PCMH Research Methods Series

Cognitive Task Analysis:

Methods to Improve Patient-Centered Medical Home Models by Understanding and Leveraging its Knowledge Work

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Cognitive Task Analysis: Methods to Improve Patient-Centered Medical Home Models by Understanding and Leveraging its Knowledge Work

This brief focuses on using cognitive task analysis (CTA) to evaluate patient-centered medical home (PCMH) models. It is part of a series commissioned by the Agency for Healthcare Research and Quality