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THE EFFECTS OF CONTINUED USE OF INTELLIGENT DECISION AIDS UPON AUDITOR KNOWLEDGE: A RESEARCH PROPOSAL

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Abstract:

The Theory of Technology Dominance (Arnold & Sutton, 1998) proposes that the continued use of intelligent decision aids in the audit task has the effect of deskilling auditors over time. This research proposal presents a study that extends and validates this theoretical framework through an integrated conceptual model. The research question examined is 'does the continued use of intelligent decision aids reduce the auditor's skills in forming their professional judgment?' No prior research has explored deskilling of auditor judgment. The research is important for practice to ensure a strong audit profession, and contributes to theory through extension of the theoretical foundations of the deskilling effect.

The theoretical extension is undertaken through an integration of cognitive load theory (Sweller, 1988), Anderson's (1993) cognitive architecture of Adaptive Control of Thought-Rational, and the Theory of Technology Dominance (Arnold & Sutton, 1998). The resultant conceptual model is planned for validation through semi-structured interviews with senior auditors.

The qualitative data is subjected to thorough textual analysis adopting both the cross-case analytical matrices of Lillis (1999) and the Leximancer textual analysis tool (Smith, 2000). As of April 2011, fifty-nine interviews have been undertaken and transcribed, with the research study planned for finalisation by September 2012.

Keywords: theory of technology dominance, intelligent decision aids, deskilling, judgment

1 Introduction

The increasing use of intelligent decision aids (IDAs) in the audit profession (Bierstaker, Burnaby, & Thibodeau, 2001) and exploratory research indicating that long-term reliance reduces an auditor's 'declarative' knowledge (Dowling, Leech, & Moroney, 2008) has led to 'alarm bells' for the development of professional auditor knowledge (Leech, 2008). That is, the modern auditor's professional skills may suffer in comparison to their counterparts of yesteryear due to deskilling from increased reliance upon the computer. Developing an understanding of the predominance of, and the reasons for, deskilling presents significant opportunities for contribution to both research and practice. The research provides practical guidance to practitioners using and implementing IDAs in audit firms, whilst the development of an integrated conceptual model for the TTD in the context of auditor deskilling also provides a significant theoretical contribution.

This research proposal outlines a research study extending and investigating the Theory of Technology Dominance (TTD) proposed by Arnold and Sutton (1998). The proposal identifies theoretical foundations, a proposed research method, and the current stage of the research and plans for completion. The TTD provides some insight into a process of deskilling that occurs for auditors relying upon IDAs in practice. IDAs are a form of expert system or decision support system intended to assist the user in making a better decision than when unaided (Arnold, Collier, Leech, & Sutton, 2004). Deskilling is a decline of the auditors' skills and abilities (Dowling et al., 2008). The research study focuses on the auditor's development of high-level judgmental skills by extending the theoretical foundation of TTD through consideration of the complementary and supportive theories of cognitive load theory (Sweller, 1988) and Anderson's (1993) Adaptive Control of Thought-Rational (ACT-R).

The research question addressed by this research study is: "does the continued use of IDAs reduce the auditor's skills in forming their professional judgment?". The motivation for examining this research question has both practical and theoretical bases. Practically, this research is motivated by the observation that IDA use has increased significantly amongst audit professionals (Bierstaker et al., 2001), and thus the potential for deskilling has increased (Arnold & Sutton, 1998). This research is also motivated by calls for further research into the process of deskilling, and strategies to mitigate its impact (Dowling & Leech, 2007; Leech, 2008; Sutton, 2006).

The remainder of this paper is organised as follows. Section 2 presents a current and relevant literature survey, and develops an integrated conceptual model. Section 3 discusses the proposed research method to validate this conceptual model. Section 4 identifies the current status of the research and plans for completion, whilst section 5 concludes this paper.

