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# Cognitive Task Analysis: Eliciting Expert Cognition in Context

Olivia Brown<sup>1</sup> , Nicola Power<sup>2</sup>,  
and Julie Gore<sup>3</sup> 

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## Abstract

Cognitive Task Analysis (CTA) is a powerful methodological approach that can enhance the rigorous elicitation and documentation of complex cognitive processes within interview-based qualitative research. We provide insights into this set of semi-structured interviewing techniques that we contend have much to offer management researchers who wish to understand the complexities of expert cognition within specific work-related tasks. Distinct from traditional semi-structured interview methods, CTA is designed to identify the knowledge requirements underpinning expertise in complex work domains. First, we present CTA as a robust approach to eliciting complex cognition and note why, when, and where management scholars might best use its techniques. Second, we provide two examples of how CTA methods have been used to research management; specifically, using the Critical Decision Method to explore management in high-stakes environments, and Applied Cognitive Task Analysis to explore global leadership. In ending, we propose greater use of this pragmatic approach in management research and highlight potential avenues for future research that will advance understanding of complex cognition at work.

## Keywords

qualitative approaches, interviewing, field research, context

## Introduction

While once considered to be the preserve of cognitive psychology, the study of judgment, expertise, and decision-making is now an established and burgeoning field within management and organization studies (Akinci & Sadler-Smith, 2012; Baldacchino et al., 2023; Dane, 2010; Dane et al., 2012; Ormerod & Ball, 2007). Managerial and organizational cognition (MOC) researchers have contributed greatly to a diverse range of scholarly inquiry, such as explicating how heuristics and biases

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<sup>1</sup>School of Management, University of Bath, Bath, UK

<sup>2</sup>Department of Psychology, University of Liverpool, Liverpool, UK

<sup>3</sup>School of Business, Economics and Informatics, Birkbeck University of London, London, UK

## Corresponding Author:

Olivia Brown, School of Management, University of Bath, Claverton Down, Bath BA2 7AY, UK.

Email: [oab42@bath.ac.uk](mailto:oab42@bath.ac.uk)

influence decision-making and demonstrating the interplay between cognition, intuition, and emotion, at both the individual and group levels within organizations (Ashkansey et al., 2017; Healey et al., 2017; Hodgkinson et al., 2018; Hodgkinson & Healey, 2014; Kaplan, 2011; Sinclair, 2011).

Alongside theoretical developments, MOC scholars have also driven innovations in methods and practices that seek to generate a more nuanced and precise understanding of the “intuitive mind” (Gore & Sadler-Smith, 2011; Hodgkinson et al., 2008; Hodgkinson et al., 2018; Sadler-Smith, 2010). While the development and use of qualitative methods has been central to MOC research (Akinci & Sadler-Smith, 2020; Kaplan, 2011), positivist, quantitative approaches have arguably become increasingly dominant (see Rabetino et al., 2021)—for instance, with the use of laboratory studies (Hodgkinson & Healey, 2008; Hsu et al., 2017; Laureiro-Martínez & Brusoni, 2018) and self-report surveys to identify cognitive styles and thinking strategies (Hodgkinson & Sadler-Smith, 2011; Li & Sullivan, 2022; Scherbaum & Meade, 2013). This can be attributed, in part, to recent advances in technology and increasingly sophisticated measures of cognitive processes and decision-making (e.g., fMRI; Massaro, 2017).

Here, we contend that organizational-based levels of cognitive inquiry continue to encounter difficulties, not least because existing knowledge-elicitation techniques and methods may fail to recognize the essential impact of context on organizational behavior (Eden & Spender, 1998; Jenkins, 1998; Johns, 2006; Massaro, 2017; Wright, 2008). Indeed, despite the many theoretical and methodological advancements made in the study of managerial cognition, a direct focus on the role of context and its influence on cognition has been limited (Johns, 2006; Phillips et al., 2004). Context can include the overarching norms and cultures within which cognition is taking place, along with the specific task demands (e.g., time pressure) that influence how an individual or team might approach a given task. Given the unpredictability witnessed in the twenty-first century to date (e.g., COVID-19, climate change, technological advancement), understanding how contextual factors influence managerial cognition is of paramount importance (Acciarini et al., 2021).

Beyond the precise measurement afforded by quantitative studies, it is not possible to understand human behavior without contextualizing the environment in which it occurs and the availability of data therein (Mills, 2018). We therefore contend that a renewed emphasis on qualitative methods is required to capture the underexplored yet inherently complex relationship between contextual factors and cognition. Qualitative approaches to studying cognition are, of course, not new (Bogner et al., 2018; Hodgkinson & Sadler-Smith, 2011; Sosniak, 2006) and MOC scholars have advanced developments in cognitive mapping, the critical incident technique (CIT) and protocol analysis (e.g., Akinci & Sadler-Smith, 2012; Chell, 2004; Gore & Sadler-Smith, 2011; Hodgkinson et al., 2008; Sadler-Smith, 2023; Sinclair, 2011). However, none of these approaches have been designed specifically with context in mind, and they do not provide researchers with the tools to probe and elicit the features of the environment that might influence cognition in practice.

In this paper, we provide robust evidence to show that Cognitive Task Analysis (CTA) is a promising methodological approach for researchers studying managerial cognition that provides an alternative to positivist approaches while lending itself to the exploration of cognition in context. CTA is a collection of interview-based, qualitative methods that are used to identify the cognitive processes and skills required to perform complex tasks carried out in demanding and contextually dependent work domains (Militello & Hutton, 1998; e.g., emergency management, medicine). Developed over three decades of research, CTA methods are widely used within human factors, ergonomics, and cognitive psychology communities, yet are underutilized by management scholars, despite having the potential to offer much insight (see Appendix; Gore & Riley, 2004; McAndrew & Gore, 2010; Osland et al., 2012).

CTA methods were originally developed in response to concerns that existing techniques did not adequately uncover the cognitive processes involved in decision-making by experts operating in

challenging environments, where an advanced understanding of the surrounding context and its influences is of paramount importance to understanding cognition (Gordon & Gill, 1997). Imagine a human resources director tasked with the allocation of new resources in response to a rapid shift to flexible home-working. While we can observe the moment in which a decision is made and the steps taken thereafter to execute that decision, what is less easy to observe is precisely *how* and *why* that decision was made and what *contextual* factors (i.e., time pressure, employee concerns) influenced the decision. For instance—what cues were utilized in the decision-making process, what contextual factors drove their behavior, and which aspects of their expertise and prior experience did the individual draw on in making that decision? It is these questions that CTA methods were designed to answer—to go beyond a description of what steps were taken to perform a task and seek to identify the underlying cognitive processes that give *contextualized meaning* to observable behavior (Klein & Militello, 2001; Schraagen et al., 2000).

Drawing on insights by psychologists who have advocated a greater focus on context in the behavioral sciences, we too promote context as a central feature for the future of managerial cognition (Hayes et al., 2016). We echo the analogy of Hayes et al. (2016) that management cognition is like an incomplete crossword puzzle, where scholars from different methodological and disciplinary backgrounds provide one another with clues that can be combined to help solve the puzzle. We do not present CTA as a critique of existing MOC methods, nor as something that should be regarded as superior, because we acknowledge that there is “no such thing as a perfect method” in studying cognition (Hodgkinson et al., 2018, p. 14). Instead, we present CTA as a complementary methodological approach that can provide us with further clues to our crossword, supporting our collective ambition to solve the complex puzzle of managerial cognition, with a specific focus on the role of context.

We first discuss the boundaries of CTA, detailing its defining features and outlining five key questions that determine when it might be used. Next, we provide a step-by-step guide to conducting CTA, with two detailed examples of its application in practice. In ending, we reflect on some specific areas of future development for this set of methods, as well as noting their limitations. It is our intention that this paper will inspire future management researchers to utilize CTA methods when exploring complex cognitive processes in the workplace, to generate unique insights into contextually rich work as it is, rather than work as it is imagined.

