Enhancing auditors' critical thinking in audits of complex estimates

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ABSTRACT
Audit practitioners, standards, and regulators continually emphasize the importance of professional judgment in the audit of complex processes and financial estimates. Despite this increasing call for more thoughtful analysis, research and inspection reports seem to suggest that auditors tend to make mechanistic audit decisions in such situations. This experiment evaluates auditor participants’ improved application of professional judgment in the audit of complex estimates when taught a specific critical thinking methodology from system dynamics. Results indicate that emphasizing the use of professional judgment is not sufficient to decrease auditors’ mechanistic mentality. As expected, however, auditors primed to take a systems-thinking perspective are better able to evaluate the complexity of the situation and to more effectively apply professional judgment. These results suggest that the goal of improving professional judgment can be achieved with an underlying change to the way auditors think.

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1. Introduction
Accounting researchers, practitioners, and regulators recognize the significant challenges auditors face when evaluating financial information with high uncertainty, like fair values and other complex estimates (e.g., Brody, Lowe, & Pany, 2003; Christensen, Glover, & Wood, 2012; Griffith, Hammersley, & Kadous, 2015), or when an audit task is, itself, complex (e.g., Alissa, Capkun, Jeanjean, & Suca, 2014). Auditors are sometimes even seen as “going through the motions” in order to satisfy those to whom they are accountable instead of applying careful professional judgment in these situations (e.g., Bratten, Gaynor, McDaniel, Montague, & Sierra, 2013). Recent studies, however, point out the challenges auditors face in applying judgment in today’s accounting and auditing environment (e.g., Glover, Taylor, & Wu, 2018; Peecher, Solomon, & Trotman, 2013). As the complexity of accounting processes and estimates continues to increase, how auditors apply judgment within this complexity has become an increasingly critical topic (e.g., Cannon & Bedard, 2016; DeFond & Zhang, 2014; Glover, Taylor, & Wu, 2016).

The audit profession has attempted to meet this challenge by emphasizing to its professionals the importance of making decisions and conclusions based on professional judgment. This has occurred through, for example, commentary (e.g., Public Company Accounting Oversight Board [PCAOB], 2005; 2007b; 2011; 2014a; 2016), regulation (e.g., PCAOB, 2007a, 2010d, 2014b), and firm methodology (e.g., Center for Audit Quality [CAQ], 2014; Ranzilla, Chevalier, Hermann, Glover, & Prawitt, 2011). While this guidance emphasizes the use of auditor professional judgment (e.g., Backof, Bamber, & Carpenter, 2016), evidence suggests that practitioners implement it in a mechanistic way (e.g., Knechel, 2013; PCAOB, 2014a; Palmrose, 2013; Wedemeyer, 2010). More direct interventions are likely required to help auditors apply professional judgment at the level needed to execute modern audit methodologies that focus on understanding business risk, especially in areas with a large degree of complexity, like estimates (e.g., Bratten, Jennings, & Schwab, 2016; Glover et al., 2018; Knechel, 2007; Power, 2007).

The current study evaluates such an intervention that would allow auditors to infuse their professional judgment with critical thinking in these situations to better develop their own expectations of complex accounting estimates. Recent research suggests
that, where critical thinking is necessary to apply judgment, skepticism can be temporarily increased by asking auditors to think broadly about a topic (e.g., Griffith, Hammersley, Kadous, & Young, 2015; Rasso, 2015). A concurrent study provides evidence that certain measurable traits can also enhance how well auditors exercise professional skepticism; auditors who naturally possess a stronger disposition to use “wise-thinking”, a measure developed based on existing psychological scales, exhibit stronger critical thinking in evaluating misstatement risk (Brewster, Pecher, & Solomon, 2017).

Expanding upon these studies, the current study employs a system dynamics thinking perspective, systems-thinking, which can be reliably taught, practiced and, notably, retained over time. Even individuals with weaker natural dispositions to engage in critical thinking traits can improve their skills (e.g., Davidz, Nightingale, & Rhodes, 2004; Frank, 2006). The current study focuses on specific learnable systems-thinking skills that can be implemented through training and in practice. Specifically, the study experimentally evaluates, across audit environments where the importance of professional judgment is either emphasized or not emphasized, how auditors apply professional judgment to determine whether a material misstatement exists in the audit of complex estimates when taught to take a systems-thinking perspective versus a linear, list-based perspective (known in system dynamics as a reductionist-thinking perspective).

Auditors should consider the overall complexity of an auditee’s business, its processes, and its environment, in assessing material misstatement risk, especially when considering complex estimates (e.g., PCAOB, 2010b, 2010d). Systems-thinking training can improve critical thinking skills by aiding auditors’ understanding of process complexity. Auditors with this skill can then better integrate process complexity into their mental models without increasing the level of cognitive effort required (e.g., Brewster, 2011; O’Connor & McDermott, 1997; Senge, 1990). Importantly, systems-thinking does not just cause the auditor to include more information in the decision process. Even reductionist-thinkers can be induced to consider, for example, multiple potential causes of a financial misstatement, by suggesting that they do so, or by making them accountable for doing so. Systems-thinking also changes how different pieces of information are integrated within a mental model that more comprehensively describes the overall situation. Additionally, systems-thinking involves creating a physical expression of the environment being evaluated, generally in the form of a documented mental model. Systems-thinking trains the auditor to envision and incorporate not only more details (detail complexity), but also elements of the process, like feedback mechanisms, non-linear patterns, etc. (dynamic complexity) (e.g., Richmond, 1993; Sterman, 2000).

Considered along with the recent literature on other critical thinking concepts described above, this suggests that systems-thinking auditors are more likely than reductionist-thinking auditors to recognize the diagnosticity of process complexity in developing an accounting estimate when evaluating the related risk of material misstatement. The current study evaluates the extent to which auditors attribute their audit decisions to the complexity of management’s business process when trained in either reductionist-thinking or systems-thinking principles. In summary, guidance emphasizes to auditors that they should think critically, but systems-thinking gives them the cognitive tools to actually think critically.

In a 2 x 2 experiment, I manipulate both emphasis on auditors’ use of professional judgment in the audit of complex estimates and thinking perspective, between subjects. The former sets up a stark contrast between whether professional judgment is emphasized (judgment-emphasis condition) or not (no-emphasis condition). This manipulation accomplishes two things. First, it analogizes the regulators’ use of new or updated standards to emphasize the importance of using judgment. Next, it sets up the measurement of “greater use of professional judgment”. Participants in the no-emphasis condition face a situation in which existing standards do not emphasize the use of professional judgment, i.e., when a potential misstatement is already greater than a set quantitative materiality level. Those in the judgment-emphasis condition are told that they will be implementing a new audit standard that allows them to use judgment, considering both quantitative and qualitative factors, in evaluating whether a misstatement is material. Not only can some small errors in estimates be considered material because of qualitative factors, but also some large errors in estimates can be considered not material because of qualitative factors.1

I also manipulate thinking perspective at two levels, between subjects; participants receive a simulated training intervention to induce either a systems-thinking or a reductionist-thinking perspective. Since system-thinking auditors are expected to recognize qualitative factors (process complexity, relative to other factors) and incorporate them into their mental models and subsequent audit decisions, they are more likely than reductionist-thinking auditors to differ in their material misstatement judgments between the two emphasis conditions. Systems-thinking auditors in the judgment-emphasis condition are less likely to consider the quantitatively large misstatement to be material to financial statement users than those in the no-emphasis condition. Reductionist-thinking auditors are likely to mechanically conclude that the misstatement is material irrespective of emphasis condition.

