Auditors' Dominant Knowledge Structure: A Reaction Time Study

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Abstract: Much research has investigated whether auditors’ knowledge of errors is structured around audit objectives or transaction cycles as the dominant organizing dimension. One segment of this research used the cue-sorting method and concluded that audit objectives are the dominant organizing dimension (Frederick et al. 1994; Nelson et al. 1995; Bonner et al. 1996). On the other hand, some non-sorting studies have found that transaction cycle is the dominant organizing dimension (Libby and Frederick 1990; Frederick 1991). The purpose of this study was to determine if audit-objective dominant knowledge structure found in sorting studies can be found with the reaction-time method, which provides a more direct measure of knowledge structure. To investigate this issue we conducted a study with sorting and reaction-time phases. Consistent with prior research (Frederick et al. 1994; Nelson et al. 1995; Bonner et al. 1996), the sorting phase found an audit-objective dominant knowledge structure that was stronger in managers than staff. However, the reaction-time phase found that managers’ knowledge was structured around transaction cycle as the dominant organizing dimension, while staff demonstrated no dominant organizing dimension. The paper concludes with a discussion of implications for future research.

Key words: dominant knowledge structure, cue-sorting method, reaction-time method, audit objectives, transaction cycle.

Data Availability: Contact the authors

I. INTRODUCTION

Over the past decade considerable research has been directed at understanding how auditors structure knowledge of financial-statement errors in memory. While knowledge of errors has both audit objective and transaction cycle dimensions, an important segment of prior research has focused on determining whether transaction-cycle or audit-objective is the dominant organizing dimension. In other words, do auditors structure their knowledge of errors in a hierarchy with specific transaction cycles as the super-ordinate dimension and audit objectives as a subordinate dimension within particular cycles (e.g. Revenue Cycle as the dominant dimension and audit objectives of Existence, Completeness, etc. as subordinate dimensions)? Or, is the relationship reversed with audit objectives as the super-ordinate dimension and transaction cycles as a subordinate dimension within particular objectives (e.g., Existence Objective as the dominant dimension and transaction cycles of Revenue, Inventory, etc. as subordinate dimensions)? The issue is important because configuring audit tasks around dominant knowledge structures is thought to be critical to auditor decision performance (Nelson et al. 1995; Bonner et al. 1996; Bedard and Chi 1993; Smith and Kida 1991).

Much of the research investigating the dominant knowledge structure issue has used the cue-sorting method. These studies conclude that auditors have an audit-objective dominant knowledge structure, with transaction-cycle as a subordinate structure (e.g., Frederick et al. 1994; Nelson et al. 1995, Bonner et al. 1996). Interestingly, other studies using non-sorting methods have concluded a transaction-cycle dominant knowledge structure (Libby and Frederick 1990; Frederick 1991). The overall purpose of the current study is to provide additional evidence using an experimental method that addresses weaknesses (discussed below) of the cue-sorting method.

Providing additional evidence is important for two reasons. First, in a sorting study, a participant is required to sort cues into categories. The resulting categories are considered evidence of the participant's knowledge structure in memory (Tyszka 1994). However, the act of sorting cues requires a participant to make conscious choices about categories (McNamara 1994). For example, a participant might attempt to sort audit errors alphabetically, which could be independent of the actual organization of knowledge. In other words, one cannot be sure that the categories resulting from a sorting study reflect the dominant knowledge structure, a subordinate knowledge structure, or whether they are the result of some undetermined intermediate process. Importantly, we recognize that free-sort data provides evidence of knowledge; instead, we are maintain that the obtrusiveness of the free-sort task makes inferences about the dominant knowledge structure somewhat problematic.

The reaction-time method, which is used extensively in psychology (Van Zandt 2002), but seldom in accounting, addresses this weakness. With this method, participants respond to cues quickly (i.e., often within a fraction of a second). This immediate response minimizes the participant's opportunity to engage in conscious, intermediate processes that could influence the inferred knowledge structures (McNamara 1994). Indeed, the participant may not even be consciously aware of the categories being investigated in a reaction-time study. Because intermediate processes may influence research results from the use of the sorting method, it is important to determine if a less obtrusive method like reaction time will obtain results similar to those obtained from a free-sort method.

Second, when the theoretical premise of the research depends on identification of the dominant knowledge structure, it is important for researchers to consider using less obtrusive methods like reaction time. For example, research investigating performance effects of a mismatch between knowledge structure and task structure require an accurate identification of the dominant knowledge structure (e.g., Nelson et al. 1995, Bonner et al. 1996). Without an accurate identification of knowledge structure, experimental results would be hard to interpret, which would make any practice recommendations premature.

To investigate this issue, a two-phased experiment was conducted with audit managers and staff serving as participants. In one phase, auditors performed a cue-sorting task (free sort) based on materials developed by Frederick et al. (1994). Consistent with prior sorting tasks, both audit managers and staff revealed audit-objective dominant knowledge structures. Similar to Frederick et al. (1994), the results were stronger for audit managers than staff. In the other phase the same auditors performed a reaction-time task based on the same materials used in the sorting phase. Audit managers' reaction times were significantly faster for transaction-cycle than audit objective. Audit staff reaction times were not significantly different for transaction-cycle and audit-objective. These results indicate that, when studied with a research method that limits the possibility of conscious intermediating processes, audit managers' knowledge of errors is structured with transaction cycle as the dominant feature.

II. PRIOR RESEARCH AND HYPOTHESES

Structure of Auditor Knowledge

Frederick et al. (1994) conducted a study of financial statement errors that provided the basis for a number of follow-up studies. In this study, participants conducted both free sorts and directed sorts[1] of thirty-five financial statement errors (e.g., accounts overstated, entries booked more than once). Three groups of participants were examined: audit managers, audit staff, and students who had completed an auditing course, but had no auditing experience. Some participants from each group were required to free sort the errors, while others were required to do directed sorts on the basis of either transaction cycle or audit objective.