2 Theoretical foundations

Cognitive load theory, the cognitive architecture ACT-R, and the TTD provide the theoretical foundations of an integrated conceptual model for this research study. These theoretical foundations and the integrated conceptual model are discussed in turn.

2.1 Cognitive load theory

Sweller (1988) set out the foundation of cognitive load theory. Cognitive load theory has been used to consider the audit process previously (for example, Libby & Luft, 1993; Libby & Tan, 1994; Rose, 2005; Rose & Wolfe, 2000). Cognitive load is the consumption of working memory during problem solution and schema acquisition (Sweller, 1988). Cognitive load theory considers that experts and novices in a problem domain adopt differing problem solving strategies. Novices identify end goals and work backwards from those goals through identified sub-goals using means-end analysis, whereas experts eliminate the backward-looking phase

(Sweller, 1988). Novices and experts differ in their ability to discern patterns. Experts acquire schemas as a result of experience with past problems, whereas novices are forced to use generalised problem-solving strategies as they do not yet possess these schemas (Sweller, 1988).

Todd and Benbasat (1992) found that IDAs tend to reduce knowledge acquisition relative to manual environments as the IDA's users can substantially reduce the cognitive effort devoted to a task. Instead, the users let the IDA 'do the work'. The user reduces cognitive load and lessens the effort expended, but in so doing the richness of the experience is reduced. This reduction of experience impedes the user's acquisition of expert schemes and reduces auditor expertise.

Libby and Luft (1993) considered an auditor's judgment skills, or expertise, to be a function of ability, motivation and experience. Here, both ability and motivation determine the amount of knowledge acquired given the opportunities for knowledge acquisition arising from the auditor's experiences. Experience provides the opportunity to learn, and the individual's ability aids in learning (Brewster, 2009). The user's cognitive load interferes with the user's knowledge acquisition from decision aids (Rose, 2002; Rose & Wolfe, 2000), and Rose (2005) showed that subjects with more interest in and perceived aptitude for the problem domain of taxation acquire more knowledge in a manual environment than a participant with less interest and aptitude. The user's willingness to devote effort to the task, or motivation (Libby & Luft, 1993), and the auditor's ability interact with the cognitive effort required by the IDA to affect the auditor's learning.

Mascha and Smedley (2007) investigated the effect of varying feedback from an IDA in the context of the audit process. Their findings showed that individuals with a high level of skill in understanding internal controls deskilled when they were assigned to non-complex cases.

Cognitive load theory suggests that where auditors reduce the cognitive effort involved in formulating a judgment and rely upon an IDA over the long term, the auditor does not acquire the knowledge and expertise to be applied in later audits. Such auditors never acquire the expert schemas noted by Sweller (1988). These auditors are thus unable to eliminate the backward-working phase and are unable to develop expertise in audit (Libby & Tan, 1994), although this effect is reduced for auditors with an interest and aptitude in the task of audit. Expansion of the TTD through integration of the cognitive load theory with the conceptual model provides a potentially richer description of the deskilling process through consideration of experience, ability, and motivation constructs.

2.2 Adaptive Control of Thought–Rational

The cognitive architecture of ACT-R was initially developed by Anderson (1993), and outlines the mechanisms by which knowledge acquisition takes place. Anderson (1993), in line with the approach adopted by Squire (1987), separated knowledge into two kinds: declarative knowledge and procedural knowledge. Taken together, declarative knowledge and procedural knowledge strongly align with the TTD concept of auditor skill (McCall, Arnold, & Sutton, 2008).

Declarative knowledge refers to the definitions, examples and rules that are stored into long-term memory (Anderson, 1993). This declarative knowledge is necessary to the task of interpretive problem-solving by the individual. Conversely, procedural knowledge is the ability to apply and extend declarative knowledge and is acquired as a result of experience (Anderson, 1993). In layman's terms, declarative knowledge is often referred to as 'know-what' (McCall et al., 2008) or 'know-about' (Nolan Norton Institute, 1998), whilst procedural knowledge is 'know-how' (Alavi & Liedner, 2001).