Consistent with predictions, the experimental evidence shows that audit seniors provided with an explicit emphasis on the use of professional judgment do not reach different audit conclusions than those not provided with this emphasis unless they were trained in systems-thinking. Thus, merely emphasizing the need to exercise professional judgment is not sufficient, by itself, to cause a significant difference in auditors’ actual use of professional judgment. In addition to such an emphasis, auditors need to be equipped with cognitive tools to engage in critical thinking. Auditors given the cognitive tools to understand that greater underlying complexity can make a relatively larger adjustment less material were more likely to come to different decisions. For reductionist-thinkers, there is no significant difference between material misstatement conclusions whether judgment is emphasized or not. Systems-thinking auditors, however, made significantly lower material misstatement decisions when judgment was emphasized versus not, consistent with the application of professional judgment, using critical thinking to incorporate diagnostic qualitative factors. Results provide evidence that the difference in decisions for systems-thinking, but not reductionist-thinking, auditors is partially due to the formers’ consideration of diagnostic qualitative factors (i.e., process complexity) in their audit decision processes.

The results of this study can inform regulators, practitioners,
and researchers. There are cognitive limits to the effectiveness of programs that emphasize or train auditors on the importance of professional judgment. In this experiment, reductionist-thinking auditors showed limited difference in their propensity to exercise professional judgment. This result is consistent with anecdotal evidence that regulatory inspectors continue to find deficiencies in auditors’ judgments related to complex estimates, even under standards that avoid bright-line requirements (e.g., Bratton, 2004; Cannon & Bedard, 2016; Glover et al., 2016). The increased use of professional judgment that the regulators intend to induce can be achieved, however, if auditors have a relatively greater systems-thinking perspective. This suggests that regulators can achieve their goals if audit practitioners and educators take certain steps to develop such a thinking perspective in audit professionals.

This study also incorporates an audit-relevant measure, i.e., diagnosticity of client process complexity, to assess the process through which systems-thinking affects auditors’ critical thinking. Previous systems dynamics research provides evidence that systems-thinkers have more accurate mental models of business environments, and that better mental models enable better judgments (e.g., Gary & Wood, 2011, 2016; Plate, 2010; Sterman, 1989). Similarly, the few accounting studies that incorporate systems-thinking concepts provide evidence that systems-thinkers are better able to depict specific mental models of complex causal relationships in accounting processes (Brewster, 2011; Humphreys, Gary, & Trotman, 2016; O’Donnell & Perkins, 2011). Consistent with the broader system dynamics literature, these studies either attribute improved judgments to richer mental models or provide richer mental models in the case materials that enable improved judgment. Extending this broader literature, this study focuses on a key step in the cognitive strategy after depicting the mental model – incorporating the complexity of the underlying business process and accounting for that business process in the auditor’s ultimate decision (in this case, material misstatement judgment). This not only more closely ties system dynamics research to accounting practice, it also relates to recent literature (e.g., Brewster et al., 2017; Griffith et al. & Young, 2015) suggesting that accountants who are either more naturally disposed to wise thinking or who receive training in critical thinking are better at recognizing diagnostic versus non-diagnostic information.

2. Background and hypothesis development

Financial statement preparers and auditors are tasked with making the most appropriate decisions based on application of professional judgment given relevant facts and circumstances (PCAOB, 2010b, 2010d, 2014a). In stark contrast to these expectations, audit professionals are sometimes accused of having a mechanistic mentality, or “going through the motions” to follow a series of rules, or perceived rules (e.g., Bratton et al., 2013; Demirkan, Peng, Minchik, Pevzner, & Sierra, 2013; Griffith, Hammersley, & Kadous, 2015; PCAOB, 2007b; Pitt, 2002; SEC, 2005).

To emphasize the importance of professional judgment, and to promote its use in practice, regulators and practitioners have introduced standards and frameworks which emphasize general guidelines or principles instead of specific bright-lines. One example is the issuance of PCAOB Auditing Standard (“AS”) No. 2201 (PCAOB, 2007a).\(^4\) PCAOB Chairman James R. Doty explicitly recognized the need for “auditors who … devise for themselves the procedures that are necessary to expose material misstatements” rather than following uniform procedures in an “unthinking, mechanistic, and wasteful way” (PCAOB, 2014a). Many audit firms have introduced so-called judgment frameworks, intended to develop practitioners’ professional judgment abilities (e.g., CAQ, 2014; Ranzilla et al., 2011).

Examples, suggestions, and other guidelines in standards, guidance, and methodologies may, however, be interpreted as additional rules, creating an even greater perception of prescription (Nelson, 2003). More recent evidence suggests that the current accountability environment gives audit professionals incentive to perform and document procedures in a manner that reduces regulatory scrutiny (Glover et al., 2018). This can actually exacerbate the mechanistic mentality – particularly problematic in audits of complex estimates, for which measurement or valuation is uncertain (e.g., Burns & Fogarty, 2010; Defond & Zhang, 2014; Peecher et al., 2013). When making these estimates, management must use computationally difficult models and significant judgment – indicative of a process with dynamic complexity. They must also consider multiple factors – indicative of a process with detail complexity (e.g., Senge, 1990; Sterman, 2000; Wood, 1986). It seems that, while it is necessary to “say” that professional judgment is important – through guidance, rules, and other communications – the complexity of the modern audit environment and cognitive limitations suggest that saying it is not sufficient. Auditors must think differently, in a way that truly incorporates judgment and complexity into the decision process.

2.1. Thinking perspectives and complex audit decisions

Recent research on professional skepticism provides evidence that auditors can be induced to at least temporarily change their thinking perspectives. For example, Rasso (2015) finds evidence that, when auditors are instructed to think “broadly about all of the evidence collectively” or “specifically about each evidence item”, the former are more likely to successfully recognize that there is more evidence of management aggressive reporting than conservative reporting. The former participants also spend more time on the task than the latter participants. Another recent study (Griffith et al. & Young, 2015) temporarily induces auditor participants to adopt either a deliberative or an implemental mindset outside of the context of the audit decision process. They find that the former consider both sides of an issue while the latter consider only one side, and provide evidence that auditors with a deliberative mindset are better able than those with an implemental mindset to recognize an unreasonable fair value estimate, based on seeded evidence of management bias. These recent findings support the notion that, on average, auditors do not naturally apply critical thinking skills, but those skills can be induced.

Still another accounting study, concurrent with the present study, takes an alternate approach to evaluating the effects of different thinking perspectives. Brewster et al. (2017) find evidence to suggest that auditors with a stronger, natural disposition to engage in “wise-thinking” more fully and critically incorporate available, diagnostic information into their judgments than do those who are lower in this disposition. The disposition measured in that study combines several measures of individuals’ tendency to be reflective, or willingness to consider multiple perspectives, as well as openness to uncertainty and doubt. The current study is similar to those described above in that it evaluates the effect of thinking perspective on auditors’ ability to use a more complete set of diagnostic information in important audit decisions. The current study extends this accounting research on thinking...
perspective in at least two important ways. First, it incorporates a concept from system dynamics, which offers a long-term method to prepare auditors to understand and verify assertions emanating from complex underlying business processes and accounting for such processes. Notably, the systems-thinking perspective is learned and retained over time, such that it becomes a part of the individual’s natural thinking process; it is not a temporary fix or short-term intervention, though aspects of the perspective can be taught in a short period of time. Second, in previous studies, different thinking perspectives seem to affect which and how much seeded case information is evaluated; the factors leading to risk of material misstatement are quantifiable. The factors that are the most diagnostic in evaluating audit-related risks are not, however, always easily quantifiable. Standards and guidance require and exhort auditors to evaluate both quantitative and qualitative factors when reaching audit conclusions about misstatement (e.g., Knechel, Krishnan, Pevzner, Siefchik, & Velury, 2013; PCAOB, 2001, 2010b). The current study evaluates the effect of systems-thinking on auditors’ incorporation of a critical qualitative (and diagnostic) factor, process complexity (PCAOB, 2010b, 2010d) in their ultimate material misstatement decisions.