In the directed sorts, managers and staff could sort equally well by audit objective and transaction cycle. However, students' directed sorts did not match well with either audit objective or transaction cycle. In contrast, free sorts by managers were much more closely correlated with audit objective than transaction cycle. Staff auditors' free sorts were also more closely correlated with audit objective, while students' free sorts were correlated about equally between audit objective and transaction cycle. Based on these results, Frederick et al. (1994) conclude that, as auditors gain experience, audit objective becomes the most salient dimension of their knowledge of errors. In other words, the sorting data suggest that experienced auditors' knowledge of errors is structured around audit objective as the dominant organizing dimension and transaction cycle serves as a subordinate dimension.

Nelson et al. (1995) conducted a study that investigated a possible mismatch between the structure of auditor knowledge and the structure of audit tasks. That is, if auditors structure their knowledge with audit objective as the dominant organizing dimension (based on Frederick et al. 1994), but audit tasks are primarily organized around transaction cycles, then there is a knowledge structure/task structure mismatch and auditor performance could suffer. To investigate this issue, Nelson et al. (1995) first had experienced auditors free sort nine errors based on Frederick et al. (1994). The results of the free sorts were consistent with Frederick et al. (1994) results, showing audit objective as the primary organizing dimension. Auditors then performed two audit planning tasks (conditional probability assessment and audit hour allocations) structured around either audit objective or transaction cycle. They found that task performance was hindered when auditors were making decisions in conditions that mismatched the structure of knowledge of errors (audit objective dominance) and the structure of tasks (transaction cycle).

In a follow-up study to Nelson et al. (1995), Bonner et al. (1996) tested the effectiveness of two decision aids in counteracting the diminishment of auditor task performance under conditions of a knowledge structure/task structure mismatch. To establish auditors' knowledge structure they first had participants (auditors with an average of 3.3 years' experience) free sort the same nine errors as used in the Nelson et al. (1995) study. The results of the free sort were similar to Nelson et al. (1995) and Frederick et al. (1994), showing an audit objective dominance. They then tested the effectiveness of two decision aids (checklist and mechanical aggregation, both of which were specifically designed to counteract the predicted knowledge structure/task structure mismatch) for conditional probability assessments. Decision aids helped auditors most when they were performing a task structured around transaction cycle. Bonner et al. (1996) conclude that tasks structured around transaction cycle are mismatched with auditors' knowledge, which appears to be structured around audit objective (based on free-sort data).

A common theme flows through the above studies. Based on free-sorts of error cues taken from Frederick et al. (1994) all conclude that although experienced auditors possess both audit objective and transaction cycle knowledge structures, audit objective is the dominant structure.[2] An important question is whether similar results have been found with other research methods. Although studies using non-sorting methods typically provide less direct evidence regarding dominant knowledge structures, the results of these studies are not always consistent with sorting results.

Libby and Frederick (1990) required auditors to generate financial statement error explanations for changes in a financial ratio profile. Participants' error explanations were classified by both transaction cycle and audit objective violated. The results showed a significant increase in transaction cycle explanations with increased experience, but a significant experience difference for audit objective explanations with experience was not found. Based on this analysis of error explanations, they infer that experienced auditors' knowledge of errors is organized primarily by transaction cycle.

Frederick (1991) studied auditors' knowledge of internal controls, using both recall and sorting methods. Free sorts resulted in about equal numbers of auditors categorizing internal controls by audit objectives (referred to as taxonomic) and by transaction cycle (referred to as schematic). However, when the recall method was used, experienced auditors recalled significantly more internal controls from the transaction cycle organization than the audit objective organization. While Frederick (1991) studied auditor knowledge of internal controls rather than knowledge of errors, the recall results were consistent with Libby and Frederick (1990) in finding a dominant transaction cycle organization.

In contrast, Tubbs (1992) conducted a conditional prediction task experiment in which participants of varying experience levels were asked to estimate the probability of occurrence of financial statement errors, half from audit objective and half from transaction cycle categories. Tubbs found that the auditors' probability estimations increased when a cue was from the same transaction cycle or the same audit objective. For audit objective, this effect increased with increased auditor experience. However, the transaction cycle result did not increase with increased experience. Based on these results, Tubbs concluded that the salience of the audit objective violated increased with experience while the salience of transaction cycle violated did not.

In summary, when the free-sorting method is used (Frederick et al. 1994; Nelson et al. 1995; Bonner et al. 1996), results indicate that auditors' knowledge of errors is structured around audit objective as the dominant organizing dimension. The only sorting result that is slightly at variance with this conclusion is Frederick (1991), who found equality between audit objective and transaction cycle organizations, and his study addressed internal control knowledge not knowledge of errors. However, his recall data showed a dominant transaction cycle organization (Frederick 1991). Further, when knowledge structure is inferred from other decisions, results are mixed. Libby and Frederick (1990) infer transaction cycle organization, while Tubbs (1992) found audit objective to be more salient as experience increased.

The discrepancies in the conclusions of the prior research about the dominant auditor knowledge structure indicate a need for clarification. This clarification is particularly important because free sorting allows conscious categorization decisions that make it difficult to distinguish between dominant and subordinate knowledge structures. Thus the overall goal of the current study is to determine if the knowledge structure exhibited by auditors varies depending upon whether free-sort or reaction-time methods are used.

