a partition in the laboratory. The partition is equipped with a mail slot through which documents can be passed to the subject.

Procedure

Each subject performed the simulation on a different day. Preliminary materials were given to each subject the day before she participated in the experiment. On the day of the experiment, prior to beginning the simulation, each subject was familiarized with the laboratory environment and the simulation procedure (described below). She was then given an unrelated concurrent verbalization warm-up task during which video and audio levels were adjusted. When the subject indicated that she felt comfortable with the laboratory environment and verbalization, the simulation was begun.

During the simulation, the researcher played the roles of the various parties in the environment. In these roles, the researcher responded to the subject's requests for information by sending information screens via the CRT display and/or by passing documents through the mail slot. There was no verbal or visual communication between the subject and the researcher at any time during the simulation.

The simulation proceeded as follows: The subject was given the case materials and told to begin verbalization. At any time during the simulation, and as often as desired, the subject was able to contact other individuals at her firm, the client, the landlord, or the landlord's auditor by means of the intercom. She then made her requests. The subject was free to request from any individual whatever documents or information she felt she required. The subject was not given a list of available documents or any advance indication as to who had any particular documents or information. As in the field, the subject was required to use information retrieved from her knowledge base and obtained from her task environment, plus the products of her cognitive processes, to properly direct her inquiries. If the individual the subject contacted was able to respond to the request, then the document or information was given to the subject via the mail slot or CRT display, as was appropriate. If the individual was not able to respond, then an appropriate reply, such as "I don't know" or "I don't have that information" was sent. The simulation proceeded in this manner until terminated by the researcher.

Induction of Verbalization

An unfamiliar task and task environment as well as cue variations induce verbalization of subjects' cognitions during their pursuit of a task.[14] In novice auditors, such circumstances are likely to challenge any self-assessments which may exist in long-term memory and create a need for explicit consideration of task and cue perceptions. As a consequence, the likelihood that automatic behaviors will be used is minimized. In expert auditors, on the other hand, greater familiarity with the task domain, a more extensive knowledge base, and superior knowledge organization are more likely to evoke automatic and habitual problem solving behaviors.[15]

Experimental Metrics

Metrics used in evaluating the experimental hypothesis are based on the four behavior sequences discussed in Section 3 and consist of frequency counts of the number of times a behavior of a given type was followed by a behavior of a different type. A behavior is classified as belonging to a major behavior category if it is one of the coded behavior sub-categories described in the **Appendix**.

5. FINDINGS AND DISCUSSION

Findings

Table 3 summarizes the subjects' behaviors during the experiment.

Table 3

Frequencies of Observed Behavior Sequences

Behavior sequence	Sequence type	Subject 1	Subject 2	Subject 3	Subject 4	Combined
p——>c	A	90	66	61	41	258
x——>p	B	31	41	34	20	126
p——>x	C	28	37	37	17	119
x——>c	D	32	53	86	52	223
Total		181	197	218	130	726

This table shows the frequency of each behavior sequence observed during the first 2100 frames of each subject's protocols. The combined column is the sum of the row frequencies.

This table was derived from analyses of each subject's problem solving behaviors over the first 2100 frames of the task. Values for U_c are shown in Table 4. Although there is some variation, the high values of U_c in the table strongly support the hypothesis. These subjects as a group and individually appear to be very unfamiliar with the task and/or the task environment. On this basis, they may be considered as novice auditors. Consequently, the data generated from this experiment can serve as a source of benchmarks for further examinations of novice problem solving behavior and in future experiments intended to understand the acquisition of expertise.

Table 4

Task Unfamiliarity (U_c)

Subject 1	Subject 2	Subject 3	Subject 4	Combined
.8133	.7628	.7989	.8455	.8017

This table shows for each subject's solution sequence and combined for all subjects, the proportion of explicit and automatic perceptions which were followed by cognitive behavior. Each instance of cognitive behavior is a sufficient indicator of unavailable task and task environment knowledge. U_c can range from a minimum of 0 to a maximum of 1. High values of U_c are indicative of novice problem solving behavior.

Discussion

Several aspects of this research have special implications for application of the model and methodology and interpretation of findings.

Application of the model and methodology. The model and methodology presented in this paper can be used to objectively measure certain attributes of behavior in the performance of auditing tasks under field-like conditions. In the field, auditing tasks 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. The application of a considerable body of domain and task knowledge.