In recent years, a small number of studies have explicitly introduced system dynamics concepts into the accounting context. Early research found differences in auditor judgments based on certain skills used in system dynamics training, like whether the auditors were primed to think of processes versus audit objectives (Borthick, Curtis, & Sriram, 2006; Curtis & Viator, 2000; Kopp & O‘Donnell, 2005; O‘Donnell & Perkins, 2011). Brewster (2011) found evidence suggesting that auditors trained to take on a systems-thinking perspective are more likely to develop accurate mental models. They better recognize information from management that is inconsistent with macroeconomic data.

More recently, Humphreys et al. (2016), while they do not describe their intervention in terms of systems-thinking theory, nonetheless do manipulate whether their participants attend to important systems-thinking concepts. Specifically, they experimentally manipulate whether or not a company’s information is presented to accountants with explicitly defined causal linkages and time delays. They find that participants that received information described in terms of systems-thinking concepts generally outperformed participants who received the same information in list form. They also find evidence that participants in the former condition develop more accurate mental models than those in the latter condition.

Traditionally, mental models play two primary roles in systems-thinking research. First, the construction of a mental model, including some form of writing down that model, helps the documenter more lucidly understand complex underlying processes. Next, the mental model is an internal representation of an external system or environment (Groesser & Schaffernicht, 2012; Senge, 1990). Because it is a visual tool used in the systems-thinking architecture, it can be used by researchers to evaluate whether the documenter correctly interpreted the processes and interactions in question (e.g., Brewster, 2011; Humphreys et al., 2016; Plate, 2010; Senge, 1990).5 While the effect of thinking perspective on mental models is not formally predicted in the current study, supplementary analyses provide insights into the role of mental models in auditor critical thinking. Participants in the current study draw a very basic mental model of the process. This is done to strengthen the manipulation and because the construction of the mental model is an element of systems-thinking (Senge, 1990). The accurate construction of mental models has been validated in previous accounting research (e.g., Brewster, 2011; Humphreys et al., 2016).

Beyond the changes to mental representations, thinking perspective affects how individuals think and what they think about. Systems-thinking research suggests that, if auditors are trained to take a systems-thinking perspective, their understanding of and appreciation for complexity is likely to increase (e.g., Richmond, 1993), allowing them to better incorporate that complexity into the decision-making process. In contrast, auditors trained to follow linear processes, similar to current audit standards, are more likely to approach their decision-making in a mechanistic manner. This is likely even when they must deal with complex estimates and complex audit regulations which do not follow linear patterns. These auditors exhibit a reductionist perspective—problems are broken into their component parts and analyzed separately (Brewster, 2011; O’Connor & McDermott, 1997; Rouse, 2007; Senge, 1990).

While understanding causal chains is an important element of systems-thinking, it is not sufficient on its own (e.g., Richardson, 1986). Complex processes, whether auditing or manufacturing, contain elements like feedback mechanisms, nonlinear relations, and time delays (Sterman, 2000). Individuals trained in systems-thinking are likely able to understand how various parts of a process work together to produce an outcome, and to better understand cause-and-effect relationships (Brewster, 2011; Frank, 2000; O’Connor & McDermott, 1997; Senge, 1990).

Valerdi and Rouse (2010) developed a summary of several conceptual competencies generally present in systems-thinkers. These are not implementable skills, per se. Rather, by learning and applying the implementable skills in the Richmond (1993), or other operational, framework (described in the Method section), an individual can achieve these observable and measurable competencies. One of these measurable competencies, understanding causal attribution (the ability to understand both detail and dynamic complexity to identify cause-and-effect) at least partially explains how induced systems-thinking skills lead to increased use of professional judgment.7

This measure has practical significance in auditor planning and reporting decisions. For example, each of the many subjective and interrelated inputs to a complex accounting estimate has the potential to cause that estimate to be incorrect. Recognizing multiple potential causes of misstatements allows auditors to judge the reasonableness of audited estimates. Also, individuals often overestimate the likelihood that future outcomes will be similar to past outcomes and underestimate the likelihood that more extreme outcomes will be realized (e.g., Lichtenstein, Fischhoff, & Phillips, 1982; Sterman, 2000). Because of their focus on complex patterns however, systems-thinkers better see how changes in one or more factors of a complex process are likely to affect outcomes, possibly in unexpected ways (Sterman, 2000).

Individuals attempt to explain the cause of unintentional outcomes by references to a person’s ability, effort, and the situation

5 Unlike previous studies, e.g., Brewster (2011), whose participants are students, with data collected over multiple sessions, my participants are professional auditors, whose firms limit the training time available for the experiment, so certain design choices were made to collect the most pertinent data. While it would likely have been valuable at the margin to collect detailed mental models, given the time constraint, I chose to rely on previous studies for evidence that this study’s manipulation likely significantly affected mental models as expected.

6 While the mental model in this study is not used as a primary measure, it provides some evidence that participants did, in fact, take on the manipulated perspective. The measure also provides evidence that, consistent with system dynamics literature, the mental model acts as an intermediary step in auditors’ decision-making. More details are included in the “Results” section.

7 Understanding causal attribution is derived primarily from the fifth competency—understand that systems have linkages and interactions, events are separated by distance and time, small events can be the cause of large effects.
This is particularly true when there is uncertainty in the process (Shields, Birnberg, & Frieze, 1981). Further, research in social psychology finds evidence of certain biases in causal attribution. For example, when an individual (“evaluator”) is asked to evaluate another individual’s decision in the presence of a negative outcome, he or she is likely to attribute the cause of the negative outcome to factors associated with the decision-maker and not the process itself (Ajzen & Fishbein, 1975; Jones & Nisbett, 1971; Malle, 2004, 2006). It follows that, when an auditor learns that a previously audited complex accounting estimate will have an ultimate value that differs from the audited value, the auditor will not generally attribute the potential negative impact to the complexity of the business or accounting processes.

Given the systems-thinkers’ ability to recognize dynamic complexity, and incorporate it into their mental models, though, they are more likely to recognize a more comprehensive range of probable causes than are reductionist-thinkers. This allows them to attribute their conclusions, to a greater extent, to factors that increase the complexity of the process, assuming those factors exist and/or are likely relevant and diagnostic (e.g., Ajzen & Fishbein, 1975; Jones & Nisbett, 1971; Malle, 2004, 2006). Specifically, systems-thinkers are more likely to recognize that the dynamic complexity of the accounting process is a significant causal factor, relative to other factors, in the ultimate realization of an estimated financial statement account. This understanding of the effects of complexity is investigated as an intermediary between thinking perspective and ultimate audit decisions. Formally, the study’s first hypothesis is stated as follows, and analyzes the role of this contextually significant measure.

**Hypothesis 1.** Auditors provided with a systems-thinking perspective are more likely than auditors provided with a reductionist-thinking perspective to attribute their audit misstatement judgments to understanding the role of process complexity in accounting estimates.

This study further predicts that the extent to which auditors apply professional judgment to audit decisions when the requirement to use professional judgment is emphasized vs. not emphasized will be moderated by auditors’ thinking perspectives. The predicted results are directional, and based on the specific information used in the experiment. To manipulate “no emphasis on professional judgment” vs. “emphasis on professional judgment”, the case materials either invoke the existing audit standard or a hypothetical new standard for determining whether a misstatement is material to financial statement users. When judgment is not emphasized, the case simply reports the quantitative audit materiality range. When judgment is emphasized, a new standard is described, emphasizing that both qualitative and quantitative factors should be considered in determining whether a misstatement will affect users’ decisions.

