

Diagnostic Reasoning During Audit Judgment:
An Alternative Cognitive Characterization

Ed O'Donnell
College of Business
Arizona State University

ed.odonnell@asu.edu

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ABSTRACT

This study examines whether forward reasoning provides a more appropriate framework for describing audit judgment than backward reasoning. Identifying the appropriate framework is important for future research because forward and backward reasoning are influenced differently by task and knowledge variables. A forward-reasoning framework is presented and evaluated using results from published studies and data from a computerized process-tracing experiment. Findings suggest that auditors rely heavily on forward reasoning, which challenges the assumption that generating and testing hypotheses is the primary focus of diagnostic reasoning during audit judgment.

Key Words: diagnostic reasoning, audit judgment, analytical procedures, forward reasoning, backward reasoning, testing hypotheses, clinical judgment, naturalistic decision-making

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In solving a problem [that requires causal reasoning], the grand thing is to be able to reason backwards. That is a very useful accomplishment, and a very easy one, but people do not practise it much. In the everyday affairs of life it is more useful to reason forward, and so the other comes to be neglected. There are fifty who can reason synthetically for one who can reason analytically...Most people, if you describe a train of events to them will tell you what the result would be. They can put those events together in their minds, and argue from them that something will come to pass. There are few people, however, who, if you told them a result, would be able to evolve from their own inner consciousness what the steps were which led up to that result.

Sherlock Holmes

INTRODUCTION AND MOTIVATION

In the seventh and final chapter of *A Study in Scarlet* (Doyle, 1887), Sherlock Holmes explains how he used backwards reasoning to solve a crime, a mental process that he believes to be uncommon in everyday life. Backward reasoning involves the deductive process of starting with a known result then analyzing events and circumstances in an attempt to diagnose the cause (Rips, 1988). The alternative, forward reasoning, involves the inductive process of synthesizing events and circumstances in an attempt to diagnose the result (Holyoak & Nisbett, 1988). Auditing research generally assumes that auditors accomplish diagnostic judgment tasks primarily through backwards reasoning (Libby, 1985; Koonce, 1993; Solomon & Shields, 1995). This study presents evidence that auditors may rely more heavily on forward reasoning and suggests that the backwards-reasoning paradigm may not provide an appropriate description of diagnostic reasoning during audit judgment.

Among other things, auditors use diagnostic reasoning to explain interperiod changes in account balances and determine the likelihood that particular fluctuation could signal a financial statement error (Libby, 1985). Studies have found that experienced professionals often rely more heavily on forward reasoning during diagnostic judgment tasks in high-accountability domains such as medicine (Elstein et al., 1990), firefighting and combat aviation (Klein, 1998), and electrical engineering (Sebogamoorthy & Chandrasekaran, 1986). Although professionals may switch back and forth between forward and backward reasoning during a diagnostic task (Elstein et al., 1993), these complementary mental activities represent mutually exclusive processes that cannot be accomplished simultaneously (Johnson-Laird, 1988). The issue is not whether auditors use backward reasoning, undoubtedly they do (Bedard & Biggs, 1991). The research question is how much do auditors rely on forward reasoning as an alternative to backward reasoning?

Determining the extent to which auditors rely on forward versus backward reasoning has implications for improving audit practice. Successful backward reasoning depends largely on generating appropriate hypotheses and constructing tests to validate those hypotheses (Elstein et al., 1978). Appropriate hypothesis generation depends on knowledge of frequency distributions (base rates) for different causal factors and knowledge of how to falsify incorrect hypotheses (Gallagher, 1996). The structure imposed on information acquisition activities is of little consequence during backward reasoning (Evans, 1982). If auditors rely heavily on backward reasoning, then decision performance will be heavily influenced by the extent and accuracy of their domain knowledge, including frequency knowledge about potential errors (Nelson, 1993) and knowledge of appropriate procedures for testing hypotheses regarding various error causes (Libby & Frederick, 1990).

Successful forward reasoning, on the other hand, depends primarily on having enough situation-specific knowledge to develop appropriate causal inferences (Groen & Patel, 1988). During forward reasoning, acquiring an adequate understanding of the situation depends on the type of information that is acquired and how that information is presented (Holyoak & Nisbett, 1988). The structure imposed on information acquisition activities is a primary factor in effective forward reasoning (Langley, Simon, Bradshaw, & Zytkow, 1987). If auditors rely primarily on forward reasoning, then decision performance will be significantly influenced by their knowledge of client business and financial conditions (Waller & Felix, 1989) and the way that knowledge is organized in memory (Bell, Marrs, Solomon, & Thomas, 1997).

Auditors acquire much of the knowledge needed for successful backward reasoning before they begin a diagnostic-reasoning task, but they acquire much of the knowledge needed for successful forward reasoning as a result of information acquired during the task. If auditors rely heavily on backward reasoning, decision performance should be enhanced by improving domain knowledge of error frequencies and hypothesis testing procedures. However, if auditors rely heavily on forward reasoning then decision performance should be improved by structuring information acquisition activities to enhance knowledge of client operations. Variables critical to effective performance during backward reasoning are of little consequence during forward reasoning, and vice-versa. As a consequence, understanding how much auditors rely on forward versus backward reasoning is essential for designing more effective auditing tasks and helping auditors develop the type of knowledge that improves diagnostic judgment.

The rest of this paper is organized as follows. The next section (a) describes how auditors use backwards reasoning, (b) explains how this paradigm has come to dominate audit judgment research, and (c) articulates potential shortcomings of the backward-reasoning

paradigm. The third section presents an alternative, forward-reasoning framework to describe auditor judgment during diagnostic tasks and explains how forward and backward reasoning differ. The fourth section explores the plausibility of the forward-reasoning framework using (a) findings from a field investigation by Hirst & Koonce (1996), (b) concurrent verbal protocols acquired during an analytical procedures experiment conducted by Biggs, Mock, & Watkins (1989), and (c) information search records obtained during a computerized process-tracing experiment that I conducted in conjunction with another study. The last section provides a summary of the findings, acknowledges the limitations of this study, and identifies promising topics for future research.

