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Patterns of Observable Strategic Behavior and Assessments of Expertise During Performance of Field Tasks

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ABSTRACT

This paper presents basic descriptive research regarding observed patterns of auditor strategic behavior during performance of field tasks. It is proposed that what are perceived as distinctive patterns of task behavior are actually observations taken from a continuum of possible patterns ranging from linear to micro-repetitive. *Ceteris paribus*, the point on that continuum at which an auditor's behavior pattern is characterized is dependent on the level (as defined) at which that auditor's behavior is examined -- the lower the level, the more likely it is that the behavior pattern will be characterized as micro-repetitive. Sequential progress through a task, beginning with information acquisition and progressing to or terminating with "end-stage" execution, is characteristic of linear process. Micro-repetitive behavior, the iterative application of linear process, is a consequence of an auditor's perception of a task as a sequence of hierarchically related sub-tasks. It is argued that a high-level linear pattern that progresses toward a task end-stage in conjunction with a lower-level micro-repetitive pattern is more likely to indicate a (relative) expert, while a lack of progress toward a task end-stage, along with an absence of micro-repetitive behavior, is more likely to indicate a (relative) novice. These conclusions are applied to analysis of the task behaviors of four first-year auditors who performed audit-related tasks in simulated auditing environments.

INTRODUCTION

This paper presents basic descriptive research regarding observed patterns of auditor strategic behavior during performance of field tasks. Knowledge of task behavior is of fundamental interest to auditors because of its potential relationship to audit effectiveness and efficiency, performance assessment, and the profession's understanding of the nature of expertise and its acquisition. While the task behavior of auditors has been a subject of interest to audit researchers for many years, the focus of these studies is primarily on judgment, decision-making, cognitive processes, and the effects of environmental manipulations on specific auditor behaviors (see Ashton & Ashton 1995 and Arnold & Sutton 1997 for comprehensive reviews). Serious research on patterns of the observable physical and social interaction (hereafter referred to as "observable behavior") of individual auditors performing "empirically intense" tasks,[1] is, to the author's knowledge, non-existent.

The apparent neglect of observable behavior in extant behavioral research suggests an implicit assumption that little is to be learned from studying this aspect of task behavior. However, there is little support for taking such a position. The productivity of any advance in knowledge is closely associated with what is already correctly, incorrectly, or incompletely known, and compared with what is known about auditors' judgment, decision making, and cognitive processes, very little is formally known about their observable behavior. To begin filling this gap in knowledge, the immediate objective must be to obtain as precise a description as possible of what auditors do during performance of field tasks. With this objective in mind, this paper focuses on patterns of observable behavior and raises two questions: (1) Are there distinctive patterns of strategic behavior? (2) What do observed patterns of strategic behavior reveal about auditor performance and expertise? Answers to these questions require that two related needs be met. The most basic need is a standardized and objective methodology for documenting observable task behaviors. Given such methodology, a database of the task behaviors of individual auditors is required because the study of individual differences helps us understand what accounts for variation in performance and expertise.

This paper attempts to address these needs by, first, proposing a model of the patterns of observable behavior during performance of an empirically intense task; second, proposing a methodology for revealing and quantifying patterns of strategic behavior given a coded protocol of an auditor's observed task behaviors; and third, applying the proposed methodology to analyze and compare the task behavior of four first-year auditors who performed audit-related tasks in simulated field environments.

The remainder of this paper is organized as follows: Section I describes previous research on patterns of strategic behavior during performance of audit tasks. Section II presents the proposed model and its implications. Section III discusses matters of implementation and statistical methodology. The experiment and behavior observation methodology are discussed in Section IV. Findings are presented in Section V followed by a discussion in Section VI. Section VII concludes the paper and proposes avenues for further research.

I. PRIOR RESEARCH

Research on *patterns* of auditor behavior is virtually non-existent. In an early paper addressing the topic of auditor expert behavior, Biggs & Mock (1983) noted that subjects in their experiment appeared to follow three different approaches to performance of their tasks. These approaches, which Biggs & Mock (1983) termed "strategies," were referred to by the terms "systematic," "directed," and "mixed". The auditor following directed strategy appeared to focus on an individual sub-issue in the task, proceeding to scan the task materials for relevant information and data, and finally processing what had been found to arrive at a decision or conclusion. This auditor then continued, in iterative fashion, to follow the same procedural sequence with successive issues until the task was completed. In contrast to this pattern, the two auditors following systematic strategy initially spent considerable time reading and absorbing the task materials. This initial information acquisition period was then followed by extensive processing of that material to arrive at the task outcome. Finally, the auditor following the mixed strategy performed in a manner that combined periods of both directed and systematic behavior. Except for this rather abbreviated mention, which was made in the context of a judgment/decision-making task, auditing behavioral research has failed to follow up on the idea that there may be certain behavioral patterns by which tasks and task behaviors may be related to research methodology, the nature of audit tasks, auditor expertise, and performance assessment.

II. MODEL

Kinds of Tasks

All tasks involve information input, unobservable mental and observable physical activity by which the input is processed, and terminate with an outcome that is the task "solution." This paper focuses on patterns of strategic behavior during performance of a specific type of task, unguided empirically intense tasks. Therefore, it is necessary to define such tasks and distinguish them from the cognitive and behavioral tasks most frequently used in auditing behavioral research.

Cognitive and Judgment/Decision-Making Tasks

The research objective in using cognitive tasks is to uncover the mental processes by which auditors use information to arrive at a conclusion. Judgment/decision-making tasks, the most common form of cognitive task, involving interaction with the sources of information input and the report of a conclusion in the form of either an evaluative statement ("judgment") or commitment ("decision"). Evaluation of the risks involved in relying on a client's procedures of internal check and control leading to a decision regarding sample size is an example of a judgment/decision-making task (*e.g.*, Biggs & Mock, 1983).

Behavioral Tasks

The objective of a behavioral task is to ascertain the effect of various environmental features or influences on an auditor's judgment, decision, or behavior. Behavioral tasks differ from cognitive tasks in that it is the effect of the environmental manipulation on some specific aspect of the auditor's behavior or the task outcome, rather than its effect on the auditor's thought processes that is the research focus. Input may be as extensive and as interactive as in a judgment/decision-making task, but the relevant outcome is the particular outcome or behavior of interest. An experiment to determine the effect of an auditor's knowledge about a reviewer's demands for support on that auditor's evidence gathering behavior (*e.g.*, the kind of explanations accepted for, and the extent of investigations made of variances) is an example of a behavioral task (*e.g.*, Peecher, 1996).

Empirically Intense Tasks

Like some more extensive cognitive and behavioral tasks, empirically intense tasks involve extensive amounts of diverse input obtained from diverse sources and reference to numerous documents. However, in addition and most discriminating, empirically intense tasks require interaction with other individuals in the task environment, and involve creation of new entities in the task environment (work papers, documents, reports, etc.) by means of interactive processes and employing diverse observable behaviors (reading, inquiry, calculating, writing, etc.) Field tasks are generally of this type. The objective of studying empirically intense tasks is to uncover the physical and social process followed by an auditor during performance of a task. Like the study of cognitive tasks, the study of empirically intense tasks is concerned with an ongoing process leading to an outcome rather than with the outcome *per se*. However, the process of interest is observable behavior rather than unobservable cognition. In contrast with what is the case in behavioral tasks, the study of empirically intense tasks is concerned with illuminating an ongoing observable processes rather than the effect of an experimental manipulation on a limited aspect of an auditor's behavior, judgment, or decision.[2]

Guided vs. Unguided Task Behaviors

In the field, observable task behavior ranges along a continuum from a guided process at one extreme to an unguided process at the other. *Guided task behaviors* are executed according to a prescribed "program" that is usually prepared by a more experienced individual. Behavior in such tasks is referred to as "guided" because the program provides the step-by-step procedure that a less experienced auditor is to follow in completing the task. *Unguided task behaviors*, on the other hand, arise when there is no guidance as to how a task is to be performed other than what an auditor can bring to bear from personal knowledge and the outcomes of current task procedures.