## **The Boundaries of CTA: What Is It and When Should It Be Used?**

CTA are a series of qualitative methods designed to explore complex cognition in experts at work by accounting for the role of context (Klein & Militello, 2001), while also ensuring that findings have applied value to practitioners (Klein et al., 1989). CTA methods are typically interview-based, recognizing that the voices of individual decision-makers are necessary to elicit complex cognition at work;<sup>1</sup> however, they can also include observations and document analyses (Clark et al., 2008; Militello & Hutton, 1998; Waring et al., 2020).

As a methodological approach, CTA is oriented around three phases of research: (i) knowledge elicitation; (ii) data analysis; (iii) knowledge representation (Crandall et al., 2006). In practice, these three components can be understood as: (i) interviewing or observing an expert to break down the steps required to perform a specific complex task; (ii) identifying and eliciting the cognitive processes adopted by the expert during task completion; (iii) analyzing and mapping the knowledge requirements, cues, strategies, and skills used by the expert during task completion and presenting this in a digestible format that can enhance knowledge transfer within the workplace (Rosen et al., 2013). While the data analysis phase draws on qualitative methods already familiar to management scholars (e.g., thematic analysis, content analysis), it is the knowledge elicitation and knowledge representation phases (discussed in detail below) that represent a new approach for such scholars. Thus, CTA offers a series of methods to identify and describe the cognitive and contextualized demands of

a given management task and to elicit the skills, cues, knowledge, and expertise utilized. Such demands, in terms of judgment, situational awareness, sensemaking, problem-solving, and macro-cognitive processing, are rarely documented explicitly when using conventional methods (Militello & Anders, 2020).

With many methods already available to management scholars, a key challenge is to determine whether CTA methods will be appropriate for the research questions posed (Schraagen et al., 2000). Indeed, the field of MOC has contributed greatly to the development of diverse methods (Kaplan, 2011) and alongside advancing traditional techniques and practices, recent advances in neuroscience have even seen MOC scholars utilizing fMRI and EEG to study cognition (Hodgkinson & Healey, 2011; Kaur, 2024; Massaro, 2017). It is not our intention to provide an exhaustive overview of the many methods that might be used to study cognition because this can be found elsewhere (see Hindle, 2004; Hodgkinson et al., 2018; Kaplan, 2011; Yates & Feldon, 2011); rather, it is to provide a guide to management scholars that will enable them to determine whether CTA methods fit the focus and aims of their research and, crucially, to highlight the benefits of applying these methods. We start, below, by identifying five key questions that researchers can use to determine whether CTA is appropriate (see Table 1).

### *Are You Studying a Complex Workplace Environment?*

CTA methods were designed specifically to understand decision-making in difficult, uncertain, and challenging contexts (Militello & Hutton, 1998). Embedded into the assumption of using CTA is that the insights gained into the cognitive skills and processes adopted by experts within a given task domain will be tied to the domain itself (Schraagen et al., 2000). Thus, CTA seeks specifically to understand how people make decisions when, for example, contextual demands derail typical processes or when unforeseen chaos is brought into the workplace. Today, we are witnessing an unprecedented shift toward organizational forms and practices that are more complex than would have seemed possible even a decade ago. Organizations must grapple with the challenges of a constantly changing and unpredictable world in the face of the impacts of, for example, the COVID-19

**Table 1.** Considerations to Determine Whether CTA Methods are Appropriate for the Research.

Question	Prompts
Are you studying a complex workplace environment?	<ul style="list-style-type: none"> <li>– Can the context of study be characterized by uncertainty?</li> <li>– Is there a high level of complexity in the task environment?</li> </ul>
Does your research focus on cognition?	<ul style="list-style-type: none"> <li>– Are you aiming to elicit complex cognition that is hard to articulate?</li> <li>– Is cognition the focus of your research or is the focus on eliciting the attributes of the task?</li> </ul>
Can you access relevant experts in the field?	<ul style="list-style-type: none"> <li>– Who is an expert within your domain of interest?</li> <li>– How might expert knowledge provide insight into the aspects of cognition you are studying?</li> </ul>
Have you considered your onto-epistemological assumptions?	<ul style="list-style-type: none"> <li>– How does the method link to your research paradigm?</li> <li>– What is the aim of your research (e.g., theory development or testing) and is the method appropriate?</li> </ul>
Do the findings of your research have the potential to impact practice?	<ul style="list-style-type: none"> <li>– Have you considered how the findings might be used by practitioners?</li> <li>– How might you ensure knowledge transfer through the representation of your findings?</li> </ul>

pandemic, the rise of artificial intelligence, and global warming. Understanding how organizations cope with and respond to dynamic contexts is therefore vital to the future of management cognition.

CTA has much to offer because it was designed to elicit cognitive processes in complex and highly uncertain task environments in which contextual demands make decision-making particularly difficult. We define a complex context as one that is characterized by a high degree of uncertainty, in which goals are ill-structured and/or ill-defined and where real-time decision-making and multitasking is required (Gordon & Gill, 1997; Orasanu & Connolly, 1993), and where significant knowledge, experience, and skill is needed to manage and contain competing or interdependent demands and goals (Gordon & Gill, 1997). This complexity might relate to a specific contained task (e.g., allocating patients to beds in intensive care units; see Power et al. (2018), discussed in detail below) or might characterize the wider environment in which several decisions must be made (e.g., implementing a global change initiative; see Osland et al. (2013), discussed in detail below).

One obvious application of CTA is in the realm of extreme environments—that is, task environments that present atypical demands and in which errors can have life or death consequences (Bell et al., 2018). Examples of teams working in such conditions include those in long-duration space flights (Salas et al., 2015), in nuclear plant control rooms (Stachowski et al., 2009), in medical emergencies (Klein et al., 2006), and in submarine command and control (Bierly & Spender, 1995; Roberts & Stanton, 2018). Extreme contexts provide management scholars with the opportunity to uncover critical new insights into human behaviors not adequately represented by studies in more conventional contexts (Hällgren et al., 2018). CTA methods are well suited to advancing the study of extreme environments and eliciting the cognitive processes that support the decision-making of experts in these contexts (see Boulton & Cole, 2016; Power & Alison, 2017).

Aside from extreme environments, CTA is also becoming increasingly relevant for understanding cognition in more conventional management settings as we witness an unprecedented shift toward more volatile and uncertain working conditions (Bell et al., 2018; Driskell et al., 2018; Golden et al., 2018; Schmutz et al., 2023). Innovative organizations succeed principally because of their ability to adapt to uncertainty and respond to continual changes in their domains (Russell & Russell, 1992). To gain competitive advantage in a marketplace, research has shown that organizations must act creatively, engage in effective knowledge management, and develop an organizational culture that is conducive to change (Adams et al., 2006; Chaston & Sadler-Smith, 2012; Cooper & Kleinschmidt, 1995). However, there remains a lack of clear evidence as to what precisely creates such capacity for change in an organization and what factors contribute toward the ability to adapt in periods of intense uncertainty (Goffin et al., 2019; Neely & Hii, 1998). It is here, in contexts of deep uncertainty and ambiguity, that CTA can provide an integrated perspective of the practices of innovation and knowledge management (Orasanu & Connolly, 1993). The strength of CTA in knowledge elicitation and cognitive mapping (e.g., via a “Knowledge Audit” or “Cognitive Demands Table”, see below) may prove very useful to management scholars seeking to identify how senior managers implement change and innovation within organizations. For example, a Cognitive Demands Table could capture what aspects of an organizational change a manager found difficult, how they overcame such difficulties, what common errors the manager encountered, and—crucially—what cues and strategies were adopted to overcome these difficulties (thereby identifying what provided the capacity for change, see Gore and McAndrew (2009)).