ACT-R presents a model for the acquisition of declarative and procedural knowledge. The model outlines two stages of individual knowledge acquisition. The first stage is the declarative stage, in which the individual acquires declarative knowledge through interpretive problem solving and the memorisation of definitions, rules, and examples. The second stage of an individual's knowledge acquisition is the procedural stage, in which the individual acquires

their procedural knowledge through the compilation of rules regarding the application of the declarative knowledge, and the ongoing tuning of these production rules.

Procedural knowledge is essential to the development of ‘true expertise’ (Anderson, 1993). ACT-R has significant implications for the measurement of an individual’s knowledge. As a skill becomes more automatic, an expert will appear to ‘skip steps’ when explaining tasks at which they are expert. ACT-R considers that experienced individuals create production rules once a skill becomes more automatic (Lehmann & Norman, 2006).

There are fundamental differences between declarative and procedural knowledge. Anderson (1982) provided an example of the mathematics student provided with the rules of algebra and its application. The student is then able to solve similar mathematical problems through interpretive problem solving. This is declarative knowledge.

After familiarisation with the rules of algebra and its application, the student compiles and tunes their own production rules regarding the application of the rules of algebra in unfamiliar situations. The student that is then able to formulate a solution from a non-mathematically expressed problem statement, for dissimilar mathematical problems, through application of the mathematical techniques of algebra, has acquired procedural knowledge. That is, the student possesses ‘know-how’ (Alavi & Liedner, 2001).

By extension from Herz and Schultz (1999), the concept of declarative knowledge aligns with the auditor’s technical skills, whilst procedural knowledge aligns with the auditor’s ability to formulate judgments. The novice auditor possessing only declarative knowledge must think through each step of the audit. Conversely, the expert auditor does not separately work through each step of the audit. The expert auditor has procedural knowledge.

ACT-R provides a model for the examination of the process of knowledge acquisition, as well as a framework for the analysis of the knowledge acquired by users in terms of declarative and procedural knowledge. Successful integration of the ACT-R theory with the conceptual model provides a potentially richer description of the deskilling process, particularly in terms of the actual types of knowledge (declarative and procedural) acquired by the auditor.

2.3 The theory of technology dominance

TTD was specifically developed in the context of the audit profession, and relates to the use of IDAs by auditors (Arnold & Sutton, 1998). IDAs are a form of expert system or decision support system, and integrate the expertise of one or more experts in a given decision domain to assist the user in making a better decision than when unaided (Arnold et al., 2004).

The TTD (Arnold & Sutton, 1998) relied upon the premise that users are insufficiently aware of the limitations of the technology used. TTD identified the factors that determine whether a user in the audit domain relies upon an IDA, the susceptibility of a user to dominance by technology in decision-making, and the implications of the deskilling of users for auditors’ professional expertise and the epistemological development of the audit profession (Sutton, 2006).

TTD considers that this dominance of the user by the technology increases the more supportive the technology being used. In particular, supportive IDAs with a high level of structural restrictiveness force the user to follow the technology or method being used, and as a result the user’s ability to recall information without access to the tool is reduced (Seow, 2008).

TTD consists of eight propositions. The first four propositions relate to the auditor’s reliance upon the tool, and identify a relationship between four identified factors (task experience, task complexity, decision aid familiarity, and cognitive fit) and a user’s reliance upon an IDA (Hampton, 2005). These propositions have been generally supported (Dowling & Leech, 2007; Leech, 2008; Sutton, 2006), although the evidence for the factor of decision aid familiarity in reliance upon the tool is not strong (Sutton, 2006). TTD’s propositions five and six relate to the susceptibility of a user to dominance by technology. Propositions five and six are well

supported by the research literature (Arnold, Clark, Collier, Leech, & Sutton, 2006; Arnold et al., 2004; Masselli, Ricketts, Arnold, & Sutton, 2002; Sutton, 2006).