Behaviors in unguided tasks are *ad hoc*. At some level, however, even guided tasks involve some *ad hoc* behaviors. For example, the instruction "obtain the client's listing of outstanding balances at year-end" does not specify how that instruction should be carried out. The novice must (and is expected to) rely on personal knowledge and other procedures, such as inquiry, to determine how this instruction is to be implemented. Tasks demanding greater levels of expertise and responsibility, such as those of senior auditors who prepare audit programs and evaluate novice work products, generally are those having a greater *ad hoc* behavior content.[3]

Underlying Methodology and Assumptions

The Solution Sequence

The methodology proposed in this paper applies to the coded behaviors of an auditor during a period of behavior observation. The protocol resulting from the process of observing and coding behaviors will be referred to as the *solution sequence*. A solution sequence need not necessarily encompass the entire task. However, for purposes of inter-auditor comparisons, it is usually necessary that the total duration of each auditor's solution sequence be the same.

Observer/Observed Systems

This paper deals with one individual's, the *observer's*, interpretation of the behaviors of another, the *observed*, in an unguided empirically intense task. What behaviors are recognized, how those behaviors are aggregated, and their patterns identified and interpreted are strictly matters determined by the observer. It is assumed that the observer's choices in these matters are rationally related to the purpose for which observation is made and that the observation methodology reliably captures and codes the required data. It can be expected, therefore, that for different observer purposes, observation methodologies, or task situations, different behavior recognition and coding systems may be employed. For example, for purposes of learning how auditors form judgments and make decisions, the behaviors recognized (cognitive operators) are not observable and the behavior capture technology required (concurrent verbal protocols), is different from, and unsuited to, the study of observable behavior in empirically intense task situations. For purposes of the latter, recognition of observable behaviors that are performed to some extent in all field audit situations and videotape based methodology would appear to be more suitable.

Assumed Behavior Recognition and Coding System

Because of the central role played by the observer in this research, the behavior recognition and coding system adopted for study of behavior patterns must meet two criteria. First, given a pattern recognition and measurement methodology, detected behavior patterns must be independent of the observer's own expertise in the task. That is, regardless of their particular expertise *in the task* and acting as measurement instruments, two individuals observing a given auditor performing a task should report the same patterns and metrics.[4] Second, the contingent nature of task behavior requires that observers adopt a system of behaviors that are recognizable and, for present purposes, relevant to detection and comparison of patterns of observable *strategic* task behavior.

Table 1 summarizes the system that is adopted for the remainder of this paper.[5] Addressing the first criterion mentioned above, given the methodology proposed in this paper, the non-task-specific nature of the behavior recognition and coding system (within the domain of empirically intense field tasks) outlined in Table 1, produces characterizations of the patterns of task behavior that are *independent of the observer's own expertise in the task.* This independence is essential if one is to avoid inter-observer differences in what are appropriate sub-tasks and their indicia as well as intra-observer inconsistencies in the associations between sub-tasks and the levels of observation. With regard to the second criterion, the five behaviors listed in Table 1 are sufficiently familiar to auditors so as not to need further explanation and readily recognized when observed. However, the assignment of these behaviors to the purposeful groups shown in the right hand column of the table requires further discussion.

TABLE 1
ASSUMED CATEGORIES OF RECOGNIZED BEHAVIORS AND GROUP ASSIGNMENTS

Behavior (j)	Purposeful behavior group (g)
Reading (j=1)	Information acquisition (g=1)
Inquiry (j=2)	
Calculating (j=3)	Environmental transformation (g=2)
Writing (j=4)	
Other (organizing, indexing, comparing, discarding, etc.)(j=5)	

Strategy and Purposeful Behavior Groups

The model assumes that rational behavior is purposeful and intentional.[6] It is also proposed that *strategy is an observer's (one's own) characterization of the purposes and intentionality of another's (ones own) behavior*. We will assume, as observers whose purpose it is to study patterns of strategic task behavior, that two categories of purposeful behavior (each covering various intentional objects) are relevant. These are *information acquisition behavior* (reading documents and displays in an auditor's work environment and inquiry of others with whom an auditor can communicate either directly or indirectly via a communication device), and *environmental transformation behavior* (calculating, writing, sorting, cross-referencing, discarding, and other behaviors whereby an auditor transforms a task environment.)

Strategic Characterization

Strategy is characterized by the type of behavior that occurs during an interval of behavior observation. In any interval during which behavior is observed, a predominance of behavior falling within the purview of one purposeful behavior group results in a characterization of the behavior during that interval that is named for that group. For example, if most of an auditor's behaviors during the past, say, ten minutes of observation consisted of writing and calculating, then (referring to Table 1) that interval would be characterized as one in which that auditor pursued an environmental transformation strategy.

Patterns of Task Behavior

In this paper, a distinction is made between *strategy* as a characterization of the purpose and intentionality of the dominant behavior during a period of time and *strategic pattern* as a description of the regularities observed in a sequence of periods of differing strategic characterization. In their 1983 paper, Biggs & Mock identified two basic patterns of strategic behavior, "directed" and "systematic," and one "mixed" pattern.[7] In this section, each of these patterns is generalized and used as the basis for anticipating an observed behavior pattern. The section concludes by proposing that observed patterns of task behavior fall within a continuum of patterns and that characterization of any specific pattern is a function of the level at which the observer makes that assessment.

Linear Behavior

Performing a field task is similar to building a house. Both must begin with a conception of what is to be the final product and both proceed in a broadly sequential manner toward a solution that is a transformation of the task environment. Thus, to build a house, one necessarily starts with land surveys and architect's drawings before proceeding to materials acquisition and construction, and to successfully perform a field task, one necessarily begins by forming an understanding of the task objective and environment before proceeding to acquire the relevant data and information and construction of the work products (work papers, reports, etc.) that represent the task solution.[8] These observations appear to be consistent with the widely accepted model of problem solving and decision theory, which virtually all texts present as a sequence of steps that may be roughly described as planning, selection, implementation, and evaluation.[9] This textbook process would suggest that the dominant pattern of strategic behavior is linear, corresponding to Biggs & Mock's (1983) "systematic strategy." In terms of the purposeful behavior groups discussed previously, such a pattern would consist of an early dominance of information acquisition strategy followed by dominant environmental transformation strategy.

Micro-Repetitive Behavior

The preceding argument notwithstanding, field tasks generally consist of a hierarchy of related sub-tasks, each of which requires iteration of the textbook linear sequence. Further, in complex tasks, each step in that linear sequence can itself be resolved into repetitions of one or more lower level sequences, each having the same purposeful linear pattern. For example, constructing the foundation of a structure is itself a task involving application of the same linear sequence of purposeful behavior as applied in construction of the frame, internal systems, etc., albeit carried out in each case with different intentionality. In addition, each step in the linear process related to one sub-task, *e.g.*, planning the foundation, in turn, requires a similar application of that same linear sequence. These ideas also apply to each step of an audit program and to the audit *in toto*. The process of repetitive application of hierarchically related sequences of behaviors will be referred to as being *micro-repetitive*. Thus, anecdotal considerations would suggest that the linearity of task processes is a somewhat superficial construct and that in fact all realistic tasks are at some level and to some extent micro-repetitive. Such considerations, therefore, argue that Biggs & Mock's (1983) "directed strategy" should be the pattern observed.