The first step in accomplishing this research goal is to replicate the two primary free-sort findings. Such a replication will establish that our participants are substantively similar to those used in prior free-sort studies. Based on the findings of Frederick, et al. (1994), Nelson et al. (1995), and Bonner et al. (1996), we predict that managers' free-sort data will exhibit an audit objective dominant knowledge structure. Based on Frederick, et al. (1994), we further predict that free-sort data will show that audit objective dominance becomes more pronounced with experience. These predictions are encompassed in the following hypothesis:

H1: In a free-sort task, both managers and staff will exhibit an audit objective dominant knowledge structure. Further, this dominance will be more pronounced for managers than staff.

Sorting and Reaction-time Methods

Because this research compares the results from sorting and reaction-time tasks, this section presents background on the two methods. The sorting method is commonly used in cognitive psychology to determine how participants classify objects (e.g., van der Kloot and van Herk 1991; Nelson et al. 1995). Participants are given cards on which stimuli are written, and are instructed to sort them into categories according to the relationships between the stimuli. In a free sort, participants are allowed to create categories according to their own wishes (van der Kloot and van Herk 1991). The underlying rationale is that the resulting categories match representations of the stimuli in memory (van der Kloot and van Herk 1991). In order to perform a sorting task, participants must consciously develop categories and then deliberately put the stimuli into those categories.

It is this conscious processing involved in categorizing stimuli that is a drawback of the sorting method when used to infer dominant knowledge structures. That is, categorizing stimuli requires conscious, non-automatic, judgments that can involve unspecified intermediate processing by the participant. Such undetermined processing mechanisms are intrusions into the data that can transform and obscure important characteristics of stored knowledge (McNamara 1994). This criticism is also consistent with preferences for concurrent as opposed to retrospective verbal protocols (Ericcson and Simon (1984).

In contrast, the reaction-time method promotes a near automatic response, thereby minimizing conscious intrusions in the process (McNamara 1994). In its simplest form reaction time measures how quickly participants respond to a target group of letters as being a word or non-word following exposure to a prime. For example, participants typically respond more quickly to a target word such as *doctor* when it is preceded (primed) by a semantically related word such as *nurse* versus an unrelated word such as *turkey* (Cree et al. 1999). Because reaction-time tasks are unaffected by participants' choices and are cognitively impenetrable, they are particularly well suited for the study of categorization of knowledge (Pylyshyn 1984).

Initially priming involved the use of single word primes, but subsequent research has involved multiple words and category/sentence verification tasks (e.g., Roth and Shoben 1983; Ratcliff and McKoon 1989; Kounios 1993; Johnson 1996). In category verification tasks, participants are presented with sentences whose truth must be verified with respect to stored semantic information (Casey and Heath 1989). Reaction times to these regimented sentences are fairly quick and participants are, at best, only dimly aware of how they go about verifying such propositions. The implication is that the processing mechanisms that allow a participant to verify these sentences are simple, experimentally controllable and understandable. Therefore, reaction-time tasks allow researchers to penetrate through these processing mechanisms to participants' underlying knowledge structures (Kounios 1996).

Category verification tasks have been one of the predominant empirical techniques for studying human semantic memory. Cognitive psychologists have used identification tasks as a means to explain the representation of concepts and categories in memory (Kounios 1993). Various psychological theories postulate that inferences about related structure comprising semantic memory can be made based on the speed of responses in these tasks (Kounios et al. 1994).

The best known of these theories is Spreading Activation (Collins and Loftus 1975; Anderson 1983; McNamara 1992).[3] In this theory, semantic memory is conceptualized as a network of interconnected nodes with each node representing a concept. Each node plays a double role as a concept defined by the network and as an attribute defining other concepts (Chaffin 1992). Nodes are connected if the concepts they represent are semantically or associatively related. Recognizing a word/concept involves activating its corresponding node in the semantic network.

Identification/verification of a relation between two nodes or concepts is done through a relatively simple search through a highly elaborate knowledge structure for a pre-stored relation (Kounios 1993). Spreading Activation explains the speed of verification of two concepts as a function of the distance between two concepts in the network and/or the level of activation in the link between the two concepts. The time required for the process to take place is inversely proportional to the strength of the link between the two nodes in question (McNamara 1992).

Thus, stronger connections result in faster reaction times and lead to two inferences, which form the bases for our hypotheses. First, following the auditor expertise literature (e.g., Bedard and Chi 1993, Libby and Frederick 1990, Frederick et al. 1994), we would expect that managers would have more organized knowledge of errors and would have faster reaction times than staff. Finding this experience difference provides assurance that we are observing evidence of knowledge structures and will provide comfort for further conclusions about organizing features of knowledge investigated in hypothesis three. Thus, we predict that regardless of the knowledge structure obtained, managers will be faster than staff.

H2: Manager reaction times will be faster than staff reaction times.

The second inference is that faster reaction times associated with different primes are the basis for concluding dominant organizing dimensions of knowledge in memory (Kounios 1993). For example, if auditors have faster reaction times to errors primed by audit objective than to the same errors primed by transaction cycle, then it follows that audit objectives have stronger associations in memory. Such a finding would be the basis for concluding that audit objective is the dominant organizing feature of auditor knowledge of errors. Further, consistent with sorting results and psychology studies (e.g., Alba and Hutchinson 1987), dominance in knowledge structures should be more pronounced for managers than staff.

As discussed in previous research (e.g., Frederick et al. 1994), there are reasons to believe that auditors may develop either a transaction cycle or an audit objective dominant knowledge structure. We treat this question as an empirical issue that deserves additional verification for two reasons. First, although sorting studies consistently show an audit objective dominant knowledge structure, potential conscious processes can intrude into a sorting task, which makes reliance on sorting results worrisome.

Second, because many prominent auditing texts (e.g., Arens et al. 2003) and the auditing literature suggests that transaction cycle is a useful basis for categorization (e.g., Coakley and Loebbecke 1985). As such, we propose competing hypotheses for whether audit objective or transaction-cycle primes will result in faster reaction times.