Given the preceding characteristics[16] and in light of the findings of this research, if a task is unfamiliar to an otherwise knowledgeable individual, the solution sequence can be expected to consist of a large number of behavior sequences, a significant proportion of which will represent cognitively mediated transitions between empirical behaviors. Such terms as "large," "significant," and the like, used in the preceding discussion, admittedly lack precision. However, they are terms commonly used in practice and the auditing literature. Discussions on the use of such terms with respect to adequate sample size, acceptable confidence levels, materiality, and the like, are familiar examples which can be validly repeated and applied here. Consequently, we may reasonably assume that auditors and auditing researchers can recognize when the specifications mentioned above have been satisfied, and that, in fact, they are satisfied in this experiment.

Operationalization of knowledge unavailability. The concept of availability as applied to knowledge can be operationalized along two different dimensions. The first of these is scope, which captures the occasions when the path to knowledge retrieval crosses the boundary from unconscious recognition and retrieval into the realm of conscious information search and recall. Scope is a positive function of the number of conscious accesses to data in memory. U_c (equation 1) is an operationalization based on scope. The second dimension of knowledge availability is depth. Depth captures the extent of the effort required to find needed information, and is a positive function of the duration of cognitive processing episodes.

For the moment, there does not appear to be a satisfactory means of capturing both scope and depth in a single availability metric. The difficulty lies in how to equate the two such that different degrees of both might still equate to equal levels of "availability." In view of this difficulty, the relevant question appears to be: For any particular purpose, which aspect of availability, depth or scope, is the more relevant? For the study of cognitively intense auditing tasks, such as those commonly employed in laboratory experimentation to study judgment and decision making, depth appears to be the more relevant conceptualization. On the other hand, for the study of empirically intense auditing tasks, scope appears to be a more relevant concept. In any case, the data base includes information regarding the duration of all behaviors, and these will be examined in future studies in this project.

The meaning of "novice". The empirical finding presented in this paper is that the data obtained from the simulation experiments represent novice problem solving behavior. This conclusion is based on the unavailability of task relevant knowledge. Conventionally, however, experience is used as a guide in classifying as novices individuals with very limited domain experience. Recently, this criterion has been called into question in favor of task-specific knowledge (e.g., Ashton 1991). In this experiment, the iterative model was used to predict the expected behavior of auditor-subjects who satisfied both the conventional and more recently suggested classification criteria. Early findings reported here are consistent with both notions of novice classification.

On a more general plane, all auditors encounter situations with which they are to some extent unfamiliar. Considered from this perspective, "expert" and "novice" begin to loose significance as descriptive terms. For example, one may be "expert" with respect to a particular knowledge domain, but not with respect to the activities of and/or auditing procedures appropriate to a new client operating in that domain. Consequently, studying the problem solving behaviors of auditors in unfamiliar situations is valuable at all levels of practice.

U_c as an indicator of novice/expert behavior. The standard for interpreting U_c is the behavior of one who has performed a task successfully so often that an automated problem solving procedure exists in long-term memory. Under this standard, a significant absence of automatic or habitual behavior in a particular task is a sufficient indicator of novice behavior. On the other hand, significant automatic or habitual behavior does not necessarily signal expert behavior. Expertise is a complex phenomenon comprising not only high levels of knowledge availability, but also the comparative efficiency and effectiveness of behavior choices. Without additional consideration being given to the nature and sequence of behaviors taken, interpretation of low values of U_c is problematic.[17] Therefore, high values of U_c are more reliable indicators of novice behavior than low values of U_c are of expert behavior.

6. SUMMARY AND INDICATIONS FOR FUTURE RESEARCH

This paper has presented early findings from a program of research based on a model of auditor problem solving behavior which takes into account the three-way interaction between task environment, auditor cognitions, and auditor behavior. This program of research involves not only the expanded model, but also the augmented methodology for observing and analyzing problem solving behavior in simulated audit environments. The model and methodology have been applied in this experiment to develop a database of novice auditor problem solving behavior which will form the basis for further study and later use in expert/novice comparisons.

It should be emphasized that the program of research mentioned above is focused on the problem solving process rather than on its product. This approach represents an extension of traditional judgment/decision making auditing research, which emphasizes the cognitive aspects of problem solving to the exclusion of its empirically observable aspects. Further, the model presented extends the conceptualization of an auditor's problem from the currently implied demand for a specific work product obtained through the application of GAAP and GAAS to a much broader behavioral concept, i.e., to extinguish a demand made on an auditor's self-concept.

Indications for Future Research

There is a clear need for replication of this study. The small sample size necessitated by the cost of a protocol study limits the kinds and precision of statistical tests which may be used. Further, the non-random manner in which subjects in this experiment were selected, an unavoidable consequence of the scheduling and economic constraints accompanying the use of practicing auditors as subjects, limits the generalizability of the findings.