The Behavior Continuum

The model proposed here takes the position that Biggs & Mock's "systematic" and "directed" patterns are in actuality the end points of a continuum of strategic behavior patterns that, for any auditor, range from linear at one extreme to micro-repetitive at the other, and that the observed pattern of strategic task behavior is at every level a mixture of both, with the dominant pattern dependant upon the level at which the observer makes the characterization. Because field tasks are assumed to be composed of a hierarchy of sub-tasks that take place over time, the *level of observation* for purposes of this research is operationalized as the relative duration of the observation interval, the longer the observation interval, the higher the level of observation. At any level of observation, the purposeful characteristics of the behaviors employed in performing individual sub-tasks are submerged into a weighted average of the dominant characteristic of all. Therefore, setting aside the nature of the task (Biggs & Mock's subjects did not perform an empirically intense task), Biggs & Mock's (1983) characterizations of their Subjects' patterns of strategic behavior, while informative, are of limited interpretive value because we lack information about the duration of the observation period(s) (each of Biggs & Mock's subjects completed their task, but the duration of their effort is not reported) and level(s) of observation used by Biggs & Mock (as observers) in arriving at their characterizations. Further, in light of what has been discussed in the preceding sections, we may surmise without much risk that Biggs & Mock's characterization of a "mixed strategy" is most likely a consequence of their segmenting their Subject's solution sequences by sub-task rather than in terms of appropriate observation intervals, as proposed in this paper. If some sub-tasks are completed in a relatively straightforward *g1g2* sequence while others require extended repetitions of that sequence before completion, then segmenting by sub-task causes the pattern of the solution sequence to be perceived as "mixed." This form of segmentation, in terms of the continuum model, represents use of observation intervals of inconsistent duration. As a consequence, pattern characterizations at different levels are co-mingled. Under the continuum model, "mixed strategies," to use Biggs & Mock's terminology, cannot exist.

Implications of the Continuum Model

Expectations from the Continuum Model

The behavior continuum proposed in the preceding section implies that at the highest levels of observation, a linear pattern is expected, beginning with a dominant information acquisition strategy, then progressing to a strategy dominated by environmental transformation. However, there is a possibility that at the highest level, no significant linearity in a subject's behavior is detected because, over the observation period, the subject did not progress sufficiently far in the task to produce a change in the dominant strategy. If such a situation exists, the continuum model predicts that task behavior will be dominated by information acquisition strategy throughout, with a shift toward environmental transformation that, though present, will not be of sufficient magnitude so as to result in a change in dominant strategy. The continuum model also implies that in addition to a linear pattern at the highest levels, at lower levels of observation, micro-repetitive patterns should become increasingly evident.

Conjunctive Effects

Conjunctive effects arise whenever the tendency of the low level pattern is to distribute strategic behaviors more or less uniformly over the solution sequence. Because the continuum model holds that behavior patterns at different levels exist simultaneously, conjunctive effects may be responsible for a failure to detect an expected higher-level pattern. One conjunctive effect of particular significance occurs when a highly repetitive low-level pattern exists in conjunction with failure to find evidence of linear process. This conjunction represents one extreme on the continuum. If neither linear nor micro-repetitive behavior patterns are detected, possible conjunctions to consider are random behavior and a micro-repetitive pattern with a period too small to be detected by the pattern recognition methodology employed.

III. IMPLEMENTATION AND STATISTICAL METHODOLOGY

Basic Constructs and Metrics

Time

The location in time at which a recognized behavior commences is denominated in frames. A *frame* is the shortest interval of constant duration utilized by the behavior observation methodology and is used as the fundamental measure of time along the solution sequence.[10] By aggregating behaviors recognized in contiguous sequential frames, a solution sequence may be divided into subsets of various duration that will be referred to as "*observation intervals*" or, where the meaning is unambiguous, simply as *intervals*. The duration of observation intervals is arbitrary and set by the observer, the entire solution sequence being an interval of the whole. Intervals are designated by their chronological position on the solution sequence either by numeral (*e.g.*, 1, 2, etc.) or ordinal designation (*e.g.*, "early," "late," first, second, etc.).

Strategy

Operationally, strategy is a perception based on the mix of behaviors of common purpose (*i.e.*, purposeful groups) during an observation interval. The *mix* of a behavior, $j \in \{1, 2, \ldots b\}$, during an observation interval *t*, is the ratio of the frequency of that behavior to the frequency of all behaviors during that interval. *Strategic emphasis* (ρ_{tg}) during interval *t* refers to the mix of behaviors in purposeful group $g \in \{g1\ g2\}$ during that interval, *i.e.*, $\rho_{tg} = \Sigma^{j=\{g\}} n_{tj} / \Sigma^{b} n_{tj}$, where $\{g\}$ is the set of behaviors assigned by the observer to purposeful group *g*, and the magnitude of ρ is the *intensity* of the strategic emphasis.[11] The *dominant strategy* during any interval refers to the purpose of the group whose strategic emphasis in that interval is most intense. A *strategic shift* refers to a change in the *intensity* of the strategic emphasis but not necessarily a change in dominant strategy from one interval to the next. Qualitatively, a strategic shift has direction, either increasing or decreasing; quantitatively, a strategic shift has magnitude, *i.e.*, $\Delta \rho_{tg} = \rho_{tg} - \rho_{(t-1)g}$.

Phases and Cycles of Strategic Behavior

A *phase* is a period measured in either frames or intervals during which the dominant strategy remains unchanged. A *phase shift* occurs at any point in time at which the dominant strategy changes. A *cycle* consists of a phase dominated by information acquisition strategy followed by a phase dominated by environmental transformation strategy. Partial cycles exist in units of one-half.[12] Micro-repetitive strategy is quantified by counting the number of cycles observed in a solution sequence, the greater the number of cycles, the greater the micro-repetitive component of task strategy.

Use of shorter observation intervals increases both the measured frequency of cycles and the accuracy with which the duration of phases is measured.[13] However, there are practical limits on how small one can usefully make such intervals. At the extremes, the smallest interval is a single frame and the largest is the complete solution sequence. Use of the former is tantamount to use of the raw observation protocol without any analysis; use of the latter will suppress any useful indication of micro-repetitive behavior. Within these extremes, smaller intervals reduce the density of included data, adversely affecting statistical validity, and exponentially increase the amount of analytical effort required. The most important consideration once a suitable interval size has been selected is that the same size interval be used in all inter-auditor comparisons.

Examining Linear Task Behavior

At the highest level of observation we may investigate change in both strategic emphasis and strategic dominance.

Change in Strategic Emphasis

The linear pattern of strategic behavior requires that initial task behavior be devoted to information acquisition and that later task behavior be devoted to environmental transformation. Therefore, if a solution sequence were to be bisected at its chronological midpoint and in each of the resulting intervals, the behaviors categorized into purposeful groups of information acquisition ($g1$) and environmental transformation ($g2$) behavior, a significantly greater emphasis on environmental transformation behavior between the early and late segments of the solution sequence should be observed. Failure to observe a linear pattern can imply (1) a significant high frequency micro-repetitive process, (2) a failure of the subject to make substantial progress in the task, or (3) a completely random process. Each of these possibilities can be investigated by means of further analysis.

Change in Strategic Dominance

In order to complete an empirically intense task, a linear process necessarily requires that there be a transition from the initial information acquisition phase to an *end-stage* during which environmental transformation behavior dominates. Solution sequences that fail to arrive at such an end-stage give evidence of a slower rate of progress in the task compared with solution sequences of auditors performing the same task and arriving at an end-stage.

There are two possible exceptions to the preceding, both of which are subject to further clarification. First, it is possible that an observer of the behavior of an auditor employing a very low frequency micro-repetitive pattern may have captured only one cycle of that pattern in the solution sequence. If this is in fact the case, the auditor's true pattern will be indistinguishable from that of a linear pattern. However, comparison with findings from observations of other auditors performing the same task may assist in resolving this ambiguity. Second, failure to find significant progress toward an end-stage may be a consequence of a low-level high frequency micro-repetitive pattern, a conjunctive effect.