Competing knowledge structure hypotheses:

H3a: In a reaction-time task, both managers and staff will exhibit an audit-objective dominant knowledge structure. Further, this dominance will be more pronounced for managers than staff.

H3b: In a reaction-time task, both managers and staff will exhibit a transaction-cycle dominant knowledge structure. Further, this dominance will be more pronounced for managers than staff.

III. RESEARCH METHODS

Participants

Twenty-seven audit staff and 26 experienced senior/manager auditors successfully completed the task. Consistent with prior research using a free-sort methodology (e.g., Frederick, et al. 1994), the staff auditors had less than one year of audit experience (μ = 8 months) while the experienced senior/manager auditors had from three to 10 years' experience (μ = 4.6 years).[4]

Overview of Materials and Procedures

All participants completed both a free-sort and reaction time experimental task. Although the free-sort task is discussed first, the order of the tasks was counterbalanced and a distractor task was performed between tasks. The Frederick, et al. (1994) instrument was used for the free-sort task. This instrument required participants to sort 35 financial-statement errors into groups of "audit differences that go together." The participants were allowed to create as many groups as they felt were appropriate. They were then asked to designate a title for each group of errors.

Before beginning the reaction-time task, participants read detailed instructions that were adapted from instructions used in psychology (e.g., Johnson 1996). The participants were asked to respond quickly and accurately. They were told that the experiment was a test of both speed and accuracy. To familiarize the participants with the reaction-time task and software, a short practice session was administered. The practice questions were not related to accounting. E-Prime software was used to collect the reaction-time data. This software recorded participants' reaction time (in milliseconds) and accuracy for each question, which is the standard practice in reaction-time studies (Piolat et al. 1999). Additionally, the software randomized the order of presentation.

In the experimental task, participants were first given either an "audit objective" (e.g., cut-off, valuation) or "transaction cycle" (e.g., inventory, payroll) prime. The prime remained on the screen until the participant pressed the space bar. After a 100 millisecond blank interval the test sentence appeared (e.g., Finished goods received next period were recorded in the current period). Participants then pressed a key to indicate whether the test sentence was or was not an example of the preceding audit objective or transaction cycle error.

The 35 financial-statement errors used in the free-sort task were used as test sentences.[5] Additionally, to ensure a balance between test sentences that were and were not an example of each audit objective and transaction cycle error, these 35 sentences were also matched with an incorrect audit objective and transaction-cycle primes. As all 35 test sentences were matched with a correct and incorrect prime for both audit objective and transaction cycle, each participant responded to 140 prime/test sentence combinations.

Variables

The free-sort hypothesis was tested by comparing the free sorts of participants in our study to the audit objective and transaction cycle directed sorts documented in Frederick et al. (1994). Using two experience levels (managers and staff) and the two categorizations (audit objective and transaction cycle) as the independent variables, we determined which directed sort our participants' free sorts most closely resembled with a similarity measure as the dependent variable.

The reaction-time hypotheses were tested using a dependent variable of participants' time to verify (i.e., reaction time) whether a financial-statement error was or was not an exemplar for a primed audit objective or transaction cycle. Consistent with the psychology literature (McNamara 1994; Chaffin and Hermann 1988), only the reaction times for which a participant accurately responded "correct" for both the audit objective and transaction-cycle primes were analyzed.[6] Thus, prime (audit objective or transaction cycle) was a within-subject independent variable and experience (managers and staff) was a between-subject independent variable.

IV. RESULTS

Results for Free Sort

Consistent with Frederick, et al. (1994) the sorting data for each participant were converted to a 35x35 binary symmetric similarity matrix. A value of one was assigned to the matrix element if the two cards were sorted into the same pile, and zero otherwise. The data were then aggregated to form a pooled similarity matrix for both the manager and staff experimental conditions. The value assigned to the diagonal element of each pooled matrix represented the total number of participants in that condition. The value assigned to the off-diagonal elements represented the number of participants who sorted the two cards into the same pile. To determine the categorization used by the participants, the Average Linkage method of hierarchical cluster analysis was performed for each treatment group using the pooled similarity matrix as input to produce an aggregate group matrix with values of one if the two cards were sorted into the same category and zero otherwise.[7]

The sorting hypothesis (H1) predicts that auditors' free sorts will more closely resemble audit objective than transaction cycle directed sorts and that this difference will be more pronounced in managers, thus, replicating previous sorting findings (Frederick, et al. 1994; Nelson et al. 1995; Bonner et al. 1996). To test this hypothesis we analyzed the proximity (or dissimilarity) matrix associated with the hierarchical cluster analysis. A proximity matrix is a 35x35 matrix in which each matrix element represents the squared Euclidian distance (hereafter, distance) between the respective errors. Hierarchical cluster analysis forms categories by grouping errors in a manner that minimizes errors' distance from other errors in the group. We compared the within group distances between errors when matching the audit objective and transaction cycle directed sorts from Frederick, et al. (1994).[8] Table 1 presents the results of an ANOVA model in which categorization (audit objective versus transaction cycle) and experience (manager vs. staff) are the independent variables and the distances between errors grouped in the same category is the dependent variable.

[Insert Table 1 about here]

As hypothesized, our results replicate Frederick et al.'s (1994) free-sort findings in two critical ways. First, the significant main effect for categorization ($F = 96.419$; $p < 0.001$) indicates that our auditors' free sorts more closely resembled the audit objective directed sort. Second, although the staff's free sort was closer to audit objective ($\mu = 1174$) than transaction cycle ($\mu = 2116$), the difference between these two dimensions was not as large as it was for managers ($\mu = 1056$ vs. $\mu = 2308$; $t = 2.06$; $p = 0.020$).