Auditors are asked to judge the likelihood that a quantitatively large potential misstatement in a complex estimate would affect an investor’s decisions. In the audit case presented to participants, the potential misstatement is multiple-times the quantitative threshold. When judgment is not emphasized, auditors are following existing audit materiality guidance which emphasizes the use of bright-line rules (PCAOB, 2010c). In the condition in which professional judgment is emphasized, participants are told to consider both quantitative (bright-line) and qualitative factors to determine whether a misstatement would affect financial statement users. The qualitative factors in the case imply that, because of the complexity of the process, an estimate within the quantitative materiality range is actually no more likely to be realized than an estimate within several multiples of the quantitative materiality range.

Systems- (versus reductionist-) thinking auditors better incorporate a more comprehensive set of information into their judgments. As such, they understand the role that qualitative elements of business and accounting processes, like process complexity, play in making complex accounting estimates. Because of this advanced understanding, systems-thinkers better grasp that the potential misstatement is not an isolated event, but a symptom of process complexity, that there are many other ways that a misstatement might occur, and that the potential misstatement can be very quantitatively large. At the same time, while systems-thinkers better understand the ways a misstatement might occur, when primed to focus on professional judgment they are also likely to more fully consider the many qualitative factors suggesting that a quantitatively large misstatement is not material to financial statement users. Critical thinking that incorporates an understanding of and appreciation for process complexity will result in differences in judgment between the no-emphasis and judgment-emphasis conditions. Critical thinkers are less likely to judge that the potential misstatement is material when professional judgment is emphasized than when it is not emphasized in this scenario. Since systems-thinkers are expected to exhibit critical thinking and reductionist-thinkers are not, this difference in judgments is predicted to occur for the former, but not the latter. This leads to the study’s hypotheses for the direct and indirect effects of thinking perspective on audit judgment:

**Hypothesis 2.** Auditors who attribute their misstatement judgment relatively more to process complexity are more likely to judge the likelihood of material misstatement to be lower when professional judgment is emphasized vs. not emphasized.

**Hypothesis 3.** Auditors with a systems-thinking perspective will judge the likelihood of material misstatement to be lower when professional judgment is versus is not emphasized, whereas auditors with a reductionist-thinking perspective will exhibit less, if any, such difference between emphasis conditions.

The pattern of the overall predictions for all hypotheses is depicted in Fig. 1.

### 3. Method

#### 3.1. Experimental design and participants

The hypotheses are tested with a 2 × 2 between subjects experimental design. See Appendix A for a graphical depiction of the overall design. The manipulation of no-emphasis vs. emphasis on professional judgment occurs immediately after participants begin the experiment. The induced systems-vs. reductionist-thinking perspective manipulation begins immediately afterward and is carried out via a set of instructions describing the development of audit-focused mental models. Shortly before responding to the first dependent measure question, participants are reminded of their respective emphasis conditions.

Participants’ material misstatement decisions are captured at two points in time. Initial decisions are based on a description of audit procedures completed to date. After receiving new information suggesting the previously audited warranty reserve estimate is likely incorrect, participants make a second material misstatement decision. This information is captured twice so that the initial decision can be used as a baseline for individuals’ idiosyncratic
feelings toward material misstatement reporting when no material misstatement is evident. The dependent measure of interest is the change in judgment caused by the new information, which does suggest a quantitatively material misstatement exists.

Fig. 2 depicts the point estimate and estimation error ranges given to participants both before and after the new information. Note that the updated estimate of future warranty costs is $6 million greater than the original point estimate ($25 million), representing a difference that is 3-times quantitative materiality ($2 million). The case study describes other qualitative factors, similar to those described by Christensen et al. (2012), which suggest that the difference may not be material to users. For example, the estimation error range around the point estimate is a 4-times quantitative materiality, the hypothetical client’s process for developing the estimate is dynamically complex, and management has very good internal controls over financial reporting. These qualitative factors suggest that management’s recorded estimate is still likely to be reasonable, even given the new information suggesting a quantitatively large potential change to the estimate. Finally, the updated estimate is still within the original estimation error range.

Participants for the experiment are 118 senior auditors from a Big 4 public accounting firm who had a mean level of experience of approximately 46 months and a range of 30–80 months. Two participants failed to answer one or more of the dependent variable questions and are eliminated from all analyses, leaving 116 usable responses. There was no significant difference in experience level across treatment conditions and the participants were randomly assigned to treatment conditions. Participants were, on average, familiar with the accounting for estimates, with a mean response of 4.9 on a 7-point scale anchored on 1 = “not familiar at all”, 7 = “very familiar”, and 4 = an unlabeled midpoint. Participants were relatively unfamiliar with the accounting for warranties, with a mean of 2.7 on the same scale.

3.2. Procedures and variables

3.2.1. Manipulation of emphasis on judgment

All participants begin the experiment by reading through a case study describing a fictitious technology manufacturing company, and its complex warranty reserve estimation process. Early in the case study, participants in the no-emphasis condition are simply told that quantitative materiality is $2 million, which is a percentage of 3-year average revenues. Those in the judgment-emphasis condition receive the same information, but are further told that they will be implementing a new audit standard that
allows them to use judgment in evaluating whether a misstatement is material. Not only can some small errors in estimates be considered material because of qualitative factors, but also some large errors in estimates can be considered NOT material because of qualitative factors. Further, bright lines or quantitative methods are not always appropriate in determining the materiality of an error to annual financial statements. The rationale for, and background of, the new standard are also briefly described to participants.

This experimental manipulation replaces an existing audit standard with a hypothetical one. The purpose of the manipulation is not to propose the implementation of such a standard, however. Instead, it creates a very stark manipulation of emphasizing professional judgment vs. not emphasizing judgment, in order to set up the measurement of “greater use of professional judgment” in an experimental setting. This emphasis might also have been manipulated through, for example, formal regulator communications or firm-level methodologies.

In all conditions, participants learn that internal controls were appropriately tested and found to be operating effectively, and substantive test outcomes of the accounting estimate conclude that management’s point estimate and estimation uncertainty range (± 4-times quantitative materiality) are reasonable. Shortly before making their first decision whether or not to accept the potential of a material misstatement, participants are all reminded of the quantitative materiality amount for the audit. Those in the judgment-emphasis condition are also reminded of the new materiality standard that they are implementing.

3.2.2. Thinking perspective manipulation

While reading the case information, participants are also given cues or “pointers” to help them understand the components of a client system and how they interact. These cues are designed to prompt participants to exhibit either a systems-thinking perspective based on system dynamics or a reductionist-thinking perspective. Some previous accounting research finds evidence that simply providing accountants with a visual causal chain describing a process is enough to improve certain judgments, including the relevance of information in decision-making (e.g., Cheng & Humphreys, 2012). System dynamics, however, prescribes a more comprehensive approach, suggesting that simple causal chains and even linked causal loops are not sufficient (e.g., Plate, 2010; Richardson, 1986; Sweeney & Sterman, 2000). This is further supported by accounting research that finds the positive effects of providing causal links are improved by incorporating other elements similar to those in system dynamics (e.g., Humphreys et al., 2016; Tayler, 2010) or that providing visual causal links alone can even be detrimental to cognition (e.g., Grossman & Welker, 2011). The current study therefore incorporates a set of factors grounded in system dynamics education to manipulate this construct.