### *Does Your Research Focus on Cognition?*

CTA methods are only relevant to research that is focused on complex cognition, especially aspects of cognition that are difficult to articulate and observe (Militello & Hoffman, 2008). As noted by Roth et al. (2014), it is not sufficient to tell a compelling story of workplace activities using CTA; the findings must also yield insights into cognitive challenges and focus on the role of expertise in enabling

practitioners to navigate these challenges. This focus distinguishes CTA from existing approaches within the management literature, which do not probe for specific details of cognition and deeper insights into unconscious thinking, judging, perceiving, or decision-making (Stanton et al., 2017). If the research question is focused primarily on identifying the characteristics or attributes of a task, then it is likely that an alternative method such as CIT would be more appropriate. Indeed, while CTA methods were originally developed as an extension to CIT, and both methods focus on challenging incidents, the aims and applications of the two methods are distinct (Hoffman et al., 1998; Klein et al., 1989). For example, the CIT is used to describe the objectives of an activity and what a person does to accomplish these by having them reconstruct and outline the details of a specific incident (Flanagan, 1954). Thus, the CIT method is focused upon developing a descriptive narrative of how specific behaviors relate to a specific incident. In contrast, the aim of CTA is to unpack the underlying cognitive processes adopted by an expert operating in a complex task environment (Militello et al., 1997). As such, rather than being the core focus of study, the task (or incident) is used as a context with which to explore these cognitive processes (via deepening probes).

Given the welcome advancement of managerial cognition, we believe there are many opportunities for management scholars to utilize CTA in their research. For instance, while there has been a long-standing focus on cognition in the strategy literature (see Acciarini et al., 2020; Kaplan, 2011), much of this research has sought to identify individual dispositions and personality traits that might influence cognitive styles and decision-making (Elenkov et al., 2005; Helfat & Peteraf, 2015). In recent years, researchers have called for further innovation in the study of strategic leaders; for instance, by stepping beyond generalized performance indicators that might determine success and toward a more nuanced understanding of how senior individuals influence their firms and enact decisions within complex settings (Samimi et al., 2022). This approach is compatible with CTA in that it recognizes the inherent complexity of the environments in which strategic leaders operate and opens the door to a deeper exploration of cognitive processes.

Management scholars might, similarly, consider applying CTA in the study of entrepreneurial cognition. Cognitive processes such as perception and intuition are understood to play a vital role in the creation of new ventures, leading to an emerging trend across the entrepreneurial literature for studies grounded in cognitive psychology (Forbes, 1999; Shepherd, 2015). And yet, the field of entrepreneurship remains underdeveloped in comparison to other fields of management; there remains an emphasis on the individual attributes and cognitive styles of successful entrepreneurs, and a focus on research that utilizes experimental manipulation to determine the causal mechanisms that lead to the emergence of such entrepreneurs (Chen et al., 2015; Hsu et al., 2017; Shepherd et al., 2015; Short et al., 2010). In contrast, the focus within CTA on intuitive cognition (or “gut feeling”), and on probing participants’ appreciation for the “big picture”, their ability to “notice,” to recognize conditions as “opportunities,” and to “improvise” offers an alternative mode of inquiry by which to capture how entrepreneurial decisions are made in real-world contexts and the cognitive skills and strategies that guide behavioral actions (see Sadler-Smith & Shefy, 2004).

### *Can you Access Relevant Experts in the Field?*

A third essential consideration when using CTA is ensuring that the prospective sample of participants are experts, because eliciting and utilizing expert knowledge is at the center of CTA methods (Roth et al., 2014). In simple terms, an expert can be defined as an individual who is “outstanding in terms of speed, accuracy, and automaticity of performance” (Hatano & Inagaki, 1984, p. 31). However, CTA methods also allow us to study expertise in a more nuanced way. Instead of the traditional approach of comparing experts to novices, or identifying an expert using a proscriptive formula, CTA embraces the many levels of expertise that exist when someone develops from journeyman to master, and thus does not view expertise as an endpoint in organizational learning

but, rather, as a process (Hoffman, 1998). CTA methods also align with the theoretical positioning of cognitive psychologists and human factors researchers, suggesting that we have much to learn from experts and how they perform in complex, challenging environments (see for example, de Groot, 1946/1946/1965; Ericsson et al. 2006, 2018; Hoffman & Lintern, 2006; Shanteau, 1992; Ward et al., 2020). Promisingly for the application of CTA to the study of managerial cognition, this same perspective is common within the management and organization literature (Simon, 1987; Heimstädt et al., 2024). Indeed, expertise has long been regarded as having “explanatory potential” for a broad range of phenomena in management studies (Heimstädt et al., 2024, p. 1).

Consistent with the recent review by Heimstädt et al., of expertise in management research, we contend that the concepts of cognition and intuition are inherently tied to the understanding of what it means to be an expert at work. Thus, we suggest that the focus within CTA methods on eliciting and documenting expert knowledge has the potential to assist management and organization scholars with an alternative and more nuanced lens through which to understand MOC. As Ward et al. (2018, 2020) highlight, with the world of work becoming ever more cognitively challenging and technological, the urgency of the need for proficient and expert workers has increased, as has the value attributed to eliciting and sharing skills and tacit knowledge across the workplace such that it is not lost (see Marr & Spender, 2004; Spender & Grant, 1996). Because experts often find it difficult to reflect upon their own cognitive processes, CTA techniques are designed to provide structured and effective methods to elicit, capture, and, most importantly, share detailed insights relating to MOC (Feldon & Clark, 2006).

Management scholars may therefore consider utilizing CTA methods to further the study of expertise in the workplace. For instance, there is a growing interest in how we might improve our understanding of expertise and, indeed, how workers might sustain the value of their expertise by being more flexible (Frie et al., 2024). This “flexexpertise” has been heralded as necessary in the context of increasingly volatile and uncertain working environments, in which adaptivity is becoming increasingly important (Baran & Woznyj, 2020; Dane, 2010; Frie et al., 2024). Here, we contend that CTA’s usefulness in eliciting contextual cognition may form a bridge to exploring the link between expertise, adaptivity, and flexibility (Ward et al., 2018) by providing a rich understanding of how experts respond to and embrace dynamic contexts.

### *Have you Considered Your Onto-Epistemological Assumptions?*

A risk with all qualitative research is a failure by researchers to consider their positionality with regards to their onto-epistemological assumptions (Bansal et al., 2018). Historically, CTA methods have been applied by scholars with a predominantly realist, post-positivist positioning. Central to this is the assumption that there are certain known components that characterize expert cognition (e.g., enhanced mental models, advanced sensemaking capabilities) but these can only be partially accessed and understood through the subjective views of an expert sample (Gore et al., 2018; Ward et al., 2018). For example, Klein’s (1989) seminal recognition-primed decision model argues that experts utilize common cognitive processing patterns involving mental simulation to rapidly make choices in messy task environments, but that not all experts will make the same decision when faced with the same information (although all expert insights are valid). According to this perspective, one might argue that although there exists truthful knowledge about the process of expert cognition, this process can produce diverging but equally valid expert views dependent on subjective experience. And yet, CTA researchers could also adopt a constructivist perspective in their research, given the emphasis on the linkage of knowledge and expertise to context and to the experience, knowledge, and skill of an individual (Militello & Anders, 2020; Morris et al., 2021).

Therefore, we suggest that CTA can be utilized by scholars with varying onto-epistemological perspectives, as long as this is carefully considered and communicated. This view is concurrent



with the assessment of CIT by Chell (1998), in which they argue that the method can be applied in a variety of paradigms as long as the researcher “considers very carefully the nature of the research problem to be investigated, and thinks through *how* the technique may most appropriately be applied in the particular researchable case” (Chell, 1998, p. 51). However, we would add that a core assumption of CTA-based studies is that it is not the researcher’s role to judge the validity of an expert’s choice (thus differentiating CTA from CIT), but to instead develop understanding of how that choice was reached by focusing on the cognitive processes, skills, and strategies adopted by the expert (Klein & Militello, 2001). It therefore resembles a process of discovery (Militello et al., 2011), lending itself to the initial phases of theory development, as opposed to the latter phases of theory testing and confirmation (see Carlile & Christensen, 2005). Relatedly, CTA methods might be used to “problematize” existing theory (Alvesson & Karreman, 2007); for example, in challenging existing understandings of cognition by exploring what cues, strategies, and processes are utilized in exceptional and challenging contexts (see, also, Shepherd & Suddaby, 2017). Therefore, while CTA can be applied within diverse research paradigms, it is unlikely to be suited to studies in which the intention is to elicit generalizable knowledge about a phenomenon or to quantitatively compare responses from two distinct groups.