Measuring the Extent of Micro-Repetitive Processes

The basic techniques for investigating strategic dominance can also be applied at lower levels to investigate patterns of micro-repetitive strategic behavior. A complete cycle of a micro-repetitive process consists of a phase of dominant information acquisition behavior followed by a phase of dominant environmental transformation behavior. Given a solution sequence suitably segmented at an appropriate level and in which the phases of dominant strategic behavior have been identified, we can count the number of cycles in that sequence. This number, or *frequency*, is a quantitative measure of the degree of micro-repetitive behavior, the higher the frequency, the greater is the micro-repetitive component of an auditor's strategic task behavior.

Statistical Methodology

Sources of experimental error

In this experiment, the sources of error in evaluating the significance of findings are (1) unsystematic error in over- or under-recognition of behaviors, and (2) unsystematic error in coding behaviors. Because a consistent behavior capture methodology and coding procedure is used, including the same (independent) coders for all Subject protocols, it is assumed that the incidence of experimental error is (1) constant throughout the coding process, (2) the same for all Subjects, and (3) independent of the kind of behavior.

Examination for Linear Pattern

If the task process is linear, there will be a significant shift in strategic emphasis from information acquisition strategy toward environmental transformation strategy. To test if observed shifts in strategic emphasis from early to late observation intervals are due to experimental error, we hypothesize $H1_0$: $\Delta \rho_{L,gl} = \rho_{L,gl} - \rho_{E,gl} = 0$. The standard error ($s_{\Delta\rho}$) for testing this hypothesis is $\sqrt{\rho_{gl}(1 - \rho_{gl})(1/n_E + 1/n_L)}$, where ρ_{gl} is the mean information acquisition emphasis of the solution sequence. If $\Delta \rho_{L,gl} < 0$, rejection of the null supports the alternative H1a: $\rho_{L,gl} < \rho_{E,gl}$, implying a significant shift in emphasis toward greater use of environmental transformation behavior later in the solution sequence.[14] If $\Delta\rho_{L,gl} > 0$ and $H1_0$ is rejected, the implication is that there was *increased* emphasis on information acquisition, contrary to the continuum model.[15]

Test for Progress Toward Task Completion

If the task has progressed well toward completion, there will be a shift in strategic dominance from information acquisition strategy to environmental transformation strategy. Because there are only two purposeful behavior groups, dominance by one group implies subordination by the other, and *visa versa*. To establish strategic dominance by any group in any interval it is only necessary that the intensity of that group be greater than 0.5. Because any recognized behavior may be classified as being a member of one of only two purposeful groups, the cumulative binomial distribution may be used to test the null hypotheses that $H0_{2A}$: $\rho_{t,g1} = 0.5$ and $H0_{2B}$: $\rho_{t,g2} = 0.5$, in both cases $t \in$ {early, late}. Rejection of either null in any interval implies support for the respective alternative, *viz*, Ha_{2A}: $\rho_{t,g2} > 0.5$ if $H0_{2A}$ is rejected and Ha_{2B}: $\rho_{t,g1} > 0.5$ if $H0_{2B}$ is rejected. If it is determined that group $g2$ (environmental transformation behavior) is dominant in the late observation interval, then the auditor has presumably progressed to an end-stage. Failure in any interval to reject *both* nulls implies only that we cannot say with an acceptable degree of confidence that the observed behavior during that interval is dominated by the behaviors of any particular group.

Examining Patterns of Micro-Repetitive Behavior

To uncover micro-repetitive patterns, the solution sequence must be examined at lower levels. This examination is accomplished by segmenting the solution sequence into small intervals, and testing for a shift in strategic dominance in each such interval. Small intervals are desirable because the smaller the interval, the more micro-repetitive detail potentially can be revealed. However, in the face of experimental error there is a practical limit on how small an interval can be used. As discussed earlier, if the interval is too large, micro-repetitive detail is submerged; if the interval is too small, the statistical validity of the resulting data becomes questionable. When counting cycles in the face of experimental error, assuming that a satisfactory balance is achieved in selecting an interval size, a change in phase is not recognized until there is a statistically significant shift in strategic dominance. Prior to any significant shift in dominate strategy, the phase of the previous interval as assumed to continue into the succeeding interval. In the event that the phase of the preceding interval is indeterminate, then the phase of all indeterminate intervals is assumed to be the same as that of the first interval in which there is a statistically significant determination of strategic dominance. This situation is only likely to occur in solution sequences in which statistical dominance in the early intervals is indeterminate.

Statistical Tests on Micro-Repetitive Patterns

Two statistical procedures must be employed to ascertain if the patterns obtained by the methods described above cannot be attributed to experimental error. The first procedure is a test of the significance of each interval's dominant strategy. The second procedure determines the significance of the cyclic pattern formed by adjacent intervals. The test for significance of findings related to individual intervals is carried out using the same null hypotheses and alternatives as used in testing the linear pattern for shifts in dominance, except that $t \in \{1, 2, ...\}$ for as many intervals as exist. The test for the significance of cyclic patterns is more complex.

Three parameters are required to test the significance of cyclic patterns: the number of intervals in the solution sequence, the frequency of the solution sequence, and the "determination ratio," defined below. Given an n-interval solution sequence, the bi-variate probability density is generated by systematically searching the population of all possible outcomes from the decision processes both for testing individual intervals for strategic dominance and for counting the frequency of cycles in the solution sequence. In general terms, given an arbitrary n-interval solution sequence, a three-step procedure is followed. First, all permutations in an n-interval solution sequence of two purposeful groups ($g1$ or $g2$) at two levels of intensity (dominant or not dominant, based the adopted level of alpha risk) are enumerated. Second, the frequency of cycles formed in each permutation made in step one is enumerated. In addition, for each such enumeration, the *determination ratio* (γ) is computed by taking the ratio of the number of intervals for which there is a significant finding to the total number of intervals in the solution sequence. Finally, the probabilities of distinguishable frequency and determination ratio outcomes are aggregated to produce the probability density. This generating process is described and illustrated in the notes.[16] For 2-interval sequences such as those reported in Table 4, this process requires evaluation of 16 possibilities. For sequences having a greater number of intervals, this process requires evaluation of 4^n possible outcomes, where n is the number of intervals in the solution sequence.

IV. EXPERIMENT AND BEHAVIOR OBSERVATION METHODOLOGY

This section summarizes the experiment performed and methodology employed to obtain the data upon which the findings are based. For a more complete explication of the experiment and task materials, which are extensive, see Russo 1994.

Subjects, Task, and Procedure

The Subjects were four first-year auditors from the professional staff of a Big Five auditing firm. All Subjects were volunteers who had sat for and passed some, but not all, parts of the CPA examination and all had no prior exposure to the subject matter of the task.

The task in this experiment was a review of the Statement of Operating Expenses of a new office building in which the client is a tenant, rendered pursuant to the rent escalation provisions of the client's lease. To acquaint them with the terminology, administrative, and computational procedures associated with operating expense rent escalations, on the day before the experiment, each Subject was given background material and two samples of completed review reports to study. However, none of this material provided any information on examination or reporting procedures, the landlord's procedures, or the existence and nature of any documents used in the preparation of the statement rendered to the client. Therefore, such a task, to the extent that it differs from that of financial audit, would be unfamiliar to the Subjects who participated in this experiment.

Each Subject performed the task on a different day. The task was performed in a simulated business office in which each Subject was presented with the equipment and supplies normally available in audit environments and the ability to communicate (via intercom) with and receive documents (via a mail slot) from other parties present in the task environment (e.g., client personnel, the audit partner, etc.). During performance of the task, each Subject was free to contact any party in the task environment and to request any documents or explanations required. Although the researcher played the roles of others in the task environment, no face-to-face or verbal contact took place between Subject and experimenter. Responses to requests for explanations were communicated to the Subject via a video display at the Subject's desk.