Previous literature approaches systems-thinking at either the conceptual or operational level. The latter describes skills that can be explicitly learned and implemented — these are an individual’s ability-based inputs to a decision process. This study uses elements from the seven systems-thinking skills of critical thinking, as defined in Richmond (1993), to operationalize the systems-thinking condition. According to Richmond (1993), a person should develop all of these skills to become a systems-thinker, though it is not necessary to learn them all concurrently.

The manipulation in this study primarily uses four of the seven skills described by Richmond (1993): dynamic thinking, closed-loop thinking, generic thinking, and operational thinking. See Appendix B for a graphical depiction of the elements of systems-thinking used in this manipulation. The systems-thinking manipulation prompts participants to think of process inputs and outcomes (stocks and flows), both in general and within an accounting environment. They are also asked to consider and diagram interactions between variables. This manipulation was designed to increase holistic thinking within processes, and to allow participants to explore multiple cause-and-effect relations.

The reductionist-thinking manipulation, by contrast, prompts participants to think of common business relationships between companies and their suppliers, customers, etc., or an economic web of entities. The manipulation was based on authoritative audit guidance, which provides a series of factors for auditors to consider in understanding their clients and accounts. Both manipulations are based on Brewster (2011), but are simplified to be used by participants concurrently with the case information, instead of being used as a separate training tool.

The case study used in the experiment focuses on warranty reserve estimates, and under both conditions, participants are told that their goal will be to develop a mental model related to warranty estimates. While participants are asked to document their mental models of the audit process, the change in mental models is not the construct of primary interest in this study. Using audit students, Brewster (2011) tested and found evidence that manipulations similar to those in this study do, in fact, change mental models as expected. (2011) Brewster (2011) and, because of the need to manage audit professional participants’ time on the tasks of the current study, participants were asked to only document relatively basic mental models. In this study, the mental model exercise accomplishes several things. First, it strengthens the manipulation by suggesting the participants practice what they just learned. Next, it serves as a valid manipulation check. Finally, it provides evidence that mental models were changed and that the changes are correlated with auditors’ ultimate misstatement judgments (discussed further in the Results section).

Most of the training materials in the experiment use general topics, accounting (e.g., inventory) and non-accounting (key customers, suppliers, etc.), to introduce the concepts, though the warranty reserve audit is mentioned throughout in order to keep participants on task. Only the systems-thinking manipulation discusses non-business topics (e.g., blowing up a balloon). The systems-thinking manipulation is designed to be vivid, using pictures, graphs, and colorful allegory, in line with system dynamics teaching. In contrast, the reductionist-thinking manipulation is purposely pallid, including primarily words and sentences in bulleted lists, in line with existing audit standards. In the second training cue (for both conditions), the training materials link research and development costs with warranty reserve estimates in order to keep all participants thinking of warranty reserves, however research and development information is specifically left out of the company-specific case information. Thus, the training materials in both conditions avoid giving participants any clues as to how they might respond to the primary experimental measures based on the actual facts of the case.

It is not guaranteed that induced systems-thinking will affect auditors’ decisions under the experimental conditions presented. To the extent participants have stronger innate systems- or reductionist-thinking perspectives (e.g., Toshima, 1993), their responses to the manipulation are likely to be weaker. Similarly, to the extent that auditors have received training, or have learned methodologies, based on one or the other of the perspectives, the effect of the manipulation may be weakened. Previous systems-thinking research in the audit context has used students as participants (e.g., Brewster, 2011; Hecht, 2005). These students have not been subjected to years of audit training, as have the participants in this study. This suggests that an effect based on the relatively simplistic systems-thinking cues used in this study are likely to be even stronger if implemented to a greater, more
hypothesis 1. Panel A provides descriptive statistics of the causal attribution measure of percentage-to-complexity for each of the four randomly assigned experimental conditions. Conditions are based on manipulations at two levels of thinking perspective and two levels of emphasis on professional judgment.

Table 1
Descriptive statistics and primary tests of hypothesis 1.

Panel A: Descriptive Statistics:

<table>
<thead>
<tr>
<th>Source</th>
<th>Thinking Perspective</th>
<th>Reductionist-thinking</th>
<th>Systems-thinking</th>
<th>F-Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emphasis on Judgment</td>
<td>No-Emphasis</td>
<td>N = 28</td>
<td>N = 28</td>
<td>28.4%</td>
<td>31.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.07)</td>
<td>(0.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Judgment-Emphasis</td>
<td>N = 32</td>
<td>N = 28</td>
<td>29.8%</td>
<td>32.4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.08)</td>
<td>(0.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Across Emphasis Type</td>
<td>N = 60</td>
<td>N = 56</td>
<td>29.1%</td>
<td>32.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.07)</td>
<td>(0.07)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Panel B: ANOVA: Causal Attribution to Complexity

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean Squares</th>
<th>F-Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emphasis</td>
<td>1</td>
<td>0.003</td>
<td>0.524</td>
<td>0.471</td>
</tr>
<tr>
<td>Perspective</td>
<td>1</td>
<td>0.028</td>
<td>5.603</td>
<td>0.010*</td>
</tr>
<tr>
<td>Emphasis &quot;Perspective&quot;</td>
<td>1</td>
<td>0.001</td>
<td>0.105</td>
<td>0.747</td>
</tr>
<tr>
<td>Error</td>
<td>112</td>
<td>0.005</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* One-tailed.

b After participants made their final material misstatement decisions, they also indicated the extent to which their decisions were based on the following factors: management’s ability and intelligence, management’s effort, warranty reserve complexity, and luck or other factors outside management’s influence. Attributions were on 7-point scales anchored on 1 – “not at all” and 7 – “an extreme amount”. Table 2 analyzes the percentage that participants attributed to the complexity measure, in support of hypothesis 1. Panel A provides descriptive statistics of the causal attribution measure of percentage-to-complexity for each of the four randomly assigned experimental conditions. Conditions are based on manipulations at two levels of thinking perspective and two levels of emphasis on professional judgment.

### 2.2.3. Dependent measures

Participants are asked to indicate the extent to which their decisions about the presence or absence of a material misstatement are based on measures of attribution (e.g., Malle, 2004; Weiner, 1985): management’s ability and intelligence; management’s effort; warranty reserve complexity; and luck, or other factors outside management’s influence. Participants respond on a 7-point scale anchored on 1 = “not at all” and 7 = “an extreme amount”. The proportion that participants attribute to warranty reserve complexity relative to the other measures, “causal attribution to complexity”, is used to test Hypotheses 1 and 2. The continuous measure used to test H1 is converted to a dichotomous measure, greater vs. lesser causal attribution to complexity, to test H2, by splitting responses at the median.

After receiving information suggesting the previously audited warranty reserve estimate is likely incorrect, participants are asked, “based on your understanding of materiality, if the FY2013 (i.e., 9/30/2013) balance in warranty reserves were to remain unchanged at $25 million (and no disclosure made regarding the potential alternate balance), to what extent do you believe that 2013 financial statements are materially misstated?” (emphasis is as depicted in the case). Participants respond on a 7-point scale anchored at 1 = “definitely NOT materially misstated” and 7 = “definitely materially misstated”. The primary dependent measure for hypothesis 3, extent of belief that a material misstatement exists as a result of the new information, is the difference between this measure and the related question asked prior to participants’ receiving the new information, using repeated measures ANOVA.

### 4. Results

#### 4.1. Tests of hypothesis 1 – thinking perspective and understanding of complexity

Systems-thinkers have a propensity to consider a more comprehensive information set, including both quantitative and qualitative information, in their judgments, than do reductionist-thinkers. Hypothesis 1 predicts that, relative to the level of attribution applied to management ability, effort, and luck, systems-thinking auditors will attribute more causality to process complexity than will reductionist-thinkers. That is, systems-thinkers are more likely to recognize the role of process complexity in causing potential misstatements in complex accounts than are reductionist-thinkers, so causal attribution to complexity is predicted to be higher for systems-thinkers than for reductionist-thinkers.