THE BACKWARD-REASONING PARADIGM

Auditors use diagnostic reasoning during a number of audit-related judgment tasks (e.g. internal control evaluation; going-concern judgments). However, this study focuses only on diagnostic reasoning during audit analytical procedures. The scope was limited to analytical procedures because this topic has received considerable attention in the behavioral auditing literature and because research has often failed to provide consistent evidence of the association between many task variables and decision performance during this mandatory audit judgment task (Biggs, Knechel, Waller, Wallace, & Willingham, 1995).

Auditors generally use analytical procedures to test the reasonableness of an account balance, either as an audit planning tool for targeting high-risk accounts or to provide evidence for substantive tests (Wright & Ashton, 1989). During analytical procedures, auditors exploit systematic patterns of associations among accounts to identify potential misstatements (Bedard & Biggs, 1991). To accomplish their diagnosis, they must use what they know about accounting

relations and what they have learned about client business activities to identify unexpected changes in account balances then develop tentative explanations for these unexpected fluctuations (Libby & Frederick, 1990). In short, auditors use client knowledge and accounting knowledge to search for symptoms of misstated accounts and then use diagnostic reasoning to assess the likelihood of misstatement.

Research on auditor judgment during analytical procedures has evolved in much the same fashion as research on clinical judgment by physicians. Early studies on medical diagnosis were conducted almost exclusively under one of two paradigms, either clinical-versus-statistical prediction paradigm, inspired by Bayesian models of decision making, or behavioral decision theory, inspired by the Lens model (Kleinmuntz, 1984). By the 1980's, the information processing paradigm, pioneered by Newell and Simon (1972), became the driving force in clinical judgment research (Kassirer 1989). It motivated research that examined diagnostic reasoning through verbal protocols and inspired attempts to build computational models of clinical judgment (Rabinowitz 1993).

Analytical procedures research in auditing began during the 1970's as a search for more cost-effective quantitative tools for analyzing changes in account balances and evolved into research on auditor judgment (Biggs et al. 1995). Behavioral audit research during the 1970's was dominated by studies designed around Bayes theorem or the Lens model, followed in the 1980's by research grounded in Newell & Simon's information processing paradigm (Ashton, 1982). Early attempts to describe auditor judgment during analytical procedures also involved verbal protocol studies and computational models (Koonce, 1993).

The backward-reasoning paradigm first appeared in clinical diagnosis research in the late 1970's. Shortly thereafter, it was borrowed and transferred to the auditing literature as a descriptive theory of judgment during analytical procedures.

Backward Reasoning During Medical Diagnosis

Elstein et al. (1978) introduced the theory of deductive reasoning to medicine. Their monograph, the result of a research program that spanned five years, describes medical diagnosis as a backward-reasoning process. Their hypothetico-deductive theory is grounded in the information-processing paradigm of Newell & Simon (1972). They suggest that clinicians settle on a diagnosis through an iterative, four-stage analysis, which includes (1) cue acquisition, (2) hypothesis generation, (3) cue interpretation, and (4) hypothesis evaluation. Diagnostic competence requires knowledge of (a) the relation between symptoms and various diseases, (b) procedures for recognizing and classifying symptoms, and (c) the population base-rates for different diseases.

During cue acquisition, information search is driven by broad, general hypotheses, developed early in the diagnostic process, when the symptoms are first revealed. Data are collected with a view toward their usefulness in testing hypotheses. During hypothesis generation, clinicians retrieve likely explanations from long-term memory through an associative process that links acquired cues to their knowledge of human physiology. Cue interpretation involves matching findings with conditions specified by domain knowledge and determining the diagnostic value (decision weight) of each cue. Hypothesis evaluation can be modeled either as a function of identifying the hypothesis with the maximum aggregate cue weights or the hypothesis with the maximum difference between negative and positive cue weights.

This backward-reasoning paradigm suggests that clinicians settle on a diagnosis for a patient's ailment in much the same way that Sherlock Holmes solves a crime. Both develop hypotheses capable of explaining the condition they have observed, then search for information that will either support or invalidate those hypotheses. The process of generating and testing hypotheses continues until one hypothesis survives. The surviving hypothesis is embraced as an explanation for the observed conditions and a diagnosis has been achieved (or a crime has been solved) through backward reasoning.

Subsequent behavioral research in medicine has refined the hypothetico-deductive theory by demonstrating that diagnoses often involves a considerable amount of forward reasoning (Kassirer, 1989; Gallagher 1996). Evidence suggests that more experienced clinicians may, in many situations, rely primarily on forward reasoning by learning about the patient's medical history and relying on knowledge-based inferences to provide the diagnosis (Groen & Patel, 1991). Although physicians will generally rely on backward reasoning when they encounter uncommon symptoms, they will often rely heavily, if not exclusively on forward reasoning when symptoms are familiar (Elstein et al., 1990). As a consequence, the primary focus of clinical diagnosis research has shifted toward studies that examine how domain knowledge interacts with task structure to influence physicians' forward reasoning (Elstein, et al., 1993).

Backward Reasoning During Diagnostic Audit Tasks

Libby (1985) borrowed the hypothetico-deductive framework from medicine and transferred it to auditing as a descriptive theory of diagnostic reasoning during analytical procedures. He suggested that auditors attempt to explain unexpected fluctuations in financial statement accounts by generating a hypothesis that explains the interperiod change, then analyzing patterns of changes in related account balances to evaluate that hypothesis. If the

hypothesis fails to withstand scrutiny, after gathering more client information and reconciling changes in other accounting measures, auditors generate a refined hypothesis to take its place. This iterative process continues until auditors become convinced that they have formulated a credible explanation. If the surviving hypothesis suggests a potential problem, the account is targeted for further testing.

Koonce (1993) formalized this deductive framework into a process model of auditor judgment during analytical procedures that closely parallels the four-stage analysis proposed by Elstein et al. (1978). She suggests that auditors engage in an iterative, sequential, diagnostic process that involves (1) learning about the client and identifying unexpected fluctuations, (2) generating a hypothesis to explain any unexpected fluctuation that is identified, (3) acquiring information to test that hypothesis, then (4) evaluating the hypothesis to achieve a diagnosis. This model of backward reasoning describes the theoretical framework embraced by a wide variety of studies on auditor judgment during analytical procedures (Solomon & Shields, 1995).