Of considerable interest to the current research program, propositions seven and eight of TTD consider the long-term effects of a user's dominance by intelligent technologies. Proposition seven proposes a positive relationship between continued use of an IDA and a deskilling of the knowledge worker. Deskilling is a decline of auditors' skills and abilities (Dowling et al., 2008). Proposition seven is the focus of the proposed research study. Proposition eight proposes a negative relationship between the long-term use of an IDA in a particular problem domain and the growth in the knowledge and advancement of that problem domain.

Proposition seven has had limited testing, with the findings generally in support of the proposition (Dowling et al., 2008; McCall et al., 2008). These findings however relate to auditor's technical skills rather than auditor judgment skills. Mascha (2001) showed that an IDA will deskill the end user even with only relatively short-term use. Mascha and Smedley (2007) also found support for the hypothesis that task-experienced participants who are presented with a less complex decision task will deskill.

Dowling et al (2008) found a negative relationship between the long-term use of a restrictive IDA and the user's technical skill levels. These results also suggested that the extent of decision support provided by audit support systems influences the declarative knowledge auditors store in memory, which in turn affects the auditor's task performance when the IDA is not available.

McCall, Arnold and Sutton (2008) examined deskilling in relation to end users' explicit (declarative) knowledge. Explicit knowledge aligns with auditor's technical skills and declarative knowledge. McCall, Arnold and Sutton (2008) found that users supported by a knowledge management system (a form of IDA) rather than by traditional reference materials had a significant difference in their recall of rules. However, no difference was found between these user groups in their recall of examples and definitions.

Proposition seven of TTD is generally supported in the research to date. However, the findings have been experimental rather than in the field, and focused upon the auditor's level of declarative knowledge, rather than procedural knowledge. Procedural knowledge pertains to the auditor's judgment skills. Further research is needed to examine the deskilling effect in the field in relation to the auditor's procedural knowledge. TTD provides a foundation and theoretical framework for the consideration of deskilling for the integrated conceptual model.

2.4 Conceptual Model

The cognitive load theory, ACT-R and TTD theoretical areas each outline mechanisms by which continued use of IDAs leads to user deskilling. The theoretical areas are complementary. Each theoretical area provides a significant and different lens for consideration of the relationship between IDA use and the auditor's knowledge levels. An integration of these theoretical areas into a conceptual model is an important theoretical contribution of the research study. The theoretical foundations outlined above allow the development of an integrated conceptual model. Figure 1 below presents the conceptual model.

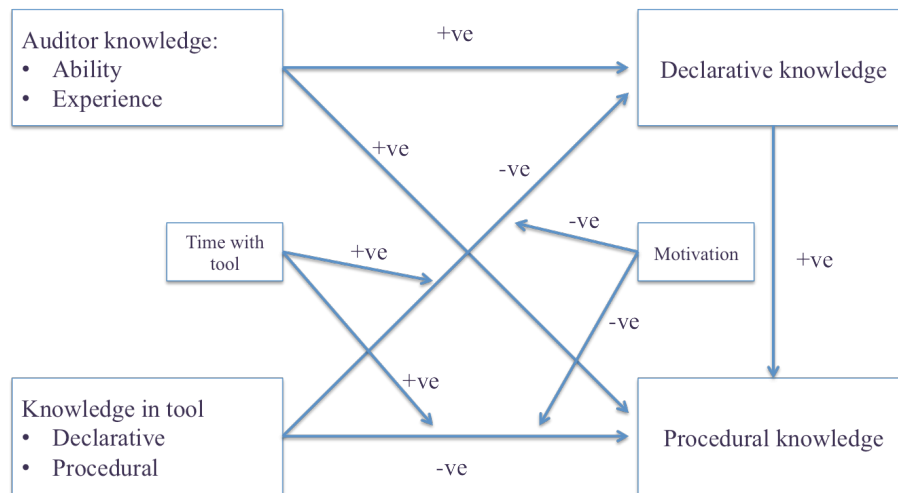


Figure 1. *A conceptual model for auditor deskilling derived from the Theory of Technology Dominance, Cognitive Load Theory, and Adaptive Control of Thought-Rational.*