Results of this analysis are included in Table 1. Descriptive statistics in Panel A suggest that, across emphasis on judgment conditions, causal attribution to complexity measure for systems-thinkers (mean = 32.2%) is greater than the measure for reductionist-thinkers (mean = 29.1%). ANOVA results for this measure (Panel B) indicate that this difference is significant (p < 0.010). Systems-thinkers attribute more causality to the complexity of the warranty reserve process, relative to other factors.⁵

⁵ In addition to attributions to complexity, participants also attributed audit results to the three components of the audit risk model: control risk (described as internal control effectiveness), inherent risk, and detection risk (PCAOB, 2010a). Attributions to complexity and inherent risk should, in accordance with audit processes and standards, be positively correlated. If systems-thinking training improved participants’ understanding of the multiple elements of the complex audit process, then a closer correlation between systems-thinkers’ (vs. reductionist-thinkers’) causal attributions between business process complexity and inherent risk judgments is likely. Untabulated analysis of Pearson correlations provides evidence of a significant difference between the correlations of systems-thinkers and reductionist-thinkers. Across emphasis conditions, there is a positive and significant correlation between these two measures for systems-thinkers (r = 0.715, p<0.001), but the correlation for reductionist-thinkers is non-significant (r = 0.077, p<0.056). The difference between these correlations is highly significant (Fisher Z = 5.107, p<0.001). Systems-thinkers more closely align the impact of process complexity with the inherent risk measure in the audit risk model, suggesting they actually better understand the audit process, providing further support for H1.
Hypothesis 2 predicts that auditors who attribute their misstatement judgment relatively more to process complexity are more likely to judge the likelihood of material misstatement to be lower when professional judgment is emphasized vs. not emphasized. As depicted in Fig. 1, understanding of complexity is the variable through which thinking perspective moderates the differing decisions based on whether professional judgment was emphasized in the case study versus not emphasized. Table 2 contains the descriptive statistics, simple effects tests used to test Hypothesis 2, and the ANOVA model on which the analysis is based. As predicted, the difference between emphasis on judgment conditions is significant when attribution to complexity is relatively higher (Pone-tail = 0.028) but insignificant when attribution to complexity is relatively lower (Pone-tail = 0.305). This analysis provides support for Hypothesis 2.

4.3. Tests of hypothesis 3 – thinking perspective and audit judgments

Hypothesis 3 predicts that auditors with a systems-thinking perspective will judge the likelihood of material misstatement to be lower when professional judgment is emphasized vs. not emphasized, and that auditors with a reductionist-thinking perspective will exhibit less or no such difference between emphasis conditions. The dependent measure used to evaluate this hypothesis is the difference between the final material misstatement decision and the initial decision.

Table 3 provides the statistics used to test this hypothesis. An overall main effect of the emphasis on judgment is implied based on the facts and circumstances of the case. Consistent with this implied pattern, the main effect of the overall emphasis on judgment is significant (Pone-tail = 0.042). However, the key feature of the prediction is a more pronounced effect for participants in the systems-thinking perspective condition. Fig. 3 depicts the mean change in material misstatement judgment by condition and shows graphical evidence of the predicted pattern. Consistent with predictions, the difference between emphasis on judgment conditions is significant in the systems-thinking condition (Pone-tail = 0.026) but insignificant in the reductionist-thinking condition (Pone-tail = 0.316). Panel B of Table 3 details tests of simple effects tests that support this result.

To supplement the primary tests of H3 above, a series of post hoc contrast regressions are performed. To represent a smaller difference between emphasis conditions for reductionist-thinkers, weights of +1 and −1 are applied to no-emphasis and judgment-emphasis conditions respectively, and weights of +2 and −2 for systems-thinkers. This contrast is significant (Pone-tail = 0.025). The residual between-participants variance is not significant (untabulated, $F_{2,112} = 0.15, P_{two-tails} = 0.857$), indicating that the hypothesisized contrast describes the data well (e.g., Guggenmos, Piercey, & Agoglia, 2018).

4.2. Tests of hypothesis 2 – understanding of complexity and audit judgments

Hypothesis 2 predicts that auditors who attribute their misstatement judgment relatively more to process complexity (versus less) will judge the likelihood of material misstatement to be lower when professional judgment is emphasized vs. not emphasized (in accordance with the facts of the experiment). As depicted in Fig. 1, understanding of complexity is the variable through which thinking perspective moderates the differing decisions based on whether professional judgment was emphasized in the case study versus not emphasized. Table 2 contains the descriptive statistics, simple effects tests used to test Hypothesis 2, and the ANOVA model on which the analysis is based. As predicted, the difference between emphasis on judgment conditions is significant when attribution to complexity is relatively higher ($P_{one-tail} = 0.028$) but insignificant when attribution to complexity is relatively lower ($P_{one-tail} = 0.305$). This analysis provides support for Hypothesis 2.

4.3. Tests of hypothesis 3 – thinking perspective and audit judgments

Hypothesis 3 predicts that auditors with a systems-thinking perspective will judge the likelihood of material misstatement to be lower when professional judgment is emphasized vs. not emphasized, and that auditors with a reductionist-thinking perspective will exhibit less or no such difference between emphasis conditions. The dependent measure used to evaluate this hypothesis is the difference between the final material misstatement decision and the initial decision.

Table 3 provides the statistics used to test this hypothesis. An overall main effect of the emphasis on judgment is implied based on the facts and circumstances of the case. Consistent with this implied pattern, the main effect of the overall emphasis on judgment is significant ($P_{one-tail} = 0.042$). However, the key feature of the prediction is a more pronounced effect for participants in the systems-thinking perspective condition. Fig. 3 depicts the mean change in material misstatement judgment by condition and shows graphical evidence of the predicted pattern. Consistent with predictions, the difference between emphasis on judgment conditions is significant in the systems-thinking condition ($P_{one-tail} = 0.026$) but insignificant in the reductionist-thinking condition ($P_{one-tail} = 0.316$). Panel B of Table 3 details tests of simple effects tests that support this result.

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The effect size of the contrast is calculated as $(\text{sum of squares of the contrast}) / (\text{sum of squares})$, Results indicate that approximately 93% of the systematic variance in the model is explained by the contrast. Additionally, since a specific pattern is not predicted, only the difference in slopes, two alternate contrasts were performed such that, as above, systems-thinkers’ differences between emphasis conditions are larger than reductionist-thinkers’, but (a) no-emphasis conditions are not different (+2, −1, +2, −3) and alternately (b) judgment-emphasis conditions are not different (+1, −2, +3, −2). Both alternate contrasts (untabulated) are significant ($p = 0.029$ and $p = 0.034$ respectively) and residuals are non-significant.