While reviewing research that supports her model, Koonce reveals how pervasive the influence of the backward-reasoning paradigm has been. After its introduction by Libby in 1985, the hypothesize-and-test theory was embraced as either an implicit or explicit assumption of most, if not all judgment studies on analytical procedures. In an examination of how analytical procedures research has influenced audit practice, Biggs et al. (1995) also acknowledge the dominant influence of the hypothesize-and-test theory.

Shortcomings of the Backward-Reasoning Paradigm

As noted above, research in medicine has revealed that physicians often rely heavily, sometimes exclusively, on forward reasoning to develop the inferences that produce a diagnosis. These studies have significantly altered the theoretical framework for diagnostic reasoning in

medicine (Patel & Groen, 1991; Elstein et al., 1993; Rabinowitz, 1993, Gallagher, 1996). In auditing, the extent to which auditors use forward reasoning during analytical procedures has not been examined because the descriptive accuracy of the backward-reasoning paradigm has never been challenged. Given the similarities between clinical diagnosis and analytical procedures, it is likely that auditors also place significant emphasis on forward reasoning. As was the case in medicine, backward reasoning may be less prevalent in auditing than was originally thought.

There is another reason to suspect that backward reasoning may be less useful than forward reasoning as a strategy for accomplishing diagnostic audit tasks. Bear in mind that, during backward reasoning, the decision maker must recognize symptoms, generate a hypothesis that explains those symptoms, then gather information to test the hypothesis. Most of the reasoning process takes place after symptoms have been identified. In medicine, most symptoms are either presented to the physician by the patient or acquired through measurement (temperature, blood pressure, etc.). This is not necessarily the case in auditing.

Unlike physicians, auditors aren't presented with symptoms. During analytical procedures, backward reasoning begins after auditors have targeted an account balance. During planning analytical procedures, auditors target accounts by identifying unexpected interperiod changes (Koonce, 1993). The extent to which a fluctuation should be categorized as unexpected may be something less than obvious. Characteristics that make a fluctuation suspicious can change from year to year as well as between engagements. Sometimes an account balance is suspicious because it has changed by a great deal but other times a balance is suspect because it has changed very little (Biggs et al., 1995).

Unlike physiology, there are few predictable natural states in business to use as benchmarks for identifying extraordinary conditions (symptoms). Physicians rely on natural

laws to identify symptoms that the human body is not functioning properly. Heart rate, blood pressure, body temperature, and other measures should all fall within a predictable range for a healthy human body. Auditors must rely on their interpretation of client business conditions to provide expectations about whether a fluctuation is reasonable (McDaniel & Kinney, 1995).

There is no static state against which to benchmark changes in account balances from one period to the next because changes in economic climate can alter the threshold for reasonable fluctuations. As a consequence, there is a considerable amount of ambiguity associated with identifying unexpected fluctuations. In light of this ambiguity, auditors may be reluctant to rely on their ability to effectively target accounts for backward reasoning.

A FORWARD-REASONING FRAMEWORK

Concerns about the efficacy of the backwards-reasoning paradigm in other decision domains contributed to the development of a literature on naturalistic decision making (Howell, 1997). This stream of research suggests that people usually make decisions through forward reasoning, by learning about the task environment and relying either on experience-based knowledge or analogical reasoning to recognize familiar patterns (Zsombok, 1997). During naturalistic decision making people rarely make decisions through backward reasoning – they don't generate and test hypotheses. Instead, they use what they have learned in the past as a basis for responding to the conditions they encounter in the present (Beach et al., 1997). Studies based on the naturalistic decision-making paradigm have provided evidence that this forward-reasoning framework is robust across a variety of high-accountability decision domains, including medicine (Bogner, 1997), systems design (Miller & Woods, 1997), business planning

(Di Bello, 1997), naval combat (Hutchins, 1997), firefighting (Klein, 1997), and aviation (Stokes et al., 1997).

Klein (1998) describes how people use forward reasoning to make every-day decisions. His recognition-primed decision making model characterizes decision-making as a process of integrating information acquired during the task with knowledge brought to the task. People experience situations in a changing context. Through forward reasoning, they evaluate cues from the decision environment by matching their observations with deterministic patterns stored in memory. People achieve a state of recognition when the cues they integrate have been mapped onto a familiar pattern. Recognition activates a network of situation-specific knowledge that, among other things, provides the decision maker with a typical response for each situation.

Anderson, Koonce, & Marchant (1991) proposed a similar framework for describing audit judgment based on the forward-reasoning theories developed by Holland, Holyoak, Nisbett, & Thagard (1986). Anderson et al. suggest that audit judgment begins with the development of a mental model of the client's activities, which provides a cognitive problem space for analyzing new information. As new audit evidence is integrated into the mental model, knowledge-based rules provide auditors with the means to recognize potential problems. These production systems, which develop as a result of experience, provide auditors with procedures for responding to familiar patterns of client information. In other words, as suggested by Gibbins (1984), auditors develop experience-based decision templates that dictate their response to different patterns of audit evidence.

The inductive audit judgment framework proposed by Anderson et al. (1991) is consistent with the recognition-primed decision-making framework suggested by Klein (1998) in that both describe decision-making as a forward reasoning process. The process of integrating

decision cues into the mental model generates knowledge-based inferences that allow the decision maker to recognize familiar patterns. Recognition activates decision templates or schema that direct the search for relevant data, specify a conclusion, and dictate a response. The decision maker reasons forward from the data to the conclusion – not backward from the conclusion to the data – by relying on decision templates that have been developed through training and experience.

By synthesizing the frameworks proposed by Anderson et al. (1991) and Klein (1998), I developed a process model for diagnostic reasoning during analytical procedures. This forward-reasoning model of auditor judgment is presented in Figure 1.

Insert figure 1 about here

Analytical procedures involve the sequential process of gathering information, evaluating that information, then gathering more information. This sequence continues in successive iterations until the auditor becomes satisfied that the task has been completed (Koonce, 1993). As the first step, an auditor must establish a goal for the desired state of knowledge (Biggs et al., 1989; Anderson et al., 1991). For example, during the planning phase, the goal might be to know which accounts (if any) have a higher probability of being misstated. When using analytical procedures as a substantive test, the goal might be to know whether the balance is consistent with related financial information.