The theoretical development of the measure of knowledge unavailability and the outcomes reported in Table 4 suggest interesting hypotheses for future testing with more experienced subjects. If, as is commonly assumed, expertise is acquired through extensive experience which is similar across auditors, then were this experiment repeated with auditors having such a degree of exposure to the task, we might expect that their levels of U_c would be significantly lower than the values reported in Table 4. It would also be interesting to compare the problem solving strategies of more experienced auditors with those of the novices who participated in this experiment.

ENDNOTES

1. See reviews by Davis and Solomon (1989), Bedard and Chi (1992). For more general discussion, see Einhorn (1974), Larkin et al. (1980), Fisk et al. (1983). For expert/novice differences, see Kiesler and Sproull (1982), Chi et al. (1981), Dawson et al. (1989).

2. For brevity, the adjective "perceived" is omitted before the terms "task environment," "task," and "solution state." Where used, these terms are always to be understood in the sense of an auditor's perceptions rather than in the sense of an objective reality.

3. The process of solving problems by progressing through a series of solutions to sub-problems is referred to by Newell and Simon (1972) as movement through "problem space."

4. Recent studies making use of this methodology include Bedard and Biggs (1991), Peters (1990), Biggs et al. (1988), Meservy et al. (1986), and Biggs and Mock (1983). Extensive research on verbal protocol methodology, covering its research foundations, validity, reliability, and application is covered by Newell and Simon (1972) and Ericsson and Simon (1980, 1984). This research establishes concurrent verbal protocols as reliable data on which to base investigations of human information processing and cognitive behavior.

5. The use of video tapes in education and training is very common (Kent and Foster, 1977; Cooper et al., 1987). Other areas where they are used include marketing and consumer research (e.g., Kessarjian, 1977), and psychology and psychiatry (e.g., Mumford et al., 1987). In accounting research, Ponemon (1991) used video tapes to determine the actual as compared with the reported time that subjects took to complete an auditing task. However, to the writer's knowledge, video tapes have not been used in the manner reported in this paper, that is, to study auditor behavior in a manner paralleling the use made of *in vivo* behavior observation in other areas.

6. The behaviors in Table 1 are defined in the coding manual. These behaviors were determined after extensive viewing of video tapes made during numerous pilot tests. Three seconds was empirically determined to be the shortest time interval during which the behaviors listed in Table 1 could be reliably coded. During pilot testing, subjects became fatigued after more than two hours of work and some suggested that a break would be appropriate. However, it was determined that a break would present methodological and analytical difficulties since cognitive activity and other task relevant behavior which might take place during the break would not be captured. Hence, it was decided to terminate the simulation after two hours.

7. For comparative studies see Biggs and Mock 1983 and Meservy et al., 1986.

8. Because of the possibility that not all cognitions may be verbalized, verbalization in the protocol is a sufficient but not necessary condition for concluding that unavailable knowledge mediated a transition from one empirical behavior to another. For the same reason, the absence of verbalization in the protocol is a necessary but not sufficient condition for concluding that an automatic process mediated the transition from one empirical behavior to another. To the extent failures to verbalize may exist, the results are biased against support of the hypothesis. Measures taken in this experiment to minimize subject failures to verbalize included verbalization exercises before the experiment and reminders to verbalize during extended periods of silence, as suggested by Ericsson and Simon. Reminders to verbalize were rare during the experiment. Further, to the extent that the task in this experiment was unfamiliar to the subjects, it required the generation of new information rather then the more rapidly accomplished recall of familiar information. In addition, the verbalization of motor processes was not a relevant part of these simulations. Consequently, the author believes that incomplete verbalizations due to factors other than the subjects use of automatic and habitual processes, if they exist in the protocols, are minimal.

9. Strictly speaking, this is true only if there are no failures to verbalize present in the protocol. See endnote 8.

10. An episode is an uninterrupted sequence of behaviors falling within the same major behavior category (see **Appendix**). The term "episode" is defined by Newell and Simon (1972, 1984) as "a succinctly describable segment of behavior associated with attaining a goal." In this paper, the meaning of the term has been broadened to include an extended period of behavior identified with a single type of behavior as specified by the model. The adoption of the term for this purpose is more convenient that the coining of a new term and little confusion will result thereby.

11. In this paper, the BGP will be treated as a "black box." It is left for future research to examine the contents of this box in detail.

12. The fact that these auditor-subjects may have been placed in an engagement environment for which they may lack the competence, guidance, and supervision required by the standards of field work is relevant to the purpose of this experiment. We wish to examine the problem solving behavior of auditors, behavior which, according to the model presented earlier, is shaped in part by the amount and kind of supervision, resources, and other aspects of the environment within which the auditors have been placed. For this purpose, the simulated engagement environment must be distinguished from the environment within which the administrative decision to so assign an auditor is made. The partner or other individual who assigns a staff auditor to an engagement is faced with a problem, viz., the assignment and supervision of an individual in accordance with GAAS. In solving the assignment problem, auditor selection, supervision, and other aspects of the engagement setting are adjusted and/or

matched to the extent that the staff auditor is deemed a "novice." This is a different problem from that addressed by this experiment, albeit a problem which may be itself worthy of study.