These results are further supported by simply comparing the errors our participants' grouped together in a free-sort task with those grouped together in the directed sorts reported in Frederick, et al. (1994) (see Tables 2 and 3 for manager and staff, respectively). These tables show that our participants' free sorts were very similar to the audit objective directed sorts for both experience levels. Given the similarity between Tables 2 and 3, we only discuss Table 2.

Our managers' grouped the errors into six categories (see Table 2). There is a heavy overlap between our managers' free sorts and the audit objective directed sorts from Frederick et al. (1994) for Categories 1, 2 and 6. Our managers broke out the two fraudulent transactions into a separate category (Category 4), while managers in the audit objective directed sort grouped them with other improper recording errors (Category 2). Further, reference to Table 1 in Frederick, et al. (1994) shows that Categories 4 and 5 in the managers' audit objective directed sorts were labeled "Proper classification within financial statements" and "Proper classification between financial statements"; whereas, our managers' free sort into one larger "Proper classification" category.

[Insert Tables 2 and 3 about here]

When comparing our managers' free sort to the transaction cycle directed sort, on the other hand, very little common grouping is noticed. In five of the six categories at most two items are grouped together. Further, the errors grouped together for each of the free-sort categories 1, 2, 3 and 5 were sorted into at least four separate categories by managers directed to sort by transaction cycle.

Results for Reaction Time

H2 predicts that managers will respond faster than staff because of more developed knowledge structures. Table 4 summarizes the results of the ANOVA with experience (manager vs. staff) as a between-subject independent variable and prime (audit objective vs. transaction cycle) as a within-subject independent variable. Consistent with H2, managers' reaction times were significantly faster than staff's ($F = 13.040$; $p < 0.001$). Further, planned contrasts suggest that this result holds for both audit objective ($t = 1.83$; $p = 0.036$) and transaction cycle ($t = 5.39$; $p < 0.001$). This result provides assurance that we are observing valid knowledge structures because of its consistency with two previously documented findings. One, the expertise literature indicates that greater experience results in more developed knowledge structures (e.g., Bedard and Chi 1993). Two, the spreading activation memory theory indicates that as knowledge structures develop, the associations between related concepts within the structure become stronger (Collins and Loftus 1975).

[Insert Table 4 about here]

H3a and H3b offer competing predictions. H3a predicts that both managers and staff will respond faster with audit-objective primes than with transaction-cycle primes, thus, supporting conclusions drawn from experiments using free-sort data (e.g., Frederick et al. 1994). H3b predicts that both managers and staff will respond faster with transaction-cycle primes than with audit-objective primes because of contradictory results in non-free-sort studies and because the transaction cycle is a useful basis for categorization in audit practice. Both H3a and H3b predict that dominance will be more pronounced in managers than in staff. Table 4 indicates that, consistent with H3a and H3b, there is a significant prime by experience interaction ($F = 4.182$; $p = 0.021$). Analysis of the planned contrasts associated with the prime by experience interaction shows that while managers' reaction times are significantly faster with transaction-cycle primes ($t = 4.98$; $p < 0.001$), there is not a significant difference for staff ($t = 1.42$; $p = 0.161$). These results provide no support for an audit objective dominant knowledge structure (H3a). H3b is partially supported in that a transaction cycle dominant knowledge structure was found for managers but not staff. This finding is consistent with the expertise literature suggesting that dominance increases with experience (e.g., Alba and Hutchinson 1987). However, the equivalence of reaction times across primes in staff is at variance with sorting results (Frederick et al. 1994) in which staff auditors also showed a dominant knowledge structure. The fact that, in this study, staff did not demonstrate a dominant knowledge structure raises the question of when a dominant knowledge structure begins to develop.

Supplemental Analysis

One challenge in sentence verification tasks, such as ours, is the wording of test sentences. Reference to the Frederick et al. (1994) stimuli (See Table 2) shows that information for transaction cycle often appears before that for audit objective. For example, in the test sentence "Goods acquired on account were not recorded," the key words for identifying the audit objective (were not recorded) appear at the end of the test sentence. While it may be possible to alter the wording of test sentences to address this issue, there are two reasons why we did not do so. First, the primary objective of the research was to determine if the reaction-time method would obtain the same results as the sorting method. Since the sorting phase of our research replicated Frederick et al. (1994) and other sorting studies (e.g., Nelson et al. 1995) also based their experimental materials on the Frederick et al. (1994) materials, we believed it was important to maintain as much comparability across methods as possible. Second, altering the wording to balance the location of key words for audit objective and transaction cycle could make the sentences difficult to read (e.g., "Not recorded were goods acquired on account") and could add noise and/or bias to the results (e.g., Kounios 1993). Thus, we recognize the wording of the test sentences as a design limitation and conduct supplemental analyses to determine if it is likely that our results were affected by the location of key identifying words for transaction cycle and audit objective in the test sentences.

First, we had an auditing professor with public accounting experience, who was unaware of the experimental hypotheses, evaluate all test sentences and identify a word or set of words that were key indicators of transaction cycle and audit objective. Based on this analysis approximately 17.5 percent of the data were from test sentences in which the information key to identifying transaction cycle did not appear earlier in the sentence. We analyzed this subset of data to determine if the results differ from results obtained from the entire data set. As shown in Table 5, the pattern of results appears consistent with the overall data set. Specifically, there is a significant prime by experience interaction ($F = 2.987$; $p = 0.043$). Consistent with the overall data set, planned contrasts of this interaction indicate that (1) managers' reaction times are significantly faster with transaction cycle versus audit-objective primes ($t = 2.47$; $p = 0.008$), (2) managers' reaction times with transaction-cycle primes are significantly faster than staff's ($t = 3.41$; $p < 0.001$), and (3) staff's reaction times are equivalent across primes ($t = 0.11$; $p = 0.913$). Inconsistent with the overall data set, managers' reaction times with audit-objective primes are not significantly faster than staff's ($t = 0.83$; $p = 0.204$). However, the overall difference in reaction times for managers and staff with audit-objective primes in the overall data set (3.206 - 3.071 = 0.135) appears consistent with that in the data subset (3.195 – 3.047 = 0.148).[9] These analyses indicate that the pattern in the experience by prime interaction found in the overall data set, including managers' faster response with transaction-cycle primes, holds even when transaction cycle does not have a location advantage in the test sentences.