As can be deduced from the preceding description, this is an unguided task because no examination program or procedure is provided to the auditor-Subjects. In addition, the task is empirically intense. The task requires considerable diverse information input from diverse documents within the auditor's immediate physical environment and from documents and individuals external to that environment, as well as the creation of new work papers, documents, and reports that represent the task solution. Therefore, there is an expectation of a considerable amount of both environmental interaction and transformation.

Behavior Observation Methodology

Subjects were videotaped during their performance of the task to capture their observable behaviors. Each Subject worked continuously at the task for over two hours. However, because of Subject fatigue and possible deterioration of performance beyond that time, only the first 2000 frames of each protocol are included in analysis. Therefore, in this experiment, no Subject can be considered as having completed the task. The experimental protocols were independently coded in terms of the behaviors described in Table 1 by the researcher and a first year doctoral student trained by the researcher. The behaviors were then classified in terms of the purposeful behavior groups and assigned to observation intervals, as required by the analytical methodology. Agreement among coders, after adjustment for chance agreement (Cohen, 1960), ranged from .792 to .754 for five behaviors over 8000 frames of behavior observation. These levels of agreement are significant at $p << .000$.

V. FINDINGS

This section presents the results of observations made of the four auditors who participated in the experiment described in Section IV. Because of the relatively large numbers of behavior observations in this experiment, the level of alpha risk used to test the significance of reported findings is one percent.

Examination for Linear Pattern

The observed frequencies of each Subject's strategic behaviors during the early and late intervals of observation are presented as Table 2. In every case, as expected from the continuum model, the emphasis on information acquisition behavior (*g1*) decreased and environmental transformation behavior (*g2*) increased as the task progressed. As shown in Table 3, the shifts in the strategic emphasis of all Subjects are too great to be due to experimental error. All four Subjects, therefore, followed a linear strategic pattern in performing the experimental task.

TABLE 2
OBSERVED FREQUENCIES OF STRATEGIC BEHAVIORS
EARLY vs. LATE INTERVALS

	Subject 1		Subject 2		Subject 3		Subject 4	
Interval (t)	Early	Late	Early	Late	Early	Late	Early	Late
$n_{t,g1}$	931	691	768	401	631	538	774	268
$n_{t,g2}$	77	317	241	609	383	479	230	741
n_t	1008	1008	1009	1010	1014	1017	1004	1009
$p_{t,g1}$	0.924	0.686	0.761	0.397	0.622	0.529	0.771	0.266
$p_{t,g2}$	0.076	0.314	0.239	0.603	0.378	0.471	0.229	0.734

This table reports the observed frequencies of purposeful group behaviors and the proportion of behaviors falling in purposeful groups *g*1 (information acquisition behavior) and *g*2 (environmental transformation behavior) during the early (frames 0-999) and late (frames 1000-1999) intervals of each subject's solution sequence.

TABLE 3
TEST FOR LINEAR PATTERN
$H1_{0:}\ \Delta\rho_{L,g1} = 0$, where $\Delta\rho_{L,g1} = \rho_{L,g1} - \rho_{E,g1}$

	Subject 1	Subject 2	Subject 3	Subject 4
$\Delta\rho_{L,g1}$	-0.238	-0.364	-0.093	-0.505
$s_{\Delta\rho}$	0.018	0.022	0.022	0.022
Z	-13.480	-16.569	-4.253	-22.685
P	**0.000**	**0.000**	**0.000**	**0.000**

This table reports the results of the test for the presence of a linear behavior process. Linear process is indicated by a significant shift over time in strategic emphasis from information acquisition strategy toward environmental transformation strategy. The null hypothesis for each subject is $H1_{0:}\ \Delta\rho_{L,g1} = 0$, where $\Delta\rho_{L,g1} = \rho_{L,g1} - \rho_{E,g1}$, and the alternative directional hypothesis is $H1_{0:}\ \Delta\rho_{L,g1} < 0$, implying the presence of a significant change in strategic emphasis toward greater use of environmental transformation (g2) behaviors. Significant findings are shown in **bold** type. Consistent with expectations from the continuum model, all subjects showed a significant shift toward environmental transformation strategy as the task progressed ($\Delta\rho_{L,g1}<0$).

Progress Toward Task Completion

Progress toward task completion is assessed based on whether an auditor showing evidence of a linear pattern has arrived at an end-stage during the late observation interval. Under the null hypothesis neither purposeful behavior group dominates the solution sequence, *i.e.*, $\rho_{g1} = \rho_{t,g1} = \rho_{t,g2} = 0.5$, $t \in$ {early, late}. Table 4 reports the probability that the dominant strategy observed in each interval is that of the purposeful behavior group indicated by the null hypothesis. The probabilities shown are based on the cumulative binomial distribution under the null hypothesis. Rejection of the null with respect to either purposeful behavior group supports the alternative directional hypotheses that the dominant behavior observed is of the group *opposite* that for which the null is rejected. Significant findings of dominant strategy are shown in **bold type.**

TABLE 4 COMPARATIVE TEST FOR PROGRESS TOWARD TASK COMPLETION $H2_{0A}$: $\rho_{t,g1}$=0.5; $H2_{0B}$:= $\rho_{t,g2}$ = 0.5								
	Subject 1[#]		Subject 2[#]		Subject 3[*]		Subject 4[#]	
Interval (t)	Early	Late	Early	Late	Early	Late	Early	Late
p($H2_{0A}$)	1.000	1.000	1.000	**0.000**	1.000	0.970	1.000	**0.000**
p($H2_{0B}$)	**0.000**	**0.000**	**0.000**	1.000	**0.000**	0.034	**0.000**	1.000

This table reports the probability that the behavior observed in each interval is that of the purposeful behavior group indicated by the null hypothesis. Significant progress toward task completion is indicated by a significant shift in strategic dominance toward environmental transformation ($g2$) behavior. The probabilities are based on the cumulative binomial distribution under the null hypothesis that the recognition and coding of any behavior is random (*i.e.*, for $H2_{0A}$, $p(x \leq n_{t,g1/} | n_t, \rho_{g1}=0.5)$ and for $H2_{0B}$, $p(x \leq n_{t,g2} | n_t, \rho_{g2}=0.5)$). Rejection of either null supports the alternative directional hypotheses that the behavior observed is of the group *opposite* that indicated by the respective null. Significant findings are shown in **bold** type. Subjects 2 and 4 progressed sufficiently in the task to have arrived at what appears to be an end-stage where environmental transformation behavior is dominant. Although Subjects 1 and 3 showed significant shifts in their strategic emphasis toward environmental transformation behavior (see Table 3), they did not progress as far toward completion of the task as did Subjects 2 and 4, and remained in a predominately information acquisition mode. Findings with respect to Subject 3 may be considered significant evidence of end-stage progress if one is willing to accept a higher level of risk (3.4 percent vs. 1 percent used throughout this paper.)

The probability of observing the reported *pattern* of significant interval behavior under the null hypothesis is insignificantly different from zero (see text).

* The probability of observing this *pattern* of significant interval behavior under the null hypothesis is 1.99 percent (see text).

Following the procedure described in note 16, the probability that the reported behavior *patterns* of Subjects 1, 2, and 4 could have arisen by chance is insignificantly different from zero, while that of Subject 3 is 1.99 percent. Subjects 2 and 4 progressed sufficiently in the task to have arrived at what appears to be an end-stage. Subject 1 showed a significant shift in strategic emphasis toward environmental transformation behavior (see Table 3) but did not progress as far toward completion of the task as did Subjects 2 and 4. Subject 1, therefore, appears to have remained in a predominately information acquisition mode. Findings with respect to Subject 3, unlike those for Subject 2, are not statistically significant under the stringent level of alpha risk employed in this research. However, given the previously reported significant linear process and the low level of alpha risk reported in Table 4 (p=.034), this Subject's late strategic task behavior is nevertheless strongly suggestive of an approach to end-stage. Alternatively, the failure to find significant progress toward end-stage at this level may be due to high frequency micro-repetitive behavior, as discussed earlier. This possibility will be taken up later in this paper.