In this conceptual model, there are two dependent constructs. ‘Declarative knowledge’ refers to the definitions, examples and rules stored in long-term memory, whilst ‘Procedural knowledge’ is the ability to apply and extend declarative knowledge (Anderson, 1993). Declarative knowledge and procedural knowledge align with the ‘skills’ of the TTD (McCall et al., 2008).

The higher the level of reliance placed upon the IDA, the higher the deskilling effect is likely to be (Arnold & Sutton, 1998; Dowling et al., 2008; Seow, 2008). Thus ‘declarative knowledge in tool’ and ‘procedural knowledge in tool’ are presented as independent constructs in the conceptual model.

The conceptual model also includes three constructs based upon the three determinants of auditor judgment skills and expertise identified by Libby and Luft (1993). Two of these determinants of auditor expertise are presented as the independent constructs of ‘experience’ (time as an auditor) and ‘ability’ (“capacity to complete information encoding, retrieval, and analysis tasks” (Libby & Luft, 1993, p428)) in the conceptual model.

The third determinant presented in Libby and Luft (1993) is ‘motivation’, and is presented in the conceptual model as a moderating construct. Motivation is the decision maker’s willingness to exert effort (Libby & Luft, 1993).

Cognitive load theory, ACT-R and TTD together suggest that a user’s continued use of an IDA can dull the professional’s decision-making skills. The final moderating construct presented in the conceptual model is ‘time with tool’. The research program adopts this conceptual model as the basis for further discussion and refinement.

3 Proposed research methodology

The research approach adopted for this study is qualitative. A series of semi-structured interviews are to be undertaken with approximately sixty senior auditors in Australia, Canada and the United Kingdom. These interviews seek to verify the conceptual model set out in Figure 1 with interview subjects through discussion of the deskilling effect.

There are several reasons for the adoption of a qualitative research approach in this study. Firstly, qualitative data enables a deeper understanding of the constructs set out in the research model. Qualitative research methods can, if rigorously applied, provide enhanced opportunities to explore the foundation of the research model with practitioners in the field.

Secondly, the conceptual model explicitly considers the relationship between the user’s continued use of an IDA and the user’s level of procedural knowledge, or judgment. There are

two principal alternatives to the adoption of qualitative research methods, being the conduct of an experiment or a survey. An experimental design has difficulty in simulating the long-term use of an IDA. Similarly a longitudinal survey design has difficulty in ensuring research participants have long-term continued use of the IDA, and in measuring declarative and procedural knowledge. Rigorous qualitative research methods are preferred in this instance.

A particular focus of this research study is the adoption and documentation of the rigorous research approach utilised. Objectivity and replicability are essential elements of rigorous research. The research approach adopted in this research is designed to follow and support the approach advocated by Lillis (1999) for the systematic and auditable analysis of qualitative data that enhances the reader's trust in the research (Mistry, 2005). This analysis is supported and complemented by the use of the Leximancer textual analysis tool (Smith, 2000), which offers an efficient and fast alternative approach to the inefficient and slow identification of expressed concepts in large transcripts (Penn-Edwards, 2010).

The approach outlined by Lillis (1999) requires a semi-structured interview protocol guiding each interview¹. Each interview is to be transcribed for later analysis utilizing a cross-case analytical matrix developed according to the steps set out in Lillis (1999). The cross-case analytical matrix requires the thematic coding of interview transcripts by individual sentence blocks, further coding into conceptual headings related to the conceptual model, and final coding into supported statements. A full audit trail from the interpreted results to the underlying interview transcript is thus preserved (Lillis, 1999). The results are portrayed in matrix form to present the commonly supported statements ranked by the number of interviewees supporting the statement, and supplemented and given context by direct quotations from interviewees.