[Insert Table 5 about here]

Second, although most psychology studies only analyze reaction times for correct responses, in some studies overall participant accuracy has been examined with the prediction that the more dominant knowledge structures also lead to greater accuracy (e.g., Chandra and Krovi 1999). Results of this analysis indicate that managers are marginally more accurate than staff ($F = 2.538$; $p = 0.059$)

and were significantly more accurate with transaction-cycle primes ($t = 6.33$; $p < 0.001$). The consistency between accuracy results and the reaction-time results provides some additional assurance that transaction cycle is the dominant knowledge structure for managers.

Based on the results of this supplemental analysis it seems reasonable to conclude managers' faster reaction times for transaction cycle were due to their dominant knowledge structure and were not an artifact of the wording of the test sentences. Finally, we add that if the wording of the test sentences drives the transaction cycle advantage, we know of no reason why it should not equally affect both managers and staff. However, the pattern of our results is inconsistent with an equal effect for managers and staff.

V. DISCUSSION

The overall purpose of this study was to determine if the audit-objective dominant knowledge structure found in sorting studies can be replicated with a reaction-time task. To investigate this issue we conducted a study with sorting and reaction-time phases. Consistent with prior sorting studies (Frederick et al. 1994; Nelson et al. 1995, Bonner et al. 1996), the sorting phase found an audit-objective dominant knowledge structure that was stronger in managers than staff. However, the reaction-time phase found a transaction cycle dominant knowledge structure for managers, while staff demonstrated no dominant knowledge structure.

We conclude that it is more likely that auditors' knowledge of errors is structured around transaction-cycle as the dominant organizing dimension for two primary reasons. First, sorting requires individuals to make conscious categorization decisions (Bedard and Chi 1993). It is important to recognize that it is likely that sorting decisions categorize errors by dimensions that are present in memory. However, this study is concerned with whether those dimensions are the dominant organizing dimensions. As discussed earlier, reaction time eliminates individuals' opportunity to make categorization decisions and thus provides a more direct test of the dominant knowledge structure. Second, the reaction-time finding of a transaction-cycle dominant knowledge structure is more consistent with how the literature indicates that auditors learn and how audits are structured (Arens et al. 2003, Coakley and Loebbecke 1985 Frederick et al. 1994, and Nelson et al. 1995).

There are two implications of our results. One, when an accurate indication of the dominant organization of knowledge is a key element of a research project, then the reaction-time method should be preferred over the sorting method. As discussed earlier in the paper, the reaction-time method provides a relatively unobtrusive method for obtaining data about how is how knowledge is linked. Moreover, reaction times are integral elements of prominent memory theories (e.g., spreading activation theory). This is not to say that sorting studies are not useful. Clearly, sorting results represent knowledge that is present in memory (Bedard and Chi 1993). Thus, sorting is useful for identifying categories of knowledge. However, reaction time allows more direct inferences about the strength (e.g., dominance) of linkages within and across categories of knowledge.

Consider two studies that investigated the potential mismatch between dominant knowledge structure and task structure, using a free-sort task to identify audit objective as the dominant knowledge structure (Nelson et al. 1995 and Bonner et al. 1996). If, as our results suggest, the dominant knowledge structure was misspecified, then it is difficult to interpret the implications of their studies. For example, based on psychology research (e.g., Sherman et al. 1992), it is possible that the distinguishing features of the audit objective dimension became more salient because of the preceding free-sort task and that this, rather than dominant knowledge structure, is responsible for the performance differences noted in the conditional probability assessments. Another explanation may be that it is possible to achieve these results without a knowledge structure/task structure mismatch. That is, auditors may have knowledge structured around transaction cycle, but when given the opportunity to take their time to sort or assess conditional probabilities they prefer to use audit objective as the basis for decisions.

The second implication has to do with the question of why auditors consistently free sort by audit objective when their knowledge is structured around transaction-cycle. Numerous sorting studies, including this one, show that when auditors are given time to freely sort audit errors, they clearly prefer to classify them by audit-objective. There are several possible reasons why this could be the case. For example, as discussed previously, a free sort is really a cognitive task that allows auditors' choices to be expressed in the results. Since auditors employ reasoning processes in sorting cues, they may be thinking more about the causes of errors, which are inherent in audit objectives (e.g., validity violation) rather than the location of the errors, which would be related to transaction cycle. Another possibility is that auditors make conscious decisions to sort cues by audit objective because they think that is what researchers expect.

While we have discussed the limitations of the sorting method, there are also limitations to the reaction-time method that should be acknowledged. First, extraneous factors can influence individual participants' reaction times such as reading speed and lapses in attention (Luce 1984). However, the within-subjects design controls for individual differences (e.g., reading speed, coordination, etc.). On the other hand, factors like lapses in attention are expected occur randomly across conditions, but must be recognized as a limitation of the reaction-time method.

There are also limitations specific to our study. First, participants typically read words providing an indication of the transaction cycle prior to that of the audit objective. We attempted to control for this issue by demonstrating that the overall results held in the subset of the data in which transaction cycle information did not appear first, and by performing a number of diagnostic tests. Second, all the participants in the prior studies came from one "Big Six" Firm (Frederick et al. 1994, Nelson et al. 1995, and Bonner et al. 1996). In contrast, this study used auditors from all "Big Five" Firms, as well as auditors from smaller firms. While we detected no firm effects our auditors did come from a more diverse pool than prior sorting studies.