### *Do the Findings of Your Research Have the Potential to Impact Practice?*

Generating meaningful impact is an important element in the application of CTA, such that the findings of the research inform future practice at work (Klein & Militello, 2001). Management scholars face the growing and pertinent challenge of ensuring that academic research has relevance and can be translated into practice (Nicolai & Seidl, 2010; Parry et al., 2020; Shapiro et al., 2007; Starkey & Madan, 2001). Some authors have gone as far as to refer to a “crisis in the field of organizational science”, with research methods and insights reaching such high levels of statistical sophistication and complexity that they fail to offer any meaningful utility to practitioners (Rynes et al., 2001). CTA methods have been designed to address these concerns—to make cognitive mapping more concrete and accessible to practitioners and researchers across a range of fields (e.g., technical specialists, HR practitioners), while simultaneously maintaining the scientific integrity of conventional methods of task analysis (Stanton et al., 2017).

As such, when applying CTA methods, scholars should consider how their findings might provide evidence-based insights into how experts carry out workplace activities and how to translate such findings into recommendations for improving decision-making and performance (Crandall et al., 2006; Gore et al., 2018). Having individuals reflect on their decision-making during critical tasks can help them to understand their thinking processes and in turn improve future performance and facilitate knowledge transfer within the workplace (Moon, 2020). Knowledge transfer is a coveted resource in management practice, as organizations seek to gain a competitive edge while simultaneously protecting their unique capabilities from external competition (Argote & Ingram, 2000). Relatedly, findings can be used to translate expert knowledge into training and protocols, by offering detailed documentation of the complex cognitive processes (e.g., expertise, sensemaking, knowledge acquisition) utilized by skilled practitioners in situ (Clark et al., 2008; Gore et al., 2018; Tofel-Grehl & Feldon, 2013). To date, this has proved especially fruitful in medical training, aviation, and the military (Campbell et al., 2011; Clark & Estes, 1996; O’Hare et al., 1998; Velmahos et al., 2004). The large effect size (Hedges’  $g = 0.871$ ) reported in a meta-analysis of 20 studies reviewing the use of CTA in training design indicates that we can expect to see similar benefits in a management context (Tofel-Grehl & Feldon, 2013). Thus, we suggest that when management scholars are seeking to work directly with end-users, the application of CTA methods provides an opportunity not only to extend research interests but also to build collaborative relationships and achieve meaningful impact on organizational practice.

## Doing CTA: The Methodology

In the following subsections, we present two examples of CTA in practice, which utilize two different methods of knowledge elicitation (and their associated methods of analysis and knowledge representation) that have the most potential for management research: the Critical Decision Method (CDM) and Applied Cognitive Task Analysis (ACTA). In doing so, we seek to address one of the primary difficulties in applying CTA methods: the choice of where, how, and when to adopt specific forms of the method (Hodgkinson & Healey, 2008; Yates & Feldon, 2011). Our reason for focusing on CDM and ACTA is that these are the two most widely used CTA methods and have therefore been applied across a diversity of work domains and academic disciplines (Boulton & Cole, 2016; Graham et al., 2023; Plant & Stanton, 2015; Swaby et al., 2022). As such, we argue that there is strong and sustained evidence of their successful transferability into management and organization studies.

CDM is a narrative-based, retrospective interview technique that requires experts to reflect on a challenging incident in a complex work domain. In doing so, it seeks to “identify the knowledge requirements, expertise and goal structures involved in performing a decision-maker’s work” (Wong, 2003, p. 327). In some instances, CDM can be paired with other methodologies such as observations and document analysis (see Clark et al., 2008; Graham et al., 2023; Waring et al., 2020); however, this is not always possible if the decision-making environment is particularly sensitive (e.g., emergency response; Power & Alison, 2017). CDM is likely to be useful to management scholars interested in studying topics such as entrepreneurship and innovation, contexts in which individuals are faced with risk and complexity.

ACTA is an interview technique designed to identify the key cognitive elements required to perform expert tasks (Militello & Hutton, 1998). It normally involves three phases: (i) developing a task diagram; (ii) a knowledge audit interview; (iii) data analysis and knowledge representation (Gore et al., 2018). Sometimes, to probe into alternative representations of cognition within the knowledge audit interview phase, researchers also utilize CDM and/or a simulation interview or simulated exercise (see Brown et al., 2020). However, ACTA is typically used in a streamlined manner, taking less time to complete than a CDM, and suited to instances in which time is limited (Militello & Hutton, 1998). ACTA is especially useful when the researcher is interested in accessing detailed knowledge about the work activities of a high-performing expert completing a domain-specific task (Klein & Militello, 2004; Militello & Hutton, 1998). We know from many years of experimental work on expertise in cognitive psychology that experts often find it very difficult to tell researchers what they know (Ward et al., 2020), so the ACTA techniques focus upon knowledge elicitation in such a way that expert cues and strategies in a professional domain are documented clearly.

While we propose that both CDM and ACTA are suited to a diverse range of management contexts, we also note that their differences dictate that there may be differences in their application (Hoffman et al., 1998; Yates & Feldon, 2011). As such, we suggest that CDM is best applied in studies that speak to its naming, that is, research contexts in which the aim is to elicit and document the cognitive processes adopted in support of critical decision-making. For instance, CDM might be used to examine complex policy-related decision-making associated with changes in human resources and workplace technology, or in unpacking the decisions made and steps taken in entrepreneurial business development. ACTA, on the other hand, is best used in circumstances in which the primary aim is to uncover the broader cognitive skills and knowledge requirements that are needed to complete a complex workplace task or activity (Hoffman et al., 1998). For example, managers having to develop complex strategies across and within senior leadership teams, or examining how the completion of a complex task might be influenced by the legal and political context of an organization. Overall, CDM may be better suited to research questions in which the decision-making itself is the focus, whereas ACTA might be better suited to research questions that seek to identify the broader range of cognitive skills and knowledge requirements needed to complete a specific workplace task.

## *Using CDM to Explore Management Decision-Making*

This section will describe the use of CDM with two examples that explore senior management decision-making, one in the emergency services (Power & Alison, 2017) and one in hospital intensive care units (ICUs) (Power et al., 2018). CDM was identified as a useful technique for knowledge elicitation in these studies because the researcher sought to explore the core challenges to decision-making in complex, uncertain environments by adopting an inductive and exploratory approach. An important requirement for researchers conducting CDM interviews is that they are familiar with the specifics of the research domain (e.g., terminology, work processes) (Crandall et al., 2006); the interviewer should strive to achieve “quasi-expert” status by increasing their understanding of the expert’s domain (Pfadenhauer, 2009). Such familiarity enhances the knowledge elicitation and knowledge representation phases because interviewees feel more able to discuss their cognition in informed yet non-competitive environments (Trinczek, 2009).

***Sweep one: Incident identification.*** The first “sweep” of a CDM interview involves the identification and description of an event that is relevant to the research question. For example, Power and Alison (2017) were interested in exploring the main challenges to emergency command decision-making that might contribute to indecision, so participants were asked to recall an especially challenging incident that they had responded to in the past where they felt indecision was prevalent. Similarly, Power et al. (2018) wanted to identify the challenges to consultant decision-making when referring a patient to the ICU, and so they asked participants to identify a particularly challenging ICU referral in which there was disagreement between medical specialties about the patient. Two key requirements for incident identification are (i) that the expert was the decision-maker during the incident (i.e., first-person narrative) and (ii) that their actions directly impacted the outcome of the incident.

Once a suitable incident has been identified and agreed upon by both the interviewer and the expert, then the expert is asked to provide a narrative walkthrough of the incident from start to finish, without interruption from the interviewer (the first sweep), although the interviewer should help to re-focus the interviewee with gentle probes if they begin to drift off-topic. By guiding the participant back to the task (or incident) at hand when conducting CDM, the aim is to ensure that the participant continually reflects on and identifies the cognitive processes and mechanisms used to approach that task. This is not intended to limit the participant’s response or to stifle conversation, but rather to keep the interview bounded within the context of one specific incident and invite opportunities to discover complex cognitive processes that may not be identified if the participants were to reflect more broadly on their work activities (Rosen et al., 2013). At the end of this sweep, it is recommended that a check is conducted for “pre-starts” (i.e., anything that happened before the incident) and “second endings” (i.e., what happened after the event), to ensure a full and informed narrative (Crandall et al., 2006).