13. The task, workpapers, other data, and facts used in this experiment are materials taken from an actual engagement carried out by the author while in public practice.

14. The task in this experiment is unfamiliar in the sense that the only exposure the subjects had to the task domain was that provided in the background materials they were given. Cue variations are of three types: cues in a form different from that in which the subject learned task relevant knowledge and skills, cues which are *prima facie* ambiguous, and incomplete sets of cues. Cues are ambiguous when they are insufficient to permit discrimination between two or more schema recalled from long-term memory. A set of cues is incomplete when the cues perceived are sufficient to cause recognition, but not all cues which should be present, given the knowledge recalled by the subject from long-term memory, have been perceived.

15. Greater familiarity with a task domain, a more extensive knowledge base, and superior knowledge organization are generally recognized characteristics differentiating experts from novices. See references in endnote 1.

16. Laboratory tasks generally lack one or more of these characteristics. In particular, the interaction and transformation characteristic is frequently absent and information input is often minimized. Most laboratory tasks are cognitively intense, i.e., they require extensive cognitive activity but only minimal interaction with and transformation of the task environment for their solution. For example, tasks involving determinations of sample size or assessments of internal control produce minimal transformation of the task environment and are almost always based on information already selected, summarized, and supplied to the subject. This situation is appropriate given that the objective of such experiments is very often the study of auditor cognitive processes. However, in the field, significant interaction with client personnel and systems, workpaper preparation, computation, the balancing of competing demands for time and attention, and other environmental interaction and transformation behaviors are a common and essential part of the pursuit of most tasks.

17. While a high value of U_c unambiguously identifies novice problem solving behavior in a particular task situation, not all novices in that situation will show high levels of U_c. For example, completely random selections of empirical behaviors will generate solution sequences having U_c levels of zero, but such outcomes would certainly not represent expert behavior. It should be noted, however, that such mindless behavior is excluded by the assumptions of purposeful behavior and a minimum level of knowledge. It should also be kept in mind when comparing problem solving behaviors that it is probably easier to recognize a lack of expertise than its presence. This is especially true in situations in which there are no normative solutions or in comparisons made among novices. In the latter cases, while *task* expertise may be lacking,

a differential in other forms of expertise may be evident in the strategies pursued. For example, of two novices with similarly high levels of U_e, one may have engaged in frequent behaviors associated with considerable task or strategic uncertainty while the other was frequently engaged in behaviors associated with task planning and execution. The nature of each of these instances of novice problem solving behavior is different, and the implications of this difference for, say, purposes of scheduling each novice for future training and staff assignments may be considerable.

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APPENDIX

Problem Solving Behavior Categories

Perception

Code	Assigned when the subject:
p1	is reading information from a document, the CRT, or scanning a document or the CRT for information, underlines or makes margin notes on a document while reading, or writes notes on memo paper while reading the CRT or a document.

Cognition

Code	Assigned when the subject:
c1	expresses uncertainty Subject states a question or expresses uncertainty about specific entities, relationships, or processes present in his/her task environment, or expresses uncertainty about strategy or how to proceed.
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 either verbally or in writing.
c3	is planning Subject states the task objective, a proximal objective, or an action which he/she will take or is going to take to further the task objective or a task related proximal objective.
c4	self-evaluates Subject makes a statement about the difficulty or complexity of the task or an aspect of the task or task environment; an assessment of the subject's state of mind, feelings, or 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 the subject, his/her work or performance in the task; expresses concern for violating a budget constraint, role behavior, or a norm.

Execution

Code	Assigned when the subject is:
x1	calculating Subject is verifying a calculation by footing, performs an original calculation, or makes an independent calculation as a verification or test of a value computed by others, an examination procedure, or planning procedure.
x2	writing Subject is writing a memo or workpaper (other than p1, x1, or x4), heading a document, or writes the draft of his/her report or a memo for the engagement file.
x3	signaling Subject is signaling with the intercom.
x4	comparing, etc. Subject is cross-referencing, indexing or comparing documents.
x5	engaged in other execution behaviors. Subject organizes his/her work area or searches the work area for a document, discards a document, places a document in the engagement folder, or organizes his/her engagement folder.
x6	requesting Subject is speaking over the intercom, requesting information or a document.

<u>Unclassified</u>

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

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