The goal for acquiring knowledge activates a mental schema that directs information search and targets the next cue (step 2). The auditor then acquires the information (step 3) and integrates this new cue with previously-acquired knowledge stored in memory (step 4). The integration process produces recognition – either that the cue is consistent with expectations and there is no cause for alarm, or that the cue does not match the expected pattern, which generates

the inference that a potential problem exists. Klein (1998) describes this process as determining whether the situation is typical. Anderson et al. (1991) describe this process as determining whether the cue is consistent with rules for associations among accounts specified by a default hierarchy stored in memory.

Auditors who decide that the cue does not infer a potential problem (step 5) and that the task is not complete (step 8) update their processing goal (step 1) and begin another iteration of the acquire-and-evaluate-cues sequence (steps 2 through 4). Auditors who decide that the cue infers a potential problem (step 5), must decide whether a concern should be documented (step 6). If enough information has been acquired to justify documenting a potential problem, then the auditor will make the appropriate entry in the audit workpapers (step 7) and proceed. If the auditor decides that more information is needed before documenting a concern (step 6), the task is obviously not complete (step 8). The auditor will update the processing goal (step 1) and gather more information (steps 2 through 4).

How Forward Reasoning Differs from Backward Reasoning

The processing steps presented in Figure 1 would be very similar to a model that described backward reasoning. However, during backward reasoning, the goal for step 1 would be to test a specific hypothesis whereas, during forward reasoning, the goal for step 1 is to learn more about the client (Anderson et al., 1991) and gain a better understanding of the situation (Klein, 1998). During backward reasoning, the targeting process in step 2 focuses on information that can be used to test the hypothesis. During forward reasoning, the targeting process involves categories of data that are much broader. Information search during backward reasoning is determined by the active hypothesis – what cues does the auditor need to test it (Koonce, 1993). Information search during forward reasoning is driven by data presentation

(Holland et al., 1986). The order in which cues are integrated makes no difference during forward reasoning (Holyoak & Nisbett, 1988). Therefore, cues are usually targeted for acquisition in the order that they appear on the display or, when a category of cues has been exhausted, on the basis of next available category (Langley et al., 1987).

When using analytical procedures as an audit planning tool, the first five steps describe the search for unexpected fluctuations, a process that involves forward reasoning. During step 6, forward reasoning and backward reasoning diverge. During forward reasoning, the decision to document a concern depends on the inference provided by the auditor's knowledge of the client's situation (Anderson et al., 1991). If, based on what has been learned so far, the auditor recognizes that the account balance doesn't match with the usual pattern for fairly-stated balances, the auditor will document a potential problem. During backward reasoning, the decision to document a concern will depend on the hypothesis testing process (Koonce, 1993). Auditors will generate a potential explanation for the unexpected fluctuation then loop back through the information acquisition and evaluation sequence to test their hypothesis. In short, a diagnosis accomplished through forward reasoning develops as a result of learning more about the situation while a diagnosis accomplished through backward reasoning develops as a result of testing potential explanations for observed conditions (Groen & Patel, 1988; Elstein et al., 1993; Gallagher, 1996).

In discussing research conducted before the naturalistic decision making paradigm evolved, Klein (1998) describes his attempts to map backward-reasoning decision processes with data he collected in the field. He gathered both current and retrospective protocols from decision makers describing the decisions they made. While analyzing those protocols, he was unable to find evidence that his subjects developed potential explanations before they came to a

conclusion. Across a variety of decision domains, his subjects seemed to acquire a relatively small number of cues and arrive at a conclusion without generating and testing any hypotheses.

Through further research, Klein concluded that subjects tended to match the information they acquired during the task with patterns of information from similar tasks, which they retrieved from memory. In novel situations, where experience-based patterns were not available, subjects relied on patterns from analogous situations. Klein found no evidence of backward reasoning across a wide variety of decision contexts. As a result, he concluded that people generally make decisions through forward reasoning, the same conclusion articulated by Sir Arthur Conan Doyle through his character Sherlock Holmes almost a century before.

If auditors rely on forward reasoning more than backward reasoning then the process through which they perform analytical procedures will differ in predictable ways. The next section describes how differences in information processing can be used to identify the type of reasoning being employed and presents evidence from three studies that auditors rely heavily on forward reasoning.

EVIDENCE SUPPORTING THE FORWARD-REASONING FRAMEWORK

This section describes evidence from two published studies and an experiment that I conducted in connection with another study. My goal in conducting the analyses described below was to search for evidence about the extent to which auditors rely on forward versus backward reasoning.

Evidence from Field Interviews

Hirst & Koonce (1996) assembled a descriptive account of how analytical procedures are used in practice. They conducted interviews with 36 audit seniors, managers, and partners

representing each of the Big Five accounting firms. Participants had experience across a wide range of industries for both large and small clients. Each interview lasted approximately two hours and was guided by a series of planned questions.

When using analytical procedures as an audit planning tool 87% of the auditors said that they usually compare current year and prior year balances for financial statement accounts to identify unexpected fluctuations. When they find a suspicious change in an account balance, the auditors said that they attempt to identify a potential explanation, either by querying their client or through their own analysis. However, of the 26 auditors asked, only 10 (38%) indicated that they “*sometimes choose*” to generate their own explanations before talking with the client. Furthermore, of 20 auditors who were asked, 100% indicated that they generally perform little follow-up work to determine the validity of an explanation.

If auditors were using backward reasoning during these planning analytical procedures then their questions for the client would be guided by a potential explanation that they generated when they encountered the unexpected fluctuation. Following up to determine the validity of an explanation is the goal of backward reasoning. However, all of the participants indicated that, as a rule, they do not try to establish the validity of an explanation during the planning phase. From their accounts, it would appear that they do little or no hypothesis testing. During planning analytical procedures, their aim appears to be identifying issues to address later in the audit rather than seeking evidence to better define those issues. These descriptive accounts from practicing auditors suggest that they rely more heavily on forward reasoning than backward reasoning when analyzing unexpected fluctuations.

During substantive testing, the goal of analytical procedures is to generate evidence about whether a particular account balance is fairly stated. Auditors indicated that they rely largely on

the prior-year balance to develop expectations about what the current-year balance should be. If the current balance does not fall within their expectations, they either generate an explanation or acquire an explanation from the client, then search for substantive evidence to corroborate that explanation. Auditor descriptions of the process they follow during substantive analytical procedures suggest that they rely heavily on hypothesis testing to validate the explanations they are given – a strategy executed through backward reasoning.