***Sweep two: Timeline verification.*** The second sweep of a CDM interview involves timeline verification via the process of “incident retelling.” Here, the interviewer narrates the expert’s story back to them on the basis of the detailed notes made. The purpose of this step is to draw out further detail and richness in the narrative and to correct any misunderstandings. In doing this, it is useful to mirror the terminology used by the expert and thereby convey “quasi-expert” standing (Pfadenhauer, 2009). It is also important that the expert is encouraged to correct any errors made during timeline verification and, at the outset, the interviewer should make clear that they have likely made mistakes during their note-taking and would like the expert to correct these. This is a useful step in building rapport because it can help to establish empathy and affiliation between interviewer and interviewee as they work together to generate meaning (Prior, 2018). Once a common understanding is established, both expert and interviewer work together to construct a timeline of the event to prepare for the next sweep (deepening probes). This helps to identify the critical junctures in the decision-making process. In

Power and Alison's (2017) study of emergency responders, the interviewer found it helpful to ask participants to imagine that a "Hollywood film" was being made about the emergency incident and to think about the key scenes that would be needed to let the story unfold. It can be useful for participants to represent this timeline visually on a piece of paper by asking them to identify the "critical turning points" of the incident in chronological order. Timelines can also be constructed using tools such as Post-it notes, which can be moved around easily if the expert wants to reorder the sequencing of events (Wong, 2003).

**Sweep three: Deepening probes.** Sweep three involves the progressive deepening of the incident elicitation by focusing attention on the critical points identified during timeline verification. The expert is asked to talk through their narrative of the incident again, but this time they are guided by the interviewer who uses "cognitive probes" to seek more detail. Cognitive probes are the questions that the interviewer has prepared prior to the interview, which are used to elicit information about both the decision-making process and the environment in which the decision was made (see Table 2 for an example of cognitive probing questions that might be used in a CDM interview). For example, in Power and Alison (2017), several probes focused on the information environment and how the information that the emergency responders received impacted upon their subsequent decision-making.

Not all probes will be used in every interview, nor is the researcher limited to the probes on their list because they can create additional ones guided by their curiosity at the time of the interview, as is standard in all semi-structured interview approaches. In general, probes tend to include questions about: the presence or absence of cues; the meaning of cues; the expectations about the situation; the goals/actions considered; the options being evaluated; the uncertainties experienced by the decision-maker (Crandall et al., 2006; O'Hare et al., 1998). The interviewer must be well-versed in the design and type of questions used to probe the responses of interviewees, without deviating too much or losing control of the area of research interest (Hoffman et al., 2006).

**Sweep four: "What if?" probes.** The final sweep of the CDM interview shifts the expert's focus away from what happened during the incident and orients their thinking on hypothetical "What if?" questions. The purpose of this phase is to generate a more analytical consideration of the situation from the perspective of the expert; specifically, in terms of what might have happened under different circumstances (Crandall et al., 2006). This final phase is especially useful for management research because it can help to generate practical recommendations derived from collective expert knowledge across interviews. If adopting a critical-realist approach, researchers can use this sweep to identify common themes across interviews that begin to identify what constitutes expertise in this context. For example, in Power et al. (2018), medical consultants were asked three key questions in the final sweep: (i) how they believed a novice might have behaved differently; (ii) what they would do differently if they were to respond again with the benefit of hindsight; (iii) what advice they would give to someone faced with a similarly challenging incident. The authors found that consultants often reflected on some of the mistakes that less experienced doctors had made in similar incidents in the past and generated ideas about systemic changes that they believed were needed in the hospital structure to alleviate the decision pressures in ICU (e.g., talking routinely in other departments about patient wishes around ICU and death). Expert insight into these questions can help to generate applicable recommendations from the research and identify avenues for future research. It also helps to guide data analysis by highlighting the aspects of the incident that the expert perceives to be most important.

**Data analysis and knowledge representation of CDM data.** Data collected from a CDM interview is rich and detailed. Power and Alison (2017) collected over 51 h of interviews from their 31 participants and took a pluralistic approach (see Frost & Nolas, 2011) to data analyses, in which they utilized reflexive thematic analysis to code for the core challenges to emergency management

**Table 2.** Example of Cognitive Probes Used in a CDM Interview Examining Decision-Making Processes.**Deepening instructions:**

Now that we have identified an incident and discussed the decisions that you took, I would like to go through the incident again in more detail. I'm going to guide you with some questions.

<b>Probe topic</b>	<b>Probe</b>
Basis of choice	<p>What were the main reasons that you took this decision?</p> <ul style="list-style-type: none"> <li>• What did you believe the consequences of your choice might be?</li> <li>• What were these beliefs based upon?</li> <li>• How did you feel when making this decision?</li> <li>• Were you following any standard rules or operating procedures?</li> <li>• Had you received training to deal with this type of incident?</li> <li>• Were you reminded of any previous experiences?</li> </ul> <p>Did you consider any other courses of action?</p> <ul style="list-style-type: none"> <li>• Why did you not take these actions?</li> </ul>
Goals	<p>What were your specific goals or objectives?</p> <ul style="list-style-type: none"> <li>• Did you have a primary goal or objective to guide your decision?</li> <li>• Did you have any competing goals or objectives?</li> </ul>
Information and cues	<p>What was the most important priority for you at this point in time?</p> <p>How did you know that you needed to make the decision? What information did you use in making your decision?</p> <ul style="list-style-type: none"> <li>• What were you looking at?</li> <li>• What pieces of information were most/least important?</li> <li>• Did you seek guidance from anyone else to make your decision?</li> </ul> <p>Where did you get this information?</p> <ul style="list-style-type: none"> <li>• How did you know to trust the information?</li> </ul>
Influence of uncertainty	<p>Was there any additional information that you would have liked?</p> <p>How certain or unsure were you about your decision?</p> <ul style="list-style-type: none"> <li>• At any point did you find it challenging to process the information you received?</li> <li>• Were you uncertain about the reliability or the relevance of the information you had available to you?</li> <li>• Did you feel confident/satisfied with your decision?</li> </ul>
Decision barriers	<p>Were you uncertain about either the reliability or the relevance of the information that you had available?</p> <p>In your opinion, what were the biggest barriers to your decision-making on that day? Were there any organizational or social barriers that made your decision more difficult?</p> <ul style="list-style-type: none"> <li>• Did you find that there were differences in opinion with your colleagues?</li> </ul> <p>Did complexity or uncertainty in the decision-making environment make your decision-making more difficult?</p>

before returning to the data to perform a grounded theory analysis to generate a theoretical model of command-level indecision during emergencies (Braun & Clarke, 2019; Glaser & Strauss, 1967). Researchers with a more theoretically informed (deductive) a priori focus could utilize more structured analysis techniques such as template analysis (King & Brooks, 2017), with the

probes used during sweep three structured around a priori template themes. The presentation of findings from CDM interviews can vary from basic visual models of core themes (see Power & Alison, 2017), to more detailed process pathways that represent the decision-making process over time (see Power et al., 2018). CDM thus offers a versatile and adaptive method for unpacking the cognitive processing of experts in a domain-specific environment. Importantly, not only does CDM enable management scholars to present real-world data with applied value to practitioners, but it also maintains rigor by following a protocol of sweeps that is specifically designed to unpack expertise and contribute to our theoretical understanding of decision-making and management.