Patterns of Micro-Repetitive Behavior

Detection of a micro-repetitive pattern involves examining the solution sequence at a low level. For this purpose, 200 frame intervals were chosen based on considerations of sufficient data density for valid statistical analysis, and meaningful revelation of micro-repetitive behavior when applied comparably across Subjects. Table 5 reports observed behavior frequencies and strategic emphasis metrics on this basis.

TABLE 5 OBSERVED FREQUENCIES OF PURPOSEFUL GROUP BEHAVIOR 200 FRAME INTERVALS										
Interval	1	2	3	4	5	6	7	8	9	10
Frames	0-199	200-399	400-599	600-799	800-999	1000-1199	1200-1399	1400-1599	1600-1799	1800-1999
Subject 1										
$n_{t,g1}$	181	197	173	179	201	51	129	150	161	200
$n_{t,g1}$	20	5	29	23	0	151	72	53	41	0
n_t	201	202	202	202	201	202	201	203	202	200
$\rho_{t,g1}$	0.900	0.975	0.856	0.886	1.000	0.252	0.642	0.739	0.797	1.000
$\rho_{t,g2}$	0.100	0.025	0.144	0.114	0.000	0.748	0.358	0.261	0.203	0.000
Subject 2										
$n_{t,g1}$	176	191	140	166	95	158	106	0	16	121
$n_{t,g1}$	23	9	63	37	109	45	98	200	186	80
n_t	199	200	203	203	204	203	204	200	202	201
$\rho_{t,g1}$	0.884	0.955	0.690	0.818	0.466	0.778	0.520	0.000	0.079	0.602
$\rho_{t,g2}$	0.116	0.045	0.310	0.182	0.534	0.222	0.480	1.000	0.921	0.398
Subject 3										
$n_{t,g1}$	186	189	75	72	109	173	45	77	114	129
$n_{t,g1}$	13	12	130	135	94	29	159	124	91	76
n_t	199	201	205	207	203	202	204	201	205	205
$\rho_{t,g1}$	0.935	0.940	0.366	0.348	0.537	0.856	0.221	0.383	0.556	0.629
$\rho_{t,g2}$	0.065	0.060	0.634	0.652	0.463	0.144	0.779	0.617	0.444	0.371
Subject 4										
$n_{t,g1}$	199	53	169	153	200	34	124	90	14	6
$n_{t,g1}$	0	148	32	50	0	166	80	113	187	195
n_t	199	201	201	203	200	171	204	203	201	201
$\rho_{t,g1}$	1.000	0.264	0.841	0.754	1.000	0.029	0.608	0.443	0.070	0.030
$\rho_{t,g2}$	0.000	0.736	0.159	0.246	0.000	0.971	0.392	0.557	0.930	0.970

This table reports the frequencies of observed behaviors and the proportion of behaviors for each purposeful behavior group during consecutive 200 frame intervals for each Subject's solution sequence.

Findings with respect to micro-repetitive patterns are shown in Table 6. Significant findings of strategic dominance in each interval are shown in **bold** type. The probability of finding a pattern of micro-repetitive behavior at the reported frequency or greater with the observed determination ratio or greater, computed by the procedure described in note 16, is insignificantly different from zero for each Subject. Cycle phases are based on patterns of adjacent intervals in which there is significant evidence of strategy dominated by behaviors in one purposeful group. The procedure and null hypotheses employed for this purpose (*viz*, $\rho_{g1} = \rho_{t,g1} = \rho_{t,g2} = 0.5, t \in \{1, 2, ... 10\}$) are the same as those employed in testing for progress in the task except for the use of adjacent intervals of 200 frames duration instead of 1000 frames.

TABLE 6
TESTS FOR MICRO-REPETITIVE BEHAVIOR
200 FRAME INTERVALS
$H3_{0A}$: $\rho_{t,g1}$=0.5; $H3_{0B}$:= $\rho_{t,g2}$ = 0.5

Interval	1	2	3	4	5	6	7	8	9	10
Frames	0-199	200-399	400-599	600-799	800-999	1000-1199	1200-1399	1400-1599	1600-1799	1800-1999
Subject 1 (cycles = 1.5, γ = 1.00, p << .000)										
P($H3_{0A}$)	1.000	1.000	1.000	1.000	1.000	**0.000**	1.000	1.000	1.000	1.000
P($H3_{0B}$)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	1.000	**0.000**	**0.000**	**0.000**	**0.000**
Subject 2 (cycles = 1.5, γ = .80, p << .000)										
P($H3_{0A}$)	1.000	1.000	1.000	1.000	0.181	1.000	0.736	**0.000**	**0.000**	0.999
P($H3_{0B}$)	**0.000**	**0.000**	**0.000**	**0.000**	0.853	**0.000**	0.712	1.000	1.000	**0.002**
Subject 3 (cycles = 2.5, γ = .80, p << .000)										
P($H3_{0A}$)	1.000	1.000	**0.000**	**0.000**	0.869	1.000	**0.000**	**0.001**	0.953	1.000
P($H3_{0B}$)	**0.000**	**0.000**	1.000	1.000	0.163	**0.000**	1.000	1.000	0.062	**0.000**
Subject 4 (cycles = 3, γ = .90, p << .000)										
P($H3_{0A}$)	1.000	**0.000**	1.000	1.000	1.000	**0.000**	0.999	0.061	**0.000**	**0.000**
P($H3_{0B}$)	**0.000**	1.000	**0.000**	**0.000**	**0.000**	1.000	**0.001**	0.954	1.000	1.000

The rows under each subject report the probability that the behavior observed in each interval is that of the purposeful behavior group indicated by the null hypothesis. The null hypothesis in each case is $H3_{0A}$:ρ_{g1}=0.5 and $H3_{0B}$:ρ_{g2}=0.5. The probabilities are based on the cumulative binomial distribution under the null hypothesis that the recognition and coding of any behavior is random (*i.e.*, for $H3_{0A}$, p($x \leq n_{t,g1} | n_t, \rho_{g1}$=0.5) and for $H3_{0B}$, p($x \leq n_{t,g2} | n_t, \rho_{g2}$=0.5)). Rejection of either null supports the alternative directional hypotheses that the behavior observed is of the group *opposite* that indicated by the respective null. The micro-repetitive patterns of subjects are all significant at the levels indicated for the frequency and determination ratio observed (see text). A cycle is counted as a complete sequence of a significant information acquisition behavior (*g1*) phase followed by a significant environmental transformation (*g2*) phase. Frames for which there is no significant change in strategic dominance are counted as part of the phase then in progress.

Subject 1's 1.5-cycle frequency begins with a phase of information acquisition behavior lasting 1000 frames, followed by a brief 200 frame phase of environmental transformation before resuming information acquisition behavior for the remainder of the solution sequence. In light of previous findings of linear process and lack of significant progress in the task, and, compared with the frequency of the other Subjects, of micro-repetitive patterns, this Subject's low frequency pattern and almost complete emphasis on information acquisition behavior engender an expectation of a protracted task duration.

Subject 2 also shows a significant 1.5-cycle frequency. The initial information acquisition phase extends for 1400 frames, followed by an environmental transformation phase of 400 frames. The final half-cycle is marked by a return to information acquisition for the remaining 200 frames. Although this Subject shows the same low frequency micro-repetitive pattern as does Subject 1, the previously reported finding of significant progress suggests an expected task duration shorter than that for Subject 1.