In summary, when auditors are attempting to identify and analyze symptoms of financial misstatements during the planning stage, it appears that they seldom use backward reasoning. Instead, they use the engagement-specific knowledge that they have acquired to develop a diagnosis by integrating account balance fluctuations and client explanations – a forward-reasoning strategy. However, when auditors must assess the risk of misstatement for a specific account, their accounts suggest that they rely heavily on backward reasoning for generating and testing hypotheses. Hirst & Koonce (1996) conclude that the emphasis auditors place on generating and testing potential explanations during analytical procedures depends on the whether they are using analytical procedures as a planning tool or for substantive testing.

Evidence from Concurrent Verbal Protocols

Biggs et al. (1989) conducted a study of auditor judgment during analytical procedures in which they asked two audit seniors and two audit managers to plan an audit engagement using an extensive case based on an actual client. The research team captured concurrent verbal protocols for all decision-making processes. Their study was conducted in two phases. During phase one, participants used analytical procedures to evaluate the case materials and develop a list of questions for their client. During phase two, participants received answers to the questions they developed during phase one and prepared the audit program.

The protocols gathered during this study provide evidence about the extent to which auditors rely on backwards reasoning. While developing his theory of recognition-primed decision making, Klein (1998) describes how he and his research team developed a system of classifying protocols to distinguish different types of reasoning. Using transcripts assembled by interviewing firefighters about a number of different cases, they developed a scheme for classifying each decision-making action that their subjects described. Then, they classified each individual protocol as belonging to one of those decision-making strategies. Using this data, they were able to examine the relative use of alternative strategies by comparing totals across categories.

I used this approach to analyze the protocols reported in Biggs et al. (1989) by developing a classification scheme for identifying activities that might involve backward reasoning. Case materials were the only information available to participants during the first phase of this study. If an auditor was engaged in backwards reasoning while conducting analytical procedures then their processing activities would involve analyzing the change in an account by examining related financial information provided in the case. In double-entry accounting, activity in one account will create activity in at least one other related account. To test a hypothesis about the unexpected fluctuation in an account using only the materials provided by the case, participants would have to examine information about changes in related accounts or financial ratios.

Evidence that participants (1) noted the fluctuation in an account then (2) acquired and evaluated information about related accounts would be a necessary (but not sufficient) condition for backward reasoning. If participants simply integrate case information without stopping to generate and test a hypothesis (by comparing information in related accounts) then they are most

likely relying on forward reasoning. I evaluated all protocols gathered during the first phase of the experiment and listed any that involved comparing financial information related to an account that had been noted in a previous protocol. My sample did not include any phase-two protocols or any phase-one protocols for preparing the audit program. Comparing the number of protocols that could have involved backward reasoning to the total number of protocols that I evaluated provides a basis for determining relative reliance on backward reasoning.

A list of the protocols that could have involved backward reasoning are presented in Table 1. Only rarely (if at all) did auditors indicate that they were acquiring information that could be used to test a hypothesis explaining why a previously-examined account had changed. The protocols demonstrate that all four participants generally acquired information about their client in the order it was presented and used this information to develop inferences that suggested planning concerns or inspired questions for their client. Taken as a whole, the descriptions provided by these protocols suggest that participants relied heavily on forward reasoning.

insert Table 1 here

Biggs et al. (1989) concluded that their participants, particularly the managers, relied on mental schema to direct their reasoning processes, an observation consistent with Gibbins (1984) thesis that experienced auditors rely on decision templates to reason forward from the evidence to a conclusion. The research team attempted to use a backward-reasoning expert system shell to model participants' decision processes but were unable to do so because the protocols conformed to a system of logic based on forward-reasoning. The findings reported by Biggs et al. (1989) suggest that auditors rely heavily on forward reasoning when using analytical procedures as an audit planning tool.

Evidence from Computerized Process-Tracing

During an experiment that provided data for another study (reference to be inserted after blind review), 28 audit seniors and managers from Big Five firms performed analytical procedures using computerized case materials. Participants completed the case in small groups at their firm's office using their own notebook computers.

Participants completed two separate analytical procedures tasks. First, they were told to assume that they had taken over as the in-charge auditor during the planning stage of a financial statement audit. They were instructed to read background information to familiarize themselves with client business activities, then use comparative financial information to perform analytical procedures and document any potential problems that they uncovered. After completing the first task, participants were told to assume that they had returned to audit the same client the next year. They were provided with information about business activities for the second year, which indicated that sales volume had increased, unit sales prices had not changed, and manufacturing costs had remained stable. Participants were directed to note that gross margin had decreased slightly from the previous year, a change that would be inconsistent with operating conditions described in the case. Then, as a second task, they were asked to use analytical procedures to develop the most likely explanation for this unexpected fluctuation.

Financial information for both tasks included comparative balance sheet, income statement, and selected ratios presented on three separate computer displays. There were 52 different line items on these three screens. In addition to the item description, every line contained four columns of financial information, including the (a) current-year balance, (b) prior year balance, (c) amount of change, and (d) percent of change.

For each line item, the description was visible at all times but the numbers were blank. Participants could display the numbers by clicking on the description. However, when they

clicked on another description, their previous selection was blanked out. Participants could re-display items as many times as they wished but only one item was visible at any time. The process-tracing software used to administer the experiment recorded all selections and provided a serial record of information search activities.

Distinguishing Forward from Backward Reasoning

I developed an algorithm for determining whether the selection of an individual information item might have been motivated by backward reasoning. When a backward-reasoning participant encountered an unexpected fluctuation during their information search, they would generate a hypothesis explaining that fluctuation, then begin to search for information to test their hypothesis. A forward-reasoning participant, on the other hand, would simply integrate the unexpected fluctuation into their mental model and continue to acquire more information about their client, until they acquired enough knowledge to develop an inference about the unexpected fluctuation.

Associations among accounting measures can be exploited to provide evidence that information search is being guided by efforts to test a hypothesis about the change in a particular account. In a double-entry accounting system, activity in one account must be mirrored by activity in at least one other account. Therefore, an explanation for the change in any account can be tested, at least partially, by obtaining information about the change in a related account. For example, suppose an auditor observes that accounts receivable has increased and hypothesizes that this increase is due to increased sales. Because accounts receivable and sales are related accounts, information useful for testing that hypothesis can be obtained by checking to see if sales has also increased.