### Table 2
Descriptive statistics and tests of hypothesis 2.

<p>| Panel A: Descriptive Statistics: Mean Change in MM (Standard Errors) |</p>
<table>
<thead>
<tr>
<th>Emphasis on Judgment</th>
<th>Lower Attribution to Complexity</th>
<th>Higher Attribution to Complexity</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-Emphasis</td>
<td>N = 27</td>
<td>N = 29</td>
</tr>
<tr>
<td></td>
<td>1.54 (0.31)</td>
<td>1.81 (0.30)</td>
</tr>
<tr>
<td>Judgment-Emphasis</td>
<td>N = 32</td>
<td>N = 28</td>
</tr>
<tr>
<td></td>
<td>1.33 (0.29)</td>
<td>0.99 (0.31)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: Simple effects tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emphasis type given higher attribution to complexity</td>
</tr>
<tr>
<td>Emphasis type given lower attribution to complexity</td>
</tr>
</tbody>
</table>

<p>| Panel C: Within Subjects Repeated Measures ANOVA |</p>
<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Mean Squares</th>
<th>F-Ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emphasis</td>
<td>1</td>
<td>7.814</td>
<td>3.004</td>
<td>0.043</td>
</tr>
<tr>
<td>Complexity Attribution</td>
<td>1</td>
<td>0.028</td>
<td>0.011</td>
<td>0.917</td>
</tr>
<tr>
<td>Emphasis* Complexity Attribution</td>
<td>1</td>
<td>2.676</td>
<td>1.029</td>
<td>0.157</td>
</tr>
<tr>
<td>Error</td>
<td>112</td>
<td>1.209</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a One-tailed. 
b Participants rated the extent to which they believed warranty reserves were materially misstated, on a 7-point scale anchored on 1 = definitely NOT materially misstated and 7 = definitely materially misstated. This was done after they were provided information about an audit client, audit procedures and testing conclusions (during regular fieldwork), and warranty reserve point estimate and estimation error range, then again after receiving new information (during audit wrap-up procedures) suggesting the audited information was likely incorrect by a quantitatively material amount. Panel A provides descriptive statistics of the change in participant material misstatement judgments between pre- and post-new-information judgments for each of four conditions. Conditions are based on the manipulation of emphasis on professional judgment, randomly assigned at two levels, and a median split of the “judgment” between pre- and post-new-information judgments for each of four conditions. Conditions are based on the manipulation of emphasis on professional judgment, randomly assigned at two levels, and a median split of the “attribute to complexity” measure used to test Hypothesis 1.

The effect size of the contrast is calculated as $(\text{sum of squares of the contrast}) / (\text{sum of squares})$. Results indicate that approximately 93% of the systematic variance in the model is explained by the contrast. Additionally, since a specific pattern is not predicted, only the difference in slopes, two alternate contrasts were performed such that, as above, systems-thinkers’ differences between emphasis conditions are larger than reductionist-thinkers’, but (a) no-emphasis conditions are not different (+2, −1, +2, −3) and alternately (b) judgment-emphasis conditions are not different (+1, −2, +3, −2). Both alternate contrasts (untabulated) are significant ($p = 0.029$ and $p = 0.034$ respectively) and residuals are non-significant.

The effect size of the contrast is calculated as $(\text{sum of squares of the contrast}) / (\text{sum of squares})$. Results indicate that approximately 93% of the systematic variance in the model is explained by the contrast. Additionally, since a specific pattern is not predicted, only the difference in slopes, two alternate contrasts were performed such that, as above, systems-thinkers’ differences between emphasis conditions are larger than reductionist-thinkers’, but (a) no-emphasis conditions are not different (+2, −1, +2, −3) and alternately (b) judgment-emphasis conditions are not different (+1, −2, +3, −2). Both alternate contrasts (untabulated) are significant ($p = 0.029$ and $p = 0.034$ respectively) and residuals are non-significant.
The complete repeated measures ANOVA on which the simple effects tests are based is included in Panel C of Table 3. Results indicate a significant overall within-subjects increase in material misstatement decision ($F_{1,88} = 73.61, p_{one-tail} < 0.001$). Overall, as predicted, auditors in the judgment-emphasis conditions increase the likelihood that investors will consider the change in estimate to be a material misstatement of financial statements less than those in the no-emphasis conditions. Also, that result is driven primarily by auditors induced to take on a systems-thinking perspective, as predicted. Within a real audit environment similar to the conditions within this experiment (e.g., complex accounting estimates), auditors that have a systems-thinking perspective are more likely to have differing decisions when professional judgment is emphasized vs. not emphasized than are auditors with a reductionist perspective, supporting the hypothesis.

### 4.4. Supplemental analyses — mental models

As described earlier, participants were asked to document their mental models of the warranty process. Documenting the mental model strengthens the manipulation, and results of the exercise are used for supplemental analyses. First, in order to assess whether the thinking perspective manipulation was successful, the number of process-based elements (consistent with stocks and flows from systems-thinking) and the number of entity-based elements (e.g., people, companies, etc.) were counted. A greater number of process-based elements in the mental model suggests that the participant had a relatively greater systems-thinking perspective. A greater number of entity-based elements suggests a relatively greater reductionist-thinking perspective. The number of entity-based elements was subtracted from the number of processed-based elements to evaluate the measured thinking perspective (positive numbers imply systems-thinking and negative numbers imply reductionist-thinking). In untabulated analysis, results show a significant main effect of thinking perspective condition on this measure ($F_{1,88} = 112.631, p_{one-tail} < 0.001$). Participants in the systems-thinking condition averaged more process-based elements ($mean = 4.4$) and those in the reductionist-thinking condition averaged more entity-based elements ($mean = 2.48$).
more entity-based elements \( (mean = -0.53) \).\(^{11}\)

The mental model measurement in the experiment is not evaluated as a formal intermediary in hypothesized tests. However, a measure was created using the calculation described immediately above in order to perform post hoc analyses. All positive differences between process-based and entity-based factors are labeled systems-based mental models and all negative differences are labeled reductionist-based mental models. Of 92 participants that responded to the mental model exercise, 59 are labeled systems-based and 33 are labeled reductionist-based mental models. The primary tests for Hypotheses 1 and 3 are replicated, replacing the manipulated “thinking perspective” variable with the measured mental model variable. Consistent with the primary results for Hypothesis 1, across emphasis on judgment conditions, the causal attribution to complexity measure for systems-based mental models \( (mean = 31.66) \) is greater than the measure for reductionist-based mental models \( (mean = 28.58) \). Untabulated ANOVA results for this measure indicate that this difference is significant \( (F_{1,88} = 3.77; p_{one-tail} = 0.028) \). Those with a systems-based mental model attribute more causality to the complexity of the warranty reserve process, relative to other factors. Similarly, when the manipulated perspective is replaced with the measure based on the mental model exercise in the analysis of Hypothesis 3, simple effects tests confirm that participants’ mental models do, indeed, appear to be modified as a result of the training manipulation. Consistent with the results of testing for Hypothesis 3, participants with systems-based mental models judge the likelihood of material misstatement to be lower when professional judgment is emphasized vs. not emphasized \( (means = 0.97 \text{ vs. } 1.88, \text{ respectively}; F_{1,88} = 4.60; p_{one-tail} = 0.018) \). Participants with reductionist-based mental models exhibit no such difference between emphasis conditions \( (means = 1.49 \text{ vs. } 1.26, \text{ respectively}; F_{1,88} = 0.18; p_{one-tail} = 0.337) \).

5. Conclusions and discussion

Previous accounting studies and results of regulatory investigations suggest that audit professionals consistently struggle with applying professional judgment in the audit of complex accounting estimates, tending to make mechanistic decisions instead. The current study suggests that auditors are subject to a cognitive limitation such that they rely heavily on cues, lists of rules, and perceived rules, rather than fully integrating available facts and circumstances, when making important audit decisions. However, critical thinking skills may help auditors overcome these limitations, increasing their ability to make more informed decisions based on professional judgment that regulators and leadership so obviously desire.