Subject 3's 2.5-cycle pattern begins with information acquisition behavior for the first 400 frames, followed by a shift to environmental transformation for 600 frames. The second cycle begins at frame 1000 with a 200 frame phase of information acquisition followed by a 600 frame phase of environmental transformation. The remaining 200 frames of the solution sequence consists of information acquisition behavior, making up the final one-half cycle. Findings regarding this Subject illustrate a strong conjunctive effect in which a low-level high frequency pattern masks evidence of a high level linear process. This Subject's behavior is dominated by environmental transformation strategy in six of ten intervals (60 percent) during which behavior was observed. These intervals are distributed equally between both the early and late halves of the solution sequence. Subject 2, on the other hand, devoted only three of ten intervals to environmental transformation (30 percent), all occurring during the late half of the solution sequence. This difference in strategic pattern reflects differences in task perception. It also explains the marginal failure, reported in Table 4, to find significant progress toward task completion for Subject 3.

Finally, Subject 4's 3-cycle frequency provides another very clear pattern of micro-repetitive strategic behavior but with different implications compared with those for Subject 3. The first cycle begins with a 200 frame phase of information acquisition, followed by a 200 frame of phase of environmental transformation strategy. The second cycle consists of a 600 frame phase of information acquisition followed by a 200 frame phase of environmental transformation strategy. The final cycle begins with a 400 frame phase of information acquisition followed by environmental transformation behavior for the remaining 400 frames. This Subject devoted only one interval to environmental transformation during the early half of the solution sequence and three intervals in the late half. This 25%/75% distribution accounts for Subject 4's strong showings of linear process and significant progress toward task completion. In light of all findings regarding the four Subjects in this experiment, Subject 4 can be expected to complete the task in the shortest period.

VI. DISCUSSION

Table 7 summarizes the observed behavior patterns and findings. Although findings regarding each of the investigations reported can provide some insight into strategic behavior, the possibility of conjunctive effects necessitates integration of findings from all investigations for a more complete understanding.

TABLE 7
SUMMARY OF FINDINGS

Pattern characteristic	Subject 1	Subject 2	Subject 3	Subject 4
Significant linearity	Yes	Yes	Yes	Yes
Significant progress to end-stage	No	Yes	No	Yes
Significant micro-repetitive pattern	Yes	Yes	Yes	Yes
Characteristics of micro-repetitive pattern:				
Frequency (cycles/2000 frames)	1.5	1.5	2.0	3.0
Determination ratio	1.00	0.80	0.80	0.90
Distribution of environmental transformation behavior (% intervals, Early/Late)	0/100	0/100	50/50	25/75
Relative expertise (see Discussion, Section VI)	4	2.5	2.5	1

Behavior Patterns and Assessments of Expertise

Two considerations color how findings from application of the model and methodology presented herein are related to assessments of expertise. First, a behavioral study such as that presented in this paper focuses strictly on process, ignoring all considerations of the quality of task outcome and considering only the grossest notions of normative task behavior. Second, evaluations of expertise in performance of a task are most meaningful when made in relative rather than absolute terms. For these reasons, the term "expertise" as used here is to be understood in the sense of a relative degree of expert-*like* task behavior. With these considerations in mind, the continuum model presented addresses behavior in unguided empirically intense field tasks, and as such, there is an expectation that task strategy necessarily progresses through stages of initial dominance by information acquisition behavior to end-stage dominance by environmental transformation behavior. In addition, it is assumed that a certain amount of sophistication is necessary in order to perceive a task as consisting of hierarchically related sub-tasks, just as it takes a certain amount of sophistication to see the operation of any complex mechanism or process as the net effect of the contributions made by specific sub-systems and their components.[17] It is this perception that makes for an expert's more efficient and effective diagnosis, correction, or modification strategies.

Accordingly, it is proposed that at the highest level, the task level, evidence of significant linearity and progress toward a task end-stage, and at lower levels, a significant micro-repetitive behavior pattern, are *presumptive* indications of comparative expertise in task performance. Further, because experts are more likely than novices to perceive a complex task as a sequence of hierarchically related sub-tasks, presumptions of greater levels of sophistication, and hence, of expertise, are bolstered by higher frequency micro-repetitive behavior patterns. On this bases, the findings show that Subjects 3 and 4 perceive their task as hierarchical in nature more clearly than do Subjects 1 and 2. Conversely, lower frequency patterns together with an absence of significant progress in a task weaken these presumptions and can be taken as reasonable evidence of a comparatively inefficient solution process. Finally, an absence of significant linearity together with a comparatively low frequency behavior pattern is presumptive evidence of relatively early stage novice behavior. Applying the foregoing to the findings summarized in Table 7, it is proposed that of the four Subjects participating in this experiment, Subject 4 is the most expert and Subject 1 the least. Although Subject 3's reported failure to reach an end-stage would normally tend to lower this Subject's ranking relative to that of Subject 2, this deficiency is offset by a higher frequency micro-repetitive behavior pattern in which information acquisition and environmental transformation behaviors are more uniformly distributed over the solution sequence. Consequently, Subjects 2 and 3 are adjudged to be tied for the second and third ranks.

VII. CONCLUSIONS

This paper reports initial basic research concerning patterns of observable behavior and their implications. Its major contributions to auditing behavioral research are: extension of our knowledge of patterns of auditor task behavior beyond the realm of extant cognitive and behavioral research to include the observable behaviors of auditors while performing unguided empirically intense field tasks; a proposal that, with the exception of random behavior, all patterns of strategic task behavior can be located along a continuum ranging from linear at one extreme to micro-repetitive at the other; and a methodology for quantifying and comparing patterns of strategic behavior.

In the Introduction, two questions related to observable patterns of task behavior are raised. In light of the model and findings reported above, these questions can now be answered. As to the first question, the findings show that what were perceived in previous research as distinctive patterns of task behavior are actually observations taken from a continuum of possible behaviors ranging from linear to micro-repetitive. *Ceteris paribus*, the point on that continuum at which an auditor's behavior pattern is characterized is dependent on the level at which that auditor's behavior is examined -- the lower the level, the more likely it is that the behavior pattern will be characterized as micro-repetitive.

As to the second question, patterns of task behavior reveal how auditors perceive the task, its environment, and the relationships among the auditor, task, and environment. The continuum model holds that micro-repetitive task behavior is a consequence of an expert auditor's perception of a field task as a sequence of hierarchically related sub-tasks. Therefore, a high-level linear strategic pattern that progresses toward a task end-stage in conjunction with a lower-level micro-repetitive pattern is more likely to indicate a (relative) expert, while a lack of progress in a task along with an absence of micro-repetitive behavior is more likely to indicate a (relative) novice.

Further Research Opportunities

This research points the way for further study at two levels. At a fundamental level, future research must be directed to increasing the power of the methodology introduced in this paper, while at a quasi-applied level are issues of more immediate significance for audit research and for gaining an enhanced understanding of auditor expertise. However, aside from its use as a guide in investigations of expert-like behavior, the continuum model provides an objective means for studying individual differences in task behavior for any purpose for which such information may be relevant.

Issues for Fundamental Research

Among fundamental issues for further research are possible extension of the proposed methodology to include examinations of tactical behavior and the implications of including intentionality of behavior in interpreting behavior patterns. While strategic patterns are examined in terms of the change in strategic emphasis (*i.e.*, the mix of purposeful and intentional groups), tactical patterns focus on the mix of within-group behaviors. Consideration of the intentionality of behavior may be of considerable assistance in resolving ambiguities regarding arrival at end-stage behavior. In addition, by comparing what is learned from studies of the observed intentionality of behavior with what is learned from both cognitive and behavioral studies, insight can be gained into the validity of inferences drawn from studies of purely observable task behavior, on the one hand, and from the current cognitive and behavioral paradigms, on the other.