In this experiment, the balance sheet, income statement and financial ratios provided the only information available for testing hypotheses. If a participant encountered an unexpected fluctuation and wanted to test a hypothesis explaining that fluctuation, information for testing that hypothesis would be limited to information about changes in related accounts or financial ratios. Under these conditions, hypothesis testing would be evidenced by gathering information about related accounts during successive information acquisitions. For example, assume that a participant examined the accounts receivable balance and found it to be larger than expected. If the participant used backwards reasoning, the next step would be to acquire information about accounts or ratios that are related to accounts receivable, such as sales or accounts receivable turnover. If the participant was using forward reasoning, there would be no hypothesis to test and the next information item acquired would not need to be an item that is related to accounts receivable.

Financial statements present information about related accounts in different places, that is, related accounts are usually not grouped together. For example, accounts receivable appears in the current assets section of the balance sheet while sales appears on the income statement. I developed a list of related accounts and ratios for each of the 52 information items that were available to participants. This list is presented in the appendix. Accounts and ratios on this list are numbered by the order that they appeared on the three information displays, from top to bottom for the (a) balance sheet, (b) income statement, and (c) financial ratios, in that order. Note that none of the information items has a number that immediately precedes or follows a related information item. In other words, no information item is presented adjacent to a related item of information. Therefore, to test a hypothesis about the change in an account using information about changes in related accounts, participants had to jump around on the

information display. A participant who used backward reasoning could not acquire information in the order it was presented.

During forward reasoning, the order of information acquisition is not important, as long as the information is relevant, and people tend to acquire information in the order that it is presented (Clancy, 1988; Langley et al., 1987). During the diagnostic task required by this experiment, participants could accomplish forward reasoning by viewing the information in presentation order. However, because related information was not grouped together, participants could not accomplish backward reasoning by acquiring information in sequential order. If participants were testing hypotheses through backward reasoning, then they would be (a) selecting related information items in successive acquisitions, which (b) could not be accomplished by acquiring information in the order it was presented.

These distinguishing characteristics of information search provided a basis for identifying whether participants were using backward reasoning when they acquired a particular item of information. Using the process-trace records captured during the experiment, I identified all information acquisitions that were followed by the acquisition of a related information item from the list presented in the appendix. Each of these cue selections represents potential evidence of backward reasoning. Cue selections that occurred in the order the information was presented provide evidence of forward reasoning. The relative use of forward versus backward reasoning can be evaluated by comparing total forward-reasoning cue acquisitions with total backward-reasoning cue acquisitions.

Analyzing Process-Trace Records

During the first exercise, participants performed analytical procedures to identify potential audit problems and document audit planning concerns. On average, they looked at 48

of the 52 items that were available and often looked at an information item more than once. Participants clicked a line to display an information item an average of 89.7 times and looked at the information items that they selected an average of 2.5 times. It is possible that participants tried to learn about their client the first time they went through the information, then selected the information again when they were performing their analysis. Therefore, first-time cue selections and re-acquired cues were analyzed separately.

Participants relied primarily on serial processing, that is, they acquired information in the order it was presented. On average, 77.8% of the first-time cues and 49.5% of the re-acquired cues were acquired in order of presentation. Based on the classification algorithm described above, only 3.4% of the first-time cues and 6.9% of the re-acquired cues could have been involved in backward reasoning.

The software used to administer this experiment captured participant documentation for potential audit problems and recorded when they interrupted their information search to document their concern. Participants documented planning concerns for an average of 3.8 accounts. By using the process trace records to identify information that was examined before a concern was documented, I determined how many concerns could have been the result of backward reasoning. If a concern targeted an account that had been involved in a backward-reasoning sequence before it was documented, then I classified it as concern that might have resulted from backward reasoning.

Of the total concerns documented, 28.9% could have been the result of backward reasoning. My classification algorithm provided a broad category for backward reasoning. In many cases, a considerable amount of information search occurred between the time the participant engaged in the backward reasoning sequence and the time the participant documented

their concern. However, I chose to make the category inclusive rather than restrictive so as not to bias the analysis against finding evidence of backward reasoning. A more complete report of the summary statistics for these process measures is presented in Table 2.

insert Table 2 here

During the second exercise, participants performed analytical procedures to explain an account fluctuation that was inconsistent with information about client business activities. Participants used the same three information displays but with different numbers. On average, participants clicked a line to display an information item 45.2 times and 55.8% of those cues were acquired through serial processing (in order of presentation). On average, only 7.9% of the cue acquisitions could have involved backward reasoning.

In summary, evidence from this computerized process-tracing experiment suggests that auditors rely more on forward reasoning than on backward reasoning. Although, there is clear evidence that auditors use backward reasoning during analytical procedures, these findings suggest that forward reasoning plays a major role in the decision-making process. The first task required participants to learn about their client then search for unexpected fluctuations before they would be in a position to switch to backward reasoning. However, during the second task, they were familiar with the information display and they were given an unexpected fluctuation to explain before they began their information search. However, there appears to be little difference in the amount of backward reasoning between the two tasks – 6.9% for the cues that were re-acquired during the first task versus 7.9% for the cues that were acquired during the second task.

SUMMARY AND CONCLUSION

This study presents evidence from several sources that auditors may not rely extensively on backward reasoning during analytical procedures. Instead, much of their diagnostic effort is accomplished through forward reasoning. Forward reasoning produces diagnostic inferences as a by-product of efforts to learn more about a decision situation. As client-specific knowledge grows, situation awareness improves and auditors are more likely to recognize patterns that signal potential problems. Backward reasoning diagnoses potential problems by generating hypotheses to explain observed conditions then gathering information to test those hypotheses. During backward reasoning, knowledge acquisition is driven by the search for information to test hypotheses.

Using an appropriate descriptive framework for examining auditor judgment is important because forward and backward reasoning are influenced differently by individual-level and task-level variables (Elstein et al. 1993). At the individual level, forward reasoning requires strategic knowledge about how to learn enough about the patient to make accurate diagnostic inferences but backwards reasoning requires relational knowledge about the conditions or symptoms associated with different problems (Clancy 1988). At the task level, forward reasoning is significantly influenced by the design of information displays and the framework used to acquire knowledge but backward reasoning is relative insensitive to these factors (Langley et al., 1987).