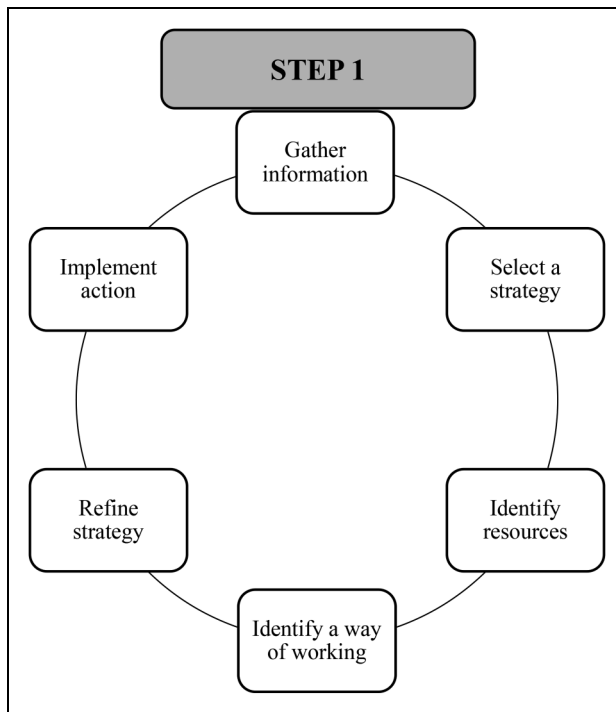
### *Using ACTA to Explore Leadership*

This section will outline ACTA with reference to studies of global leadership behavior (Osland, 2010; Osland et al., 2013; Osland et al., 2012; Osland et al., 2017). The aim of Osland et al.'s research was to explore the cognitive processes employed in global change efforts. ACTA was chosen because of its focus on expertise and eliciting cognition, both of which had yet to be explored in detail in the global leadership literature. Prior to data collection, Osland et al. consulted human resources personnel and carried out a vetting process to ensure that participants had the relevant expertise and at least 10 years' experience in senior management. This criterion was especially stringent, given Klein's (1997) conclusion that experts make up only 2–3% of a workforce. Ten participants were identified who met the criteria, concurrent with CTA guidelines that suggest a minimum of three to five experts are needed to identify expert cognitive processes (Crandall et al., 2006; Gore & McAndrew, 2009). A further ten experts were selected at a later stage for confirmatory analyses.

**Phase 1: Developing a Task Diagram.** It is recommended that researchers first develop a Task Diagram, to provide a broad “big picture” overview of the task and identify the most complex elements of both the environment and the decision-making process, which can then be explored in Phase 2 (Militello & Hutton, 1998). For example, because Osland et al. (2013) wanted to explore a strategic leadership incident involving the implementation of a global change initiative, participants were asked to produce a Task Diagram detailing the key steps involved in this implementation. Given ACTA's focus on expertise and complex cognition, it is vital at this stage that the researcher and participant work together to identify an incident that would be too complex for a novice to complete. Task Diagrams typically contain between three and seven steps, with circles linking the various steps of execution (see Figure 1). For example, a Task Diagram developed by Osland et al. (2017) represented an incident in which management decided to cut ties with their existing European distributors and form an alliance with a major distribution company that had its own European network in place.

Depending on the complexity of the task, Task Diagrams can be elicited in 10–30 min and are designed to generate a “big-picture” overview. Participants often find this phase challenging and offer too much detail, and so the interviewer must be prepared and ensure that they keep the conversation on track (for further suggestions in this regard, see Gore et al., 2018). Asking participants to divide the task into three to seven steps aligns well with their short-term memory (i.e., most people can easily remember  $7 \pm 2$  pieces of information; Miller, 1956). The researcher must remain mindful of using this Task Diagram phase to clarify which elements of a complex task experts find the most challenging, and to begin identifying the cognitive skills needed to cope with this complexity (Gore et al., 2018). The salient information obtained in this phase will be used to guide questioning in the next phase, the Knowledge Audit (Militello & Hutton, 1998), which seeks to access complex cognition, typically associated with long-term memory.

**Phase 2: The Knowledge Audit.** The Knowledge Audit represents the second phase of the ACTA method and comprises a structured set of questions and probes to unpack and document expert knowledge in relation to the specific task or incident identified in Phase 1. Knowledge Audits



**Figure 1.** Illustrative example of a task diagram, adapted from Osland et al. (2017).

were originally designed to survey different aspects of expertise required to perform a task effectively (Crandall et al., 1994). However, without the use of a Task Diagram in Phase 1, participants would lose focus and the method would fail in its objective of exploring cognition in detail (Klein & Militello, 2004). Using this method of probing is different to traditional research interviews—it is far more detailed and focuses on eliciting the aspects of expertise and complex cognition that enable task completion (Osland et al., 2013). Typically, the set of probes include reference to key elements of expert knowledge, including identification, situational awareness, perception, job smarts or workarounds, improvising, metacognitive awareness, recognizing anomalies, and self-monitoring (see Table 3). As such, the probes are designed to elicit information about both the task (e.g., job smarts and workarounds) and the task environment (e.g., situational awareness, recognizing anomalies). Osland et al. (2013, 2017) used probes to acquire further detail about how participants implemented global change initiatives, focusing on expert cues and strategies, while also noting why the identification of such cues might be difficult for a novice or inexperienced global leader.

**Phase 3: Data analysis and knowledge representation.** While ACTA is generally a more streamlined method than CDM, it still acquires rich and detailed data (Militello & Hutton, 1998). Osland et al. (2013) obtained over 30 h of rich data, from 20 Knowledge Audit interviews. As with CDM, data collected from ACTA can be analyzed in a number of ways, dependent on the aims of the study and the epistemological position of the research. For example, Osland et al. (2013) analyzed the transcripts of their Knowledge Audit using content and hierarchical task analyses.<sup>2</sup> Two coders worked independently and carried out a content analysis to identify themes. The coders implemented an inductive approach to their analysis, in which themes were derived from the data rather than from preconceived categories. This was driven from the perspective that there was limited existing research into the cognitive challenges faced by global leaders. The elicitation methods employed in Phases 1 and 2 ensured that the subsequent analysis could focus on how experts navigated their

**Table 3.** Applied Cognitive Task Analysis (ACTA) Probes Used in a Knowledge Audit.

Aspect of expertise	Example probes	Supporting literature
<i>Past and future</i> Experts know how the situation developed and know where the situation is going	Is there a time when you walked into the middle of a situation and knew exactly how things got there and where they were headed?	de Groot, 1946/1965; Endsley, 1995; Klein & Crandall, 1995. Klein & Hoffman, 1993
<i>Big picture</i> Experts understand the whole situation and understand how elements fit together	Can you give me an example of the big picture for this task? What are the major elements you have to know and keep track of?	Endsley, 1995; Klein, 1997
<i>Noticing</i> Experts can detect cues and see meaningful patterns that less experienced individuals may miss	Have you had experiences where part of a situation just “popped” out at you; where you noticed things going on that others did not catch? What is an example?	de Groot, 1946/1965; Klein & Hoffman, 1993; Shanteau, 1987
<i>Tricks of the trade (job smarts)</i> Experts can combine procedures and do not waste time and resources	When you do this task, are there ways of working smart or accomplishing more with less effort (i.e., tricks of the trade)? Are there any tricks of the trade that you have found particularly useful?	Gore & Riley, 2004; Klein & Hoffman, 1993
<i>Improvising/opportunities</i> Experts can see beyond standard operating procedures and take advantage of opportunities	Can you think of an example when you have improvised in this task or noticed an opportunity to do something better?	Dreyfus & Dreyfus, 1986; Shanteau, 1987
<i>Self-monitoring</i> Experts are aware of their own performance and notice when performance is not what it should be and adjust to get the job done	Can you think of a time when you realized that you would need to change the way you were performing in order to get a job done?	Cohen et al., 1996; Glaser & Chi, 1988
<i>Anomalies</i> Experts can spot the unusual and detect deviations from the norm	Can you describe an instance where you spotted a deviation from the norm, or knew something was amiss?	Klein, 1989; Klein, 1997; Klein & Hoffman, 1993
<i>Equipment difficulties</i> Experts know equipment can mislead and do not implicitly trust equipment as novices might	Have there been times when the equipment pointed in one direction, but your own judgment told you to do something else? Or when you had to rely on experience to avoid being led astray by the equipment?	Cannon-Bowers et al., 1993

Note. Contents of table adapted from Militello and Hutton (1998), Osland et al. (2017), Gore et al. (2018).

decision-making and leadership in ambiguous, high-risk contexts. The findings indicated that the expertise of global leaders included reading people closely, bridging cross-cultural communication, active listening, perspective taking, engaging in conscious questioning of parochial organizational views, and coaching others to develop a global mindset (Osland et al., 2013).