ENDNOTES

[1] Sorting studies usually are of two types, free sorts and directed sorts. In free sorts, participants are asked to sort cues into any categories they feel are appropriate. In directed sorts, participants are asked to sort cues into particular categories (e.g., sorting financial statement errors by audit objective or transaction cycle) and then the resulting sorting data are compared to pre-existing, standards for the categories.

[2] In another sorting study, Bonner et al. (1997) investigated whether instruction in transaction cycle and audit objective categories would facilitate learning that particular category of errors. They had students with no audit experience perform a directed sort of the same nine errors used in the Nelson et al. (1995) into three categories on the basis of either audit objective or transaction cycle. Consistent with Frederick et al. (1994), students' directed sorts did not correlate well with either audit objective or transaction cycle pre-determined categories. After instruction, however, students' directed sorts correlated perfectly with pre-determined categories for both audit objective and transaction cycle.

[3] Many other, somewhat related, network theories of memory exist. It should be noted that support exists for these theories and that psychological research has not settled on a definitive organizing principle, which elucidates the mechanics of internal human information processing (Chandra and Krovi 1999). For example, Hierarchical Network Model (Collins and Quillian 1969), Marker Search Model (Glass and Holyoak 1975), Schema Theory (Schank and Abelson 1977), Compound Cue Theory (Ratcliff and McKoon 1994) and Extended Cognitive Fit Model (Chandra and Krovi 1999). Reaching a definitive conclusion on the superiority of one of these theories is beyond the scope of this study.

[4] For ease of exposition we refer to senior/manager auditors as managers and staff auditors as staff. The experience levels of our participants are comparable to the Frederick et al. (1994) participants (median experience for managers of 5 years and for staff 1 year).

[5] Because some of the items from the Frederick et al. (1994) materials contained words that were identical to our descriptions of the transaction-cycle primes (e.g., the word "inventory" appearing in both the error description and the prime), slight wording modifications were made to approximately 50% of the test sentences. These modifications were made within the constraints of maintaining both the readability of the test sentences and comparability with the Frederick et al. (1994) materials. In one test sentence (#7) it was believed that changing "relief of inventory" to "relief of finished goods merchandise" would result in awkward or unusual wording and the word "inventory" was not changed. Inclusion or exclusion of data associated with this test sentence do not change the results and only represent about 2% of the total data.

[6] As discussed previously, each error was also matched with an incorrect audit objective and transaction-cycle prime. This was done to ensure an equal mix of "correct" true and false responses. Consistent with psychology research, these data are not analyzed (e.g., Chaffin and Hermann 1988; Collins and Quillian 1969).

[7] The hierarchical cluster analysis literature (e.g., Aldenderfer and Blashfield 1988) suggests that the two best methods are Average Linkage and Ward's. Each is superior under certain circumstances. We also performed the cluster analysis using Ward's method and the groupings were identical.

[8] We were unable to calculate the cophentic correlations with Frederick, et al. (1994) data due to data unavailability.

[9] We also performed the analysis on the overall data set in which the difference in the number of words key to identifying transaction cycle and audit objective was used as a covariate. The mean (standard deviation; range) of this location covariate is –3.71 (2.77; -8 to 3), which indicates that, on average, information key to identifying transaction cycle appeared 3.71 words before key audit objective information. Because the covariate was insignificant and the overall results were unaffected by its inclusion, we do not include the covariate in the analysis. Results were unaffected by calculating the

covariate with characters (including and excluding spaces), average word locations, and a categorical variable (transaction cycle or audit objective information first).

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TABLE 1

Results for the Effect of Categorization and
Experience on Distance between Errors Grouped in the same Category*

Panel A: ANOVA

Source of Variation	*SS*	*df*	*MS*	*F-stat*	*p-value*
Categorization	105724210	1	105724210	96.42	<.001
Experience	118176	1	118176	0.11	.743
Categorization x Experience	2113885	1	2113885	1.93	.083
Error	391452801	357	1096506		

Panel B: Descriptive Statistics (Mean, Standard Deviation)

		Categorization	
		Audit Objective	Transaction Cycle
Experience	Managers	1056 (1154)	2308 (1063)
	Staff	1174 (924)	2116 (1089)

* Distance is the Squared Euclidian distance between respective errors as taken from the proximity (or dissimilarity) matrix used in hierarchical cluster analysis. Heirarchical cluster analysis forms categories by grouping errors in a manner that minimizes an error's distance from other errors in the group.

Table 2
Free-Sort Categorizations Compared to Audit Objective Cycle and Transaction Cycle Directed Sorts for Managers

Error Number	Error	Free Sort	Audit Objective*	Transaction Cycle*
	Category 1:			
1	Next period's accounts receivable were recorded in the current period	1	1	1
6	Finished goods received next period were recorded in the current period	1	1	2
12	Raw materials were improperly shown as received after year-end.	1	1	3
13	Payments on account made next period were booked this period.	1	1	3
25	Current period's accrued interest expense on a long term loan was booked next period	1	1	5
31	Purchase of Treasury Bills were recorded in the wrong fiscal period.	1	6	6
	Category 2:			
5	Billings to legitimate customers were booked twice.	2	2	1
7	Relief of inventory was not recorded for goods shipped.	2	2	2
11	Finished goods merchandise was booked but not received.	2	2	2
14	Goods acquired on account were not recorded.	2	2	3
18	Payments on account were recorded but not made.	2	2	3
26	Bank loans were not recorded.	2	2	5
30	Loan retirement payments were booked but not made.	2	2	5

Category 3:

2	Goods returned by customers were underbooked.	3	2	1
3	The bad debt expense and allowance were underestimated.	3	3	1
8	Finished goods were not written down to net realizable value.	3	3	2
9	Overhead was overapplied to finished goods merchandise	3	5	2
16	Invoice prices of goods acquired were understated.	3	2	3
32	Sales of securities were underbooked.	3	2	6
33	Marketable equity securities were not written down to lower of cost or market.	3	3	6

Category 4:

24	Salaries were recorded for nonexistent employees.	4	2	4
35	Fictitious securities were booked	4	2	6

Category 5:

4	Other income was recorded as sales.	5	4	1
10	Expense items were improperly charged to raw material purchases.	5	5	2
17	Operating expenses were capitalized as plant and equipment.	5	5	3
23	Administrative salaries were improperly allocated to production.	5	5	4
28	Current portion of long-term loans was improperly included as noncurrent..	5	4	5
29	Capital leases were treated as operating leases	5	5	5
34	Long-term securities were included in the current portfolio.	5	4	6

Category 6:

15	Accrued operating expenses and payables were underrecorded.	6	6	3
19	Accrued salaries at year end was not recorded.	6	6	4
20	Compensated absences were not accrued.	6	6	4
21	Pension expense was not booked.	6	6	4
22	Salary withholdings were understated.	6	6	4
27	Interest expense and bond discount amortization were understated.	6	6	5

* - Taken from Frederick, et al. (1994).

Table 3
Free-Sort Categorizations Compared to Audit Objective and Transaction Cycle Directed Sorts for Staff Auditors

Error Number	Error	Free Sort	Audit Objective*	Transaction Cycle*
	Category 1:			
1	Next period's accounts receivable were recorded in the current period	1	1	1
6	Finished goods received next period were recorded in the current period	1	1	2
12	Raw materials were improperly shown as received after year-end.	1	1	2
13	Payments on account made next period were booked this period.	1	1	3
25	Current period's accrued interest expense on a long term loan was booked next period	1	1	5
31	Purchase of Treasury Bills were recorded in the wrong fiscal period.	1	2	5
	Category 2:			
7	Relief of inventory was not recorded for goods shipped.	2	2	2
14	Goods acquired on account were not recorded.	2	2	2
19	Accrued salaries at year end was not recorded.	2	2	4
20	Compensated absences were not accrued.	2	2	4
21	Pension expense was not booked.	2	2	4
26	Bank loans were not recorded.	2	2	5

	Category 3:			
2	Goods returned by customers were underbooked.	3	2	2
3	The bad debt expense and allowance were underestimated.	3	2	1
15	Accrued operating expenses and payables were underrecorded.	3	2	3
16	Invoice prices of goods acquired were understated.	3	2	2
22	Salary withholdings were understated.	3	2	4
27	Interest expense and bond discount amortization were understated.	3	2	5
32	Sales of securities were underbooked.	3	2	6
	Category 4:			
4	Other income was recorded as sales.	4	4	1
9	Overhead was overapplied to finished goods merchandise	4	4	2
10	Expense items were improperly charged to raw material purchases.	4	4	2
17	Operating expenses were capitalized as plant and equipment	4	4	7
23	Administrative salaries were improperly allocated to production.	4	4	4
28	Current portion of long-term loans was improperly included as noncurrent..	4	4	5
29	Capital leases were treated as operating leases	4	4	7
34	Long-term securities were included in the current portfolio.	4	4	6
	Category 5:			
5	Billings to legitimate customers were booked twice.	5	5	1
11	Finished goods merchandise was booked but not received.	5	5	2
18	Payments on account were recorded but not made.	5	5	3
24	Salaries were recorded for nonexistent employees.	5	6	4
30	Loan retirement payments were booked but not made.	5	5	5
35	Fictitious securities were booked.	5	6	6
	Category 6:			
8	Finished goods were not written down to net realizable value.	6	3	2
33	Marketable equity securities were not written down to lower of cost or market.	6	3	6

* - Taken from Frederick, et al. (1994).

TABLE 4

Results for the Effect of Prime and Experience on
Reaction Time*

Panel A: ANOVA

Source of Variation	*SS*	*df*	*MS*	*F-stat*	*p-value*
Between Subjects					
Experience	36591747	1	36591747	13.040	< 0.001 **
Residual	2870571398	1023	2806033		
Within Subjects					
Prime	28729658	1	28729658	13.538	< 0.001
Prime x Experience	8873778	1	8873778	4.182	0.021 **
Residual (Prime)	2170915168	1023	2122107		

Panel B: Descriptive Statistics (Mean, Standard Deviation)

		Prime	
		Audit Objective	Transaction Cycle
Experience	Managers	3.071 (1.52)	2.702 (1.42)
	Staff	3.206 (1.64)	3.101 (1.68)

* Reaction time is measured in seconds.

** One tailed equivalents for an F-test (Maxwell and Delaney 1999).

TABLE 5

Results for the Effect of Prime and Experience on
Reaction Time for all Test Sentences in which
Words Key to Identifying Transaction Cycle did not Appear First *

Panel A: ANOVA

Source of Variation	*SS*	*df*	*MS*	*F-stat*	*p-value*
Between Subjects					
Experience	12410028	1	12410028	4.498	0.018 **
Residual	474542423	172	2758968		
Within Subjects					
Prime	3834484	1	3834484	2.498	0.116
Prime x Experience	4584749	1	4584749	2.987	0.043 **
Residual (Prime)	264047113	172	264047113		

Panel B: Descriptive Statistics (Mean, Standard Deviation)

		Prime	
		Audit Objective	Transaction Cycle
Experience	Managers	3.047 (1.15)	2.607 (1.31)
	Staff	3.195 (1.59)	3.215 (1.72)

* Reaction time is measured in seconds.

** One tailed equivalents for an F-test (Maxwell and Delaney 1999).