The research method also uses the textual analysis tool of Leximancer (Leximancer Pty Ltd, 2009; Smith, 2000; Smith & Humphreys, 2006) to accompany the manually-developed cross-case analytical matrices. The Leximancer tool assists the researcher to elicit the deeper implications and acknowledged richness of qualitative research methods whilst ensuring the reliability and validity of the analysis. The textual data from interviews analysed in Leximancer considers only statements made by interviewees, expanded so that pronouns are replaced by the pronoun's antecedent, and affirmative statements given meaning (for example, an interviewee response of 'yes' would be appended by a paraphrasing of the interviewer's question). This expansion ensures that Leximancer is able to identify concepts and elicit meaning from the interview transcripts.

Leximancer complements the Lillis (1999) approach in two ways. Firstly, Leximancer identifies concepts contained within each sentence block using its own textual analysis algorithms. Leximancer allows the development of a concept map for analysis of the relationships between concepts noted by the sixty interviewees and consideration in the context of the conceptual model. Each statement is coded to indicate its affirmation or negation of the expected relationship set out in the conceptual model; further, social network analysis (Wasserman & Faust, 1994) identifies centrality of the concept to the discussion of the conceptual model. These results are presented as complementary to the cross-case analytical matrix of Lillis (1999).

Secondly, Leximancer validates the researcher coding of the manually-developed cross-case analytical matrices by identifying the unique textual attributes of each code identified from the transcript. This analysis identifies the centrality of the concepts related to the manual coding of the interview transcripts through social network analysis, and provides an objective validation of the coding undertaken without researcher interpretation.

4 Current stage of the research and plans for completion

This section identifies the current stage of the research and the timeline for its completion.

¹ A copy of the semi-structured interview protocol is available from the author upon request.

4.1 Current stage of the research

The research set out in this paper is, as of April 2011, in the primary textual analysis stage. All interviews for the initial data collection have been undertaken. Fifty-nine interviewees in total actually participated in the study across Australia, New Zealand, Canada and the United Kingdom. Each interview has been transcribed.

The thesis is in draft for the introductory, literature review, and research method chapters. Interviews are in the process of coding for the cross-case analytical matrix, and expansion of the transcripts for Leximancer analysis is ongoing. Analysis and interpretation of the results, and implications for the conceptual model, are the next major milestones to be addressed.

4.2 Plans for completion

Table 1 below sets out the remaining major milestones for this research. This timeline aims to complete the research by September 2012.

Date	Milestone
30 June 2011	Analysis of results according to Lillis (1999) method.
30 September 2011	Analysis of results using the Leximancer tool (Smith, 2000).
31 December 2011	Analysis and interpretation of complementary results.
30 March 2012	Thesis Review Milestone.
30 September 2012	Final submission of Thesis.

Table 1. The proposed timeline for the completion of this research study.

A full contingency plan has been identified for potential issues arising during the remaining time for the research. A major contingency task is the likely requirement for extensive post-hoc analysis outside of the conceptual model. Additionally, further focused interviews with a smaller group of experienced senior auditors may be required should the verification of the conceptual model suggest further conceptual validation is necessary. Analysis of this qualitative data would be undertaken in the same manner as the analysis of the primary qualitative data.

5 Conclusion

The research study proposed is motivated by the research gaps identified in prior literature (Dowling & Leech, 2007; Leech, 2008) and the opportunity for strong practical and theoretical contributions. This study will allow practitioners to increase understanding of the role of audit support tools in supporting auditor judgment skills. The integrated theoretical model proposed also advances the robustness and scope of the existing theoretical framework.

The proposed research design minimises the threats to the validity of the research results and its wider conclusions whilst ensuring a significant practical and theoretical contribution. The research proposal outlines a rigorous qualitative research design on the basis of direct access to a broad cross-section of the profession and auditable, comprehensive textual analysis.

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