Findings from ACTA are typically represented in a Cognitive Demands Table (see Gore et al., 2018; Gore & McAndrew, 2009; McAndrew & Gore, 2013; Militello & Hutton, 1998; Table 4),



**Table 4.** Cognitive Demands Table for Global Strategic Leadership, Adapted from Osland et al. (2017).

Difficult cognitive elements	Why difficult	Common errors	Cues and strategies used
Systems thinking	Numerous factors to keep in mind Rapidly changing conditions	Perceive only limited part of big picture Narrowed focus	Rely on local expertise Frame the change vision appropriately Pay attention to cross-functional global activity
Tracking progress/ large amounts of data	Numerous actors and complex tasks	Be overwhelmed by scope of the change	Create processes to monitor and measure progress
Handling ambiguity or stress	Time pressure, high-risk nature of change Personal responsibility	Fall apart Blame others Inability to monitor oneself	Awareness of stress symptoms
Reading the right cues	Challenge of distinguishing relevant cues	Miss important cues React too slowly	Watch others to interpret their behavior Consider a variety of hypotheses Understand cultural nuances

which is an outcome of ACTA intended for practitioner use and focuses on the most challenging cognitive elements of a task. By highlighting common challenges and errors, in addition to the solutions adopted to address those challenges, the Cognitive Demands Table offers a concise representation of how experienced practitioners navigate complex incidents. This representation of decision-making and problem-solving solutions can then be used to inform future training and job design. While not included in Osland et al.'s (2013) study of global leadership, the lead author later reflected that this would have been a useful method to complement their findings and represent the most difficult cognitive demands within this particular work domain (see Osland et al., 2017). Building on their team's work in 2013, Osland et al. (2017) conducted a further study of global leadership and used a Cognitive Demands Table to merge and synthesize their data, which were then used to inform global training in leadership development (see Table 4).

## Future Directions

In this paper, we have provided management scholars with a detailed explanation of the benefits of CTA methods and when best to utilize them, providing two concrete examples of how they have been used to study managerial decision-making (Power et al., 2018; Power & Alison, 2017) and leadership (Osland et al., 2013; Osland et al., 2012; Osland et al., 2017). Our aim of sharing CTA methods with a new audience follows recent calls within the management literature for qualitative researchers to demonstrate how alternative methods might be applied and adapted to garner fresh insights (Köhler et al., 2022). Building on our earlier analogy (inspired by Hayes et al., 2016), we contend that CTA provides an additional, augmentative approach to understanding management cognition by providing contextualized clues to help solve the puzzle of such cognition.

In broad terms, we expect that CTA will offer management scholars an alternative mode of inquiry to continue the critical questioning of conventional representations of management theory, especially with regard to examining cognition in context. As Bridgman and Cummings (2020) argue, continued critical questioning will assist new theories of management to enter the mainstream and advance cognition in the workplace. For instance, CTA may be used to examine the future of work, asking questions that reflect upon management and leadership *doing*, *thinking* and *acting* (see Bridgman &

Cummings, 2020), changes in requirements for building socio-technological and cognitive competence (see Gore et al., 2018; Hoffman & Woods, 2000), or the transition toward “flexpertise” in increasingly volatile and uncertain work contexts (see Frie et al., 2024). This exploration will be of paramount value to research communities, as well as speaking to the needs of practitioners who today face unprecedented changes in the way that they work (e.g., hybrid working policies, AI developments; see Benbya et al., 2020).

Extant examples of CTA studies of human–computer interactions suggest that there is great potential for management scholars to utilize these methods when seeking to understand the growing trend toward technology-assisted decision-making within organizations (Colbert et al., 2016; Klein & Militello, 2004; Mahoney et al., 2010). CTA research has long since recognized the importance of viewing human decision-makers as central actors when exploring complex sociotechnical systems in which technology can accelerate and enhance expertise (Klein, 2000)—specifically, the role of AI in assisting, rather than replacing, the decision-maker in complex, cognitively demanding situations. As discussions around the role of AI in the future of work accelerate (Anand & Rofcanin, 2022; Brown et al., 2024; Jarrahi, 2018; Munoko et al., 2020; Parry et al., 2016), CTA presents an opportunity to elicit the intuitive and hard-to-articulate aspects of human cognition not suited to automation (see Jarrahi, 2018; Sadler-Smith & Shefy, 2004) and, thereby, highlight the areas where AI developments might be best focused to support human decision-makers (e.g., information sifting, data analytics).

Throughout this article, we have highlighted the potential for CTA methods to complement and extend existing streams of research in MOC. In addition, we note that there remains scope for further development of CTA methods themselves, specifically in the application of CTA to the study of teams and in adapting CTA to study emotions. While there exists some early documentation of the use of CTA to understand cognition at the team level through observing teams *in situ* (Klein, 2008, existing empirical studies have tended to employ methods to interview team members individually to ascertain the skills (e.g., communication) and cognitive processes (e.g., situational awareness, team mental models) utilized by teams during complex tasks (see Flin et al., 1996; Pugh et al., 2011).

Concurrently, despite much research in the study of team cognition, scholars have noted how a lack of precisely defined processes in the emergence of team knowledge has limited the collective understanding of how expert team cognition arises and is sustained (Grand et al., 2016; Kozlowski & Chao, 2012). Future explorations of CTA might examine how to develop the methods to better study team cognition in context, perhaps through focus-group-style interviews or by exploring how findings obtained at the individual level might be aggregated and/or compared at the team level. For instance, Akinci and Sadler-Smith (2019) successfully adapted CIT to examine intuition in senior police commanders, and their findings illustrated how teams engaged in organizational learning and collective intuition during team-based decision processes. A similar adaptation to CTA methods could provide a new and innovative way to examine how cognition emerges and develops within teams, and generate new theory as to how cognitive processes might impact on team behaviors.

Finally, it is worth noting that while CTA methods were originally developed to study what has since been termed “cold” cognition (i.e., to elicit knowledge, skills, cues, etc.; see Hodgkinson & Healey, 2014), future adaptations might use and/or combine CTA methods with other methodologies to examine “hot” cognition—that is, to explicate how emotions influence cognition and decision-making. There has been much conjecture within the field of MOC on the need to better acknowledge the role of emotions in decision-making processes (see Ashkansey et al., 2017; Brundin et al., 2022; Hodgkinson & Healey, 2014), and an adapted version of CTA that focuses on eliciting emotions is ripe for further exploration (Crowson et al., 2020), as are the possibilities of combining CTA with other methodologies to examine the affective and implicit aspects of cognition (see Hodgkinson

et al., 2018; Hoffman, 2023). Future explorations of CTA in multi-method studies should ensure the sustained relevance of these methods to MOC scholars, as we witness an increase in methodological pluralism and the triangulation of data sources in the study of cognition at work (Christofi et al., 2024; Hodgkinson et al., 2018).

## **Limitations**

CTA methods rely on verbal responses from participants and thus it is important to consider how this might influence the interpretability and validity of the findings. While debate as to the validity of verbally reported data is too lengthy and complex to adequately cover here, it is important to acknowledge that CTA is not immune from the typical criticisms of memory failure that have been directed at interview-based methodologies (Hoffman et al., 1988). It is, of course, possible that during a CTA interview, a participant might select a task or incident that occurred a significant time ago. However, we would counter that CTA methods were designed precisely with such concerns in mind. For instance, in CDM, participants are instructed to recount a specific incident first, before the researcher repeats it back, with an invitation to the participant to intervene should any inconsistencies or corrections arise. This is by design, rather than coincidence, and is intended to facilitate accurate recall (see also Fisher & Geiselman, 1992).