The evidence presented in this study raises doubts about whether the backward-reasoning paradigm provides an appropriate description of auditor judgment during diagnostic tasks. Previous research has relied almost exclusively on a backward-reasoning framework for examining auditor judgment during diagnostic tasks (Koonce, 1993; Biggs et al., 1995; Bedard,

Mock, & Wright, 1999). The findings from this study suggest that future research should explore judgment through a less restrictive framework – one that recognizes and accounts for extensive use of forward reasoning.

Limitations

This study was not designed to provide definitive evidence about the extent to which auditors use forward versus backward reasoning. Instead, the objective was to evaluate the possibility that forward reasoning plays a significant role in during audit judgment. This study should be construed as a reasonableness test for the forward-reasoning framework – not a test of a forward-reasoning theory of decision-making. None-the-less, several limitations must be considered when interpreting these findings.

The evidence presented in this study relies on characteristics of information search to distinguish type of processing. Both the protocols gathered by Biggs et al., (1989) and the process-trace records from my experiment provide descriptions of information search activities. This data reveals a great deal about what information was used during the decision-making process and the sequence in which it was integrated. However, this evidence sheds relatively little light on the cognition that occurred while analytical procedures were being performed. A rigorous test of differences in cognition must be accomplished through an experimental design that accounts for the ways that both reasoning alternatives will change the decision (see Brown & Solomon, 1991 for an example of an experimental design for distinguishing configural processing).

The algorithm that I developed for classifying backward-reasoning cue acquisitions assumes that auditors will choose to acquire information from the display rather than retrieve a previously-examined cue from long-term memory. Bonner & Pennington (1991) note that

auditors can hold no more than six cues in working memory and that any additional cues must either be acquired through information search or retrieved from long-term memory. If participants had examined information that would be useful for hypothesis testing before they encountered the unexpected fluctuation, then they might be able to conduct a hypothesis test by retrieving information about related accounts from memory rather than by acquiring them again from the information display. I did not account for this possibility when classifying cues by type of reasoning. I assume that auditors are more likely to look at the display than rely on memory but I can offer no evidence that this assumption is valid.

Implications for Future Research

Previous research has revealed a wealth of information about how auditors generate and test hypotheses when they use backward reasoning. Future studies should examine how auditors incorporate forward reasoning into diagnostic judgment tasks by addressing the following questions.

Is one type of reasoning more effective than the other and, if so, under what conditions? This study suggests that auditors rely more on forward reasoning. Is that an effective strategy? Would auditors be able to diagnose problems more effectively if they used backward reasoning more often? Are there certain task-specific conditions under which backward reasoning is more likely to produce the better decision? Perhaps fluctuations in certain types of accounts can be more effectively evaluated with backward reasoning. Understanding when forward and backward reasoning are most effective would help auditors develop more effective reasoning strategies.

Given that auditors use both types of reasoning during a diagnostic task, what individual-level and task-level factors cause auditors to switch from one reasoning strategy to the other?

Evidence from the three studies discussed above suggests that auditors use both forward and backward reasoning. Do auditors tend to use backward reasoning for certain types of task conditions and forward reasoning for others? Does the type of knowledge that an auditor brings to the task influence the choice to rely on backward versus forward reasoning? Knowledge and task conditions often interact to influence decision performance (Libby & Luft, 1993). Do these variables from the natural audit ecology interact to influence the type of reasoning that auditors employ during a diagnostic judgment task?

Can task structure be modified to influence the type of reasoning that auditors use? Although most task-specific conditions are dictated by the audit environment, auditors have considerable control over how they structure their judgment tasks. Technology has made it possible to accumulate, aggregate, analyze, and display information in a wide variety of formats. A number of audit firms have revised the framework they use to acquire client-specific knowledge by increasing their focus on business processes (Lemmon, Tatum, & Turley, 2001). How do these types of task-structure options affect reliance on forward versus backward reasoning? Do certain task-structure variables influence the type of reasoning auditors are likely to use? Understanding how different information presentations and knowledge-acquisition frameworks influence reasoning strategy could provide valuable insight for re-designing audit procedures.

Research that addresses these and other issues related to how, when, and why auditors use forward versus backward reasoning could make significant contributions to audit practice. Studies that address these questions would also help audit judgment researchers learn more about the cognition that drives diagnostic judgment.

Appendix
Account Relationships for Identifying Backward Reasoning Cues

Number	Description	Related Accounts
101	Cash and equivalents	104, 112, 113, 138
102	Accounts receivable (net)	121, 140, 141, 144
103	Inventory	112, 121, 122, 144, 146
104	Prepaid expenses	101, 127, 132
105	Total current assets	142
106	Land and buildings	114, 116, 127, 132
107	Machinery and equipment	114, 116, 127, 132
108	Furniture and fixtures	114, 116, 127, 132
109	Accumulated depreciation	127, 132
110	Other assets (net)	129, 133
111	Total assets	151
112	Accounts payable	101, 103, 130, 135
113	Accrued expenses	124, 130, 131, 135
114	Current maturities of long-term debt	143, 145, 147
115	Total current liabilities	142
116	Long-term debt	106, 107, 143, 145, 147
117	Common stock	101, 106, 107, 143, 150
118	Paid-in capital	101, 106, 107, 143, 150
119	Retained earnings	136, 138
120	Total liabilities and stockholders' equity	143
121	Net sales	102, 130, 136, 144, 148
122	Cost of goods sold	103, 144, 146
123	Gross profit	144
124	Compensation	121
125	Catalogs and promotions	121
126	Shipping	121
127	Occupancy	121
128	Bad debts	102, 121, 140, 141
129	Other	121
130	Total selling expenses	121, 148
131	Compensation	113
132	Occupancy	106, 107, 108, 109, 127
133	Other	129
134	Interest	114, 116, 145, 152
135	Total general expenses	148
136	Income from operations	123, 148

Appendix (continued)
Account Relationships for Identifying Backward Reasoning Cues