The current study, however, evaluates the effects of a training technique shown in previous studies in organizational research to have longer lasting effects on cognition. The interaction between emphasis on professional judgment and thinking perspective shows that auditors that are taught to be systems-thinkers make decisions more in line with the use of critical thinking skills and enhanced use of professional judgment. Communicating the importance of professional judgment is unlikely sufficient, by itself, to reduce the mechanistic mentality that auditors are sometimes accused of having, particularly in highly complex accounting contexts. Not only do participants in the study make judgments more consistent with the use of professional judgment after being introduced to systems-thinking concepts, but they are more likely to recognize that dynamic process complexity is a causal factor in accounting outcomes. This study, therefore, extends previous research in accounting that extolls the virtues of Type 2 thinking. Unlike interventions that induce auditors to consider more evidence, systems-thinking training also induces them to consider that information in more complex ways. Thus, this research contributes to systems-thinking literature by identifying at least one competency through which systems-thinking affects judgments in an audit context, whereas previous literature in this area evaluated “cognitive architecture” (Brewster, 2011) and measurement tools (Humphreys et al., 2016). Future research could extend this even further by evaluating the interaction between systems-thinking and other measured or induced Type 2 thinking processes. For example, future research may be able to identify inherent traits or simple cues that make accountants and auditors more or less disposed to integrating systems-thinking into their decision contexts.

The study also adds to systems-thinking and audit decision-aid research, as well as to audit practice, by evaluating the effect of relatively minimal cues to systems-thinking. Participants in the study spent between 14 and 50 min \( (mean = 28 \text{ min}) \) on the entire task, including reading the case study, being cued on thinking perspective, and answering all questions. Even with this minimal intervention, participants showed a statistically significant difference in both both measured misstatement decisions and in their relative judgments about complexity between the two thinking perspective conditions. This suggests that even simple cues or decision aids may be useful in reducing auditors’ mechanistic mentality, in certain contexts, at least in the short-term. System dynamics research suggests that, when taught these skills over a longer period of time, the systems-thinking perspective becomes more ingrained into an individual’s decision processing. Therefore, while the results of this experiment, using minimal cues in a case study setting, suggest the systems-thinking perspective can be induced and can increase the use of professional judgment in the short-term, theory suggests that longer-term, repetitive training, as in formal firm settings, is likely to have the same effect on a more permanent basis. This suggests audit firms that incorporate elements of systems-thinking in their formal training can increase the use of professional judgment in the audit of complex estimates.

This study is subject to a number of limitations which may create additional opportunities that can be explored in future research. For example, in the experiment, the systems-thinking perspective was induced using several elements that previous research suggests work together to create an overall systems-thinking perspective. This experiment is unable to determine whether any single element had a greater effect on thinking-perspective than others. Future research might break the elements into smaller units in order to develop more specific interventions. Additionally, the systems-thinking intervention utilizes pictures, allegory, and examples, possibly creating a more engaging thinking process in unanticipated ways. This is consistent with the teaching of systems-thinking, however it has the potential to change the way participants think about factors other than process complexity. This study is designed to evaluate only the effect on integration of complexity into the thought process, but not to evaluate factors like creativity, engagement, etc. Future studies might seek to evaluate these factors and ways to implement them in audit practice if they are shown to increase the use of professional judgment.

Another limitation is that the study evaluates the reduction of mechanistic decisions through systems-thinking in a specific audit context. An existing audit standard is modified, and auditor-specific information drives the directional predictions of more extreme judgments in line with the manipulated audit standard; this was done in order to cleanly test the theory. There are likely to

\(^{11}\) Ninety-two of 116 participants completed the mental model exercise. Only those participants’ responses are included in supplemental analyses. Results are unchanged if the 24 removed participants are included as zeros.
be context-specific situations in which systems-thinkers’ judgments are less extreme, instead of more extreme, than those of reductionist-thinkers. There are also likely to be context-specific situations in which systems-thinking may not improve auditors’ decisions at all. For example, less complex financial statement accounts, or those that require less estimation or speculation, may be better evaluated in a linear, or mechanistic fashion. An example of this might be physical inventory counts (though, arguably, deeper thought into the business might still lead to better valuations of, for example, obsolete inventory). Future research can examine the limits of systems-thinking usefulness in an audit context.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.aos.2018.06.002.

Appendix A. Experimental Design

<table>
<thead>
<tr>
<th>Case Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants receive case information about eduTECH, a company with a complex (detail and dynamic) warranty estimation process. Participants assume the role of audit senior for the client. The emphasis on judgment manipulation is introduced; all participants are given quantitative materiality guidance, one-half are also introduced to a hypothetical standard allowing bi-directional qualitative materiality. Throughout the case, participants receive cues to help them understand the components of a client system, and how those components interact. The thinking perspective manipulation is introduced; all participants receive pointers (in call-out boxes): one-half are based on current audit guidance; one-half are based in system dynamics processes (see Appendix B). All participants are given the same quantitative materiality, warranty reserve point estimate, and estimation error range (4x quantitative materiality in each direction).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial Judgment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants are asked the extent to which they believe the point estimate is materially correct (not correct = material misstatement).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants receive information that the originally audited estimate is likely less than the amount that will be ultimately realized. The difference is 3-times quantitative materiality (greater than quantitative materiality but within the original estimation error range). The difference was caused by an event that occurred before year-end but primarily affects future warranty expenses.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Judgment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants are asked the extent to which they believe the recorded point estimate (still based on the original amount) is materially misstated.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Self-Reporting of Process Measures for Second Judgment</th>
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<tbody>
<tr>
<td>Participants separately self-report the extent to which their MM and MW decisions were based on:</td>
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<tr>
<td>• Management’s ability and intelligence</td>
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<tr>
<td>• Management’s effort</td>
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<tr>
<td>• Warranty reserve complexity</td>
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<tr>
<td>• Luck, or other factors outside management’s influence</td>
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<tr>
<td>Participants separately self-report the extent to which their MM and MW decisions were based on:</td>
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<tr>
<td>• The effectiveness of eduTECH’s internal controls</td>
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<tr>
<td>• Inherent uncertainty in the warranty reserve process</td>
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<td>• The effectiveness of substantive testing</td>
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<th>Post Experimental Questionnaire and Demographics</th>
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Appendix B. Sample Systems-Thinking Manipulation

Panel A: Dynamic Thinking – change over time
Imagine you and a friend each decide to blow up a balloon. You blow up your balloon manually; you take a breath and blow it into the balloon. But each time you take another breath, a little air leaks out. See the graphic below, on the left. Your friend is lazy, and uses an automatic pump, so the inflow is a bit smoother. See the graphic on the right. You each take off the end of your balloon with a simple knot which will, of course, allow the air to slowly leak out. You leave your balloon at home and, as expected, over many days, your balloon deflates. Your friend, on the other hand, decided to take the balloon to a party, where somebody stuck it with a pin, causing the air to flow out of the balloon very quickly.

Panel A presents the portion of the systems-thinking manipulation that introduced the concept that complex systems change over time, a component of the dynamic thinking skill.

Panel B: Closed-Loop Thinking & Operational Thinking – feedback loops

In short, the level of warranty reserves depends, in part, on the level of R&D. The level of R&D depends upon the level of warranty reserve. This is called a feedback loop. Feedback loops are an important element of mental model development, partially because they help identify unexpected relationships.

Panel B presents the portion of the systems-thinking manipulation that introduced feedback loops, a component of the closed-loop thinking and operational thinking skills.

Panel C: Generic Thinking – impact of unexpected events

Unexpected events can have big implications for stocks and flows. For example, in the late 1970s, Atari video games were the rage. Sales (the flow) doubled every year from 1976 through 1982. The market became saturated very abruptly, though, in 1982-83, and revenues (the stock) dropped from $2 billion in 1982 to $100 million by 1984. Atari never saw it coming.

Panel C presents the portion of the systems-thinking manipulation that introduced the potential impact of unexpected events, a component of the generic thinking skill.

References