Likewise, it is also plausible that participants will introduce biases when recounting their experiences or even cite fabricated knowledge to provide a stronger post hoc rationale for their decision-making (Hoffman et al., 1998). While this is important, regarding it as a limitation rests on the notion that the very purpose of CTA is to ascertain a precise representation of exactly what happened in any given incident and to determine what the “correct” decision would have been. However, this is not the intended purpose of CTA, which does not attempt to extract knowledge in a manner akin to “the mining of gold” (Hoffman et al., 1998). Indeed, this is a key aspect that distinguishes CTA from CIT, wherein it is assumed that the interviewee can make a judgment surrounding the success or failure of a participant and discern a clear understanding of the consequences of their actions (Bailey, 1956; Flanagan, 1954). Whereas the primary aim of CIT is to explore “what helps or hinders in a particular experience or activity” (Butterfield et al., 2009, p. 268), CTA is not limited to responses that can be anchored or verified (Klein et al., 1989) and does not seek to determine the optimal outcome of a decision or action. Often, the nature of complex work environments means that it is difficult to objectively judge the success of an expert’s actions because the context is so unique.

Instead, CTA is designed to uncover and elicit how an individual navigated a particular incident and to elicit the cognitive skills and strategies that they used. The extent to which the individuals’ responses are regarded as “true” ought then to be determined by the onto-epistemological position of the researcher. For example, a constructivist approach might assume that because individuals construct meaning according to their own cognitive functions and processes, the “true” reality of an incident is of little importance because it is the participants’ reflections of their own cognition that matter (see Kartoshkina & Hunter, 2014). However, a realist might assume that there are commonalities in cognitive processes between individuals and thus look to compare a sample of participants in an effort to identify common truths that might (a) fuel the development of theoretical frameworks (e.g., to identify perceptual cues utilized by managers operating in a certain context) or (b) be used to translate expert knowledge into training materials (see Gore et al., 2018; Tofel-Grehl & Feldon, 2013). We therefore suggest that while CTA cannot escape the inherent limitations of a verbal method, these limitations are addressed in both the design of the data collection phase (i.e., through incident recall and the use of cognitive probes) and through the researcher’s clear explication of their onto-epistemological position.

Finally, and comparably to many other qualitative methods, CTA techniques are limited by being time-consuming and thereby expensive; significant time is also required for researchers to develop advanced interviewing skills (Brooks & King, 2017; Klein & Armstrong, 2005; Köhler et al., 2022; Militello & Anders, 2020; Schraagen, 2009; Yardley et al., 2020). Without sufficient training, it is possible for researchers to become distracted by participant-led narratives that stray from the boundaries of their research and the focus on cognition throughout (Roth et al., 2014). As such, while we have highlighted the potential and benefits of CTA, and where and when it might be suited to management studies, we urge management scholars to consider carefully how they might adopt a CTA approach and to invest time in crafting their skills in this innovative and diverse set of methods. Scholars are encouraged to take time to engage with the existing literature, developed over decades of research, that offers detailed procedural guidelines to ensure insights are garnered in a systematic, careful manner (see Appendix; Crandall et al., 2006; Militello & Hutton, 1998). This framework encourages scholars to develop a clear research strategy and ensures the focus remains on complex cognitive processes such as decision-making, judgment, and problem-solving (Crandall et al., 2006; Militello & Anders, 2020).

## Conclusion

As management scholars continue to explore new ways of studying complex cognition, we contend that the time is ripe to consider additional methodologies currently underutilized in the field (Hodgkinson et al., 2018). As highlighted by Plakoyiannaki and Budhwar (2021, p. 6), and by Pratt et al. (2020, p. 7), qualitative scholars must continue to consider creative and diverse ways to promote craft and methodological pluralism within their research (Cunliffe, 2011). We have presented CTA as a promising methodological approach for management scholars, which can rigorously articulate the complex cognition of experts at work by paying close attention to the role of context. It is our intention that this paper encourages greater use of CTA in management research, contributing critical insights into how we might meet future challenges in our understanding of managerial cognition.

## Appendix

### *Table of Resources on Cognitive Task Analysis.*

Description of resource	Source
<i>Working Minds</i> is a seminal book on CTA that provides detailed, practical guidance for scholars intending to utilize CTA methods in their research.	Crandall et al. (2006)
<i>Cognitive Task Analysis</i> is a book that offers a comprehensive overview of the diversity of CTA methods and showcases their use across a range of work domains. The book also addresses a number of methodological questions such as which method to use when.	Schraagen et al. (2000)
This paper provides the first published description of the CDM. The authors outline the origins of the method and how it provides an extension to CIT, in addition to including examples of CDM research.	Klein et al. (1989)
	Hoffman et al. (1998)

(continued)

(continued)

Description of resource	Source
This paper provides a detailed explanation of CDM as one form of CTA, including how to design a CDM study.	
This paper introduced Applied Cognitive Task Analysis as a specific form of CTA to understand cognitive demands and expertise at work.	Militello and Hutton (1998)
This book chapter provides an overview of the many different CTA techniques and methods, in addition to outlining how CTA methods have contributed to knowledge elicitation.	Clark et al. (2008)
The Naturalistic Decision-Making Association website provides an extensive list of tools and methods, including ACTA and CDM, as well as links to resources and published research on the methods.	<a href="https://naturalisticdecisionmaking.org/new-ndm-tools/">https://naturalisticdecisionmaking.org/new-ndm-tools/</a>
The Naturalistic Decision-Making Association website has a specific section dedicated to showcasing the use of CTA across contexts. Scholars can access example short papers that highlight how CTA can be used to study expert cognition across a variety of work domains.	<a href="https://naturalisticdecisionmaking.org/cta-in-eaffect/">https://naturalisticdecisionmaking.org/cta-in-eaffect/</a>

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## ORCID iDs

Olivia Brown  <https://orcid.org/0000-0002-6403-0271>

Julie Gore  <https://orcid.org/0000-0003-1758-2871>

## Notes

1. We recognize that (for some researchers) the term ‘elicitation’ has connotations of positivist, experimental approaches to research. However, in the context of CTA the term has long been used to describe the process of identifying and documenting expert cognition (e.g., Hoffman, 1998; Militello & Hutton, 1998). We have therefore retained the term throughout this paper owing to its historical importance in the development of CTA methods but would caution that the use of this term is not intended to indicate the epistemology of the method.

2. Owing to the lack of detail in Osland et al. (2013) about their hierarchical task analysis, we focus here on the results of their content analysis. For a detailed explanation of hierarchical task analysis please see Stanton (2006).

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## Author Biographies

**Olivia Brown** is an Associate Professor in Digital Futures at the University of Bath, School of Management and Deputy Director of the Bath Institute for Digital Security and Behaviour. She is a social psychologist, interested in how intra- and inter-group processes influence individual and group behavior. Her award-winning research has two core strands—identifying what supports effective teamwork and decision-making in uncertain and stressful environments and examining how online interactions can facilitate offline collective action. Olivia is an Associate Editor of *Journal of Cognitive Engineering and Decision Making* and serves on the Editorial Board of the *Journal of Occupational and Organizational Psychology*.

**Nicola Power** is a Senior Lecturer in Psychology at the University of Liverpool. Her research focuses on the socio-cognitive processes involved in decision-making and teamwork under pressure. Specifically, Nikki is interested in the psychology of indecision and decision inertia—identifying the principles that predict why decision-making derails in high pressured work environments (e.g., emergency services, NHS). Nikki has expertise in designing and delivering immersive simulations to both train and research decision making with practitioners, using both quantitative and qualitative techniques, and she is an experienced public speaker who was the 2019 Margaret Mead Award Lecturer at the British Science Festival.

**Julie Gore** is a Professor of Organizational Psychology, Fellow of the British Psychological Society at Birkbeck, University of London, Director of the Professional Doctorates in Occupational Psychology/Evidence Based HRM, Visiting Professor at the University of Bath, UK. Her award-winning international research in applied psychology examines expertise and Naturalistic Decision Making (NDM), across a range of professions working under uncertainty. Julie is Editor-in-chief of the *Journal of Occupational and Organizational Psychology* and an Editor of *The Oxford Handbook of Expertise*.