Issues of More Immediate Application

Overcoming the Limitations of A Purely Cognitive Paradigm

What an auditor does, how it is done, and what in the environment are the objects of an auditor's actions are not always discernable from protocols of cognitive processes. It is widely acknowledged that as auditors gain expertise, the cognitive aspect of their mental processes give way to subconscious, automatically mediated behavior transitions. Because automatic mental processes are not accessible by current cognitively-based methodologies, it is essential that the observable behavior of auditors be incorporated into the behavioral research program (see Russo 1999 and forthcoming in 2002 for examples.) Further, obtaining the most valid understanding of these relationships requires that auditor behavior be studied under the most realistic conditions and in the least intrusive manner. While concurrent verbalization of cognitive processes has been shown to be a valid report of information processed consciously during performance of a task (Ericsson & Simon 1993), it cannot be taken for granted that the technology for obtaining such protocols is completely benign, and laboratory situations are not, and can never be, field conditions.[18] It is, therefore, important to be able to capture and interpret behavior under actual field conditions. Video tape methodology and an analytical approach such as that presented in this paper provide additional but less intrusive means for enhancing our knowledge and understanding of auditor behavior.

Enhanced Understanding of Auditor Expertise

Setting aside the very significant and as yet unsettled questions of who is an expert and what is the nature of expertise, the summary of findings and crude ranking reported in Table 7 suggest that it may be possible to develop an objective scale by which the relative expertise of auditors and their progress toward greater expertise may be measured. In the context of empirically intense tasks, much is still to be learned.

ENDNOTES

1. "Empirically intense" is a term used by Russo (1999, forthcoming in 2002) to differentiate certain kinds of field tasks from the laboratory tasks traditionally used in auditing behavioral research. In brief, solutions to empirically intense tasks are transformations of the auditor's physical and/or social task environment by means of highly interactive behaviors. A more complete differentiation among major kinds of tasks involved in auditing behavioral research is provided later in the text.

2. Russo's (1999) study of auditors performing an empirically intense field task combines observable and cognitive behavior in assessing the effect of experience on *changes* in auditor expertise, but does not examine behavior patterns.

3. Experienced auditors will often follow "check lists" and other aids as a means of gaining assurance that all necessary procedures have been followed and considerations taken into account. However, such practice aids are more in the nature of lists of sub-task objectives rather than in the nature of detailed prescriptions of steps to be followed. To the extent that the nature of these devices is more of the former than the latter, they require a greater *ad hoc* input, and, consequently, a greater level of expertise to use properly. Consequently, use of check lists and similar devices by experienced auditors is not likely to change the assertions made in the text.

4. The emphasis on the phrase *in the task* is important. The observer must be knowledgeable only to the extent that the behaviors covered by the coding system can be recognized, given the task domain. However, it is not necessary that the observer be knowledgeable about the task objective, procedures or sub-tasks generally performed in the task domain, resources appropriately or inappropriately utilized, etc., or be capable of evaluating the quality of the task behaviors or the task outcome.

5. The validity of the behavior observation system, i.e., whether the system actually captures and measures what it purports to capture and measure, is a matter that must be resolved to the satisfaction of those using the resulting data, and in particular, to the observer.

6. Purposeful behavior is action that is consistent with one's beliefs and opinions at the moment. Intentional behavior is action directed at some entity in the actor's environment. For example, reading a newspaper or reading a map can both be considered as purposeful behaviors (becoming informed about the outcome of an election and locating the shortest route connecting two locations on the earth's surface) but have different intentionality (a particular newspaper and a particular map.) If one assumes that behavior is rational, then one can infer from observing these behaviors that the actor holds certain beliefs and opinions (*e.g.*, that the newspaper is a factual report of an actual event, etc., and that the map is an accurate depiction of the physical relationships among certain features on the earths surface, etc.)

7. Biggs and Mock described the patterns of behavior mentioned as "strategies", failing to make distinction mentioned earlier between *strategy* and *strategic pattern.*

8. The AICPA standards of field work reflect the basic linear sequence in that they require that the audit be planned and competent evidence accumulated before an opinion (the work product of an audit) is expressed.

9. For example, Horngren, *et al.* (*Cost Accounting* 9th ed. 1997: 385) list the following steps: Gather information, Make predictions, Choose an alternative, Implement the decision, and Evaluate performance.

10. The duration of a frame is limited by the observer's ability to reliably capture, recognize, and code observed behavior. In the experiment described later in this paper, the frame size used was 3 seconds (See Russo 1994:208).

11. The mean strategic emphasis of any observation interval, t, that is made up of any number of contiguous sub-intervals or frames (*e.g.*, t', $t'+1$, $t'+2$, ... $t'+\beta$) is the sum of the strategic emphasis of each of the constituent intervals weighted by the frequency of behaviors in each (i.e., $\rho_t = \sum_{t'}^{t'+\beta} \rho_i n_i / \sum_{t'}^{t'+\beta} n_i$). Successive intervals need not be of equal duration.

12. For example, assume observed phases of $g1, g2, g1$. This sequence illustrates 1.5 cycles. The duration of a phase is not considered in counting fractional cycles.

13. A rare exception to this statement occurs in cases in which an auditor performs behaviors in a single purposeful group throughout the solution sequence.

14. Because there are only two purposeful behavior groups, decreased emphasis on one implies increased emphasis on the other.

15. In such a case, subject to comparison against other auditors, one would have to question if any progress is being made toward completion of the task.

16. Evaluation of the probability distribution of sequence frequencies for two intervals proceeds as follows: There are two possible strategies, each with probability 0.5, for the first interval. For each of these, there may be either a significant or not-significant finding. Thus for the first interval there are $2^2 = 4$ outcomes. For each of these outcomes, using the same reasoning for the second interval, there are also 4 possible outcomes. Thus, in total there are 4 x 4 = 16 possible outcomes to evaluate by use of the rules for counting cycles. Following this procedure, the resulting sequences for the initial g1 branch is {g1g1, g1**g1**, g1g2, g1**g2**, **g1**g1, **g1g1**, **g1**g2, **g1g2**}, where a **bold** notation indicates a significant finding in any interval. Using p=.01 as a level of significance, the resulting probabilities, in the respective order of the preceding sequences, are {.245025, .002475, .245025, .002475, .002475, .000025, .002475, .000025}. Finally, the cycle count and determination ratio, respectively, of each outcome is {0, 2, 0, 2, 2, 2, 2, 1} and {0, 2, 0 2, 2, 1, 2, 1}. Because the branching of the decision tree thus generated is symmetric for a given initial choice in the first interval, the volume of evaluation can be reduced by one-half, the resulting probabilities doubled to obtain the final distribution. The bi-variate probability density thus determined for the full decision tree is:

Frequency (cycles)	Determination ratio		
	0	2	1
0	0.98010	-	-
2	-	0.01980	0.00005
1	-	-	0.00005

This procedure was also followed for 10-interval sequences to obtain the probabilities of the patterns reported in Table 6. For 10 intervals, there are $4^{10} = 1{,}048{,}576$ branch outcomes to be evaluated in the complete decision tree. A computer program written by the author for this purpose is available upon request.

17. For example, non-accounts are more likely to incorrectly describe the effects of a transaction or transaction error than are accountants because they possess an incomplete or inaccurate understanding of the various sub-systems comprising an firm's financial information system and their inter-relationships. Accountants, on the other hand, tend to perceive a firm's financial information system as composed of specific interacting sub-systems, e.g., sales-accounts receivable-cash receipts; purchases-accounts payable-cash disbursements; etc. Having this more sophisticated model, they easily bring to bear relevant relationships, eschew irrelevant relationships, and can be assured that the issue in question is traced completely through the relevant components of all related systems, analyses, and reports.

18. Use of concurrent verbal protocol methodology requires the cooperation of the Subject. In contrast, video tape recording of a Subject's task behaviors can be accomplished under field conditions in a completely passive manner.

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