Number	Description	Related Accounts
137	Beginning retained earnings	143, 150
138	Dividends	101, 136, 150
139	Ending retained earnings	143, 150
140	Accounts receivable turnover	102, 121
141	Bad debts expense to net sales	102
142	Current ratio	105, 115
143	Debt to equity	114, 116, 117, 118, 119
144	Gross profit margin	121, 122, 123
145	Interest expense to long-term debt	114, 116, 134
146	Inventory turnover	103, 122
147	Long-term debt to total assets	111, 114, 116
148	Net Income to net sales	121, 136
149	Quick ratio	101, 102, 112, 113
150	Return on equity	136, 117, 118, 119
151	Return on total assets	111, 136
152	Times interest earned	134, 136

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Figure 1
Process Model for Diagnostic Reasoning During Analytical Procedures

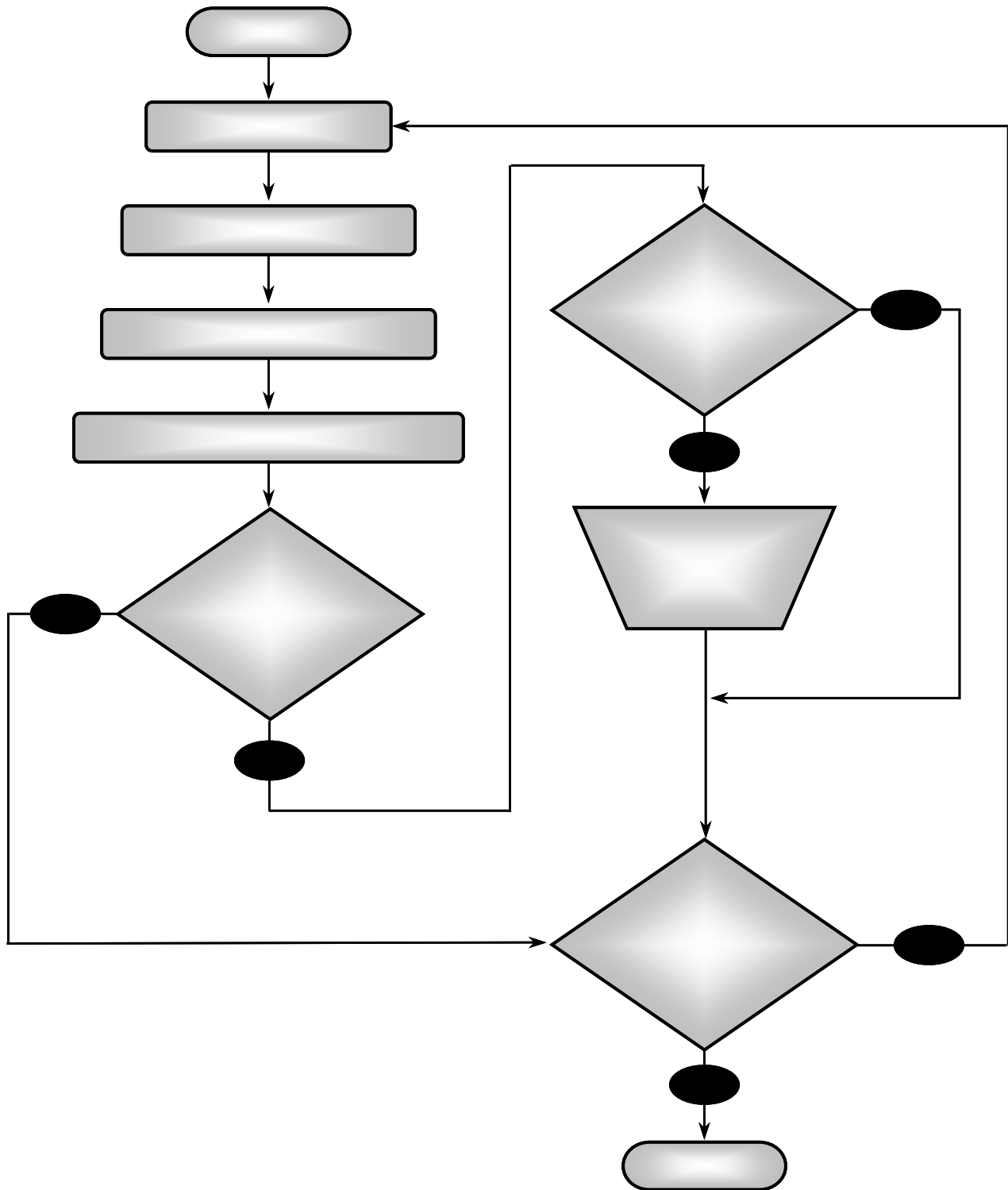


Table 1
Backward-Reasoning Protocols

	<u>Manager 1</u>	<u>Manager 2</u>	<u>Senior 1</u>	<u>Senior 2</u>
Line number for backward-reasoning protocols	2.9; 2.11; 2.19.1	2.4.2; 3.1; 3.4; 6.1.2	none	3.4
Total protocols examined	90	44	33	32
Percent that could have involved backward reasoning	3%	9%	0%	3%

(Biggs et al. (1989) included all of the protocols in Appendix B)

Table 2
Summary Statistics for Process Measures

Panel A: First Analytical Procedures Task				
	<u>Sample Mean</u>	<u>Standard Deviation</u>	<u>Minimum Observation</u>	<u>Maximum Observation</u>
Total cue selections (number of times participants clicked on an information item to view it)	89.7	49.1	29.0	225.0
Cues Selected During Serial Processing:				
First-time cues	77.8%	13.9%	37.5%	94.2%
Re-acquired cues	49.5%	16.0%	28.3%	85.3%
Cues Selected During Backward Reasoning:				
First-time cues	3.4%	3.7%	0.0%	16.3%
Re-acquired cues	6.9%	4.4%	0.0%	16.9%
Planning Concerns Documented:				
Number of accounts targeted	3.8	2.3	0.0	9.0
Potentially targeted through backward reasoning	28.9%	31.0%	0.0%	100.0%
Panel B: Second Analytical Procedures Task				
	<u>Sample Mean</u>	<u>Standard Deviation</u>	<u>Minimum Observation</u>	<u>Maximum Observation</u>
Total cue selections (number of times participants clicked on an information item to view it)	45.2	30.1	8.0	133.0
Number of cues selected during serial processing	55.8%	17.2%	22.5%	87.5%
Cues selected during backward reasoning	7.9%	9.4%	0.0%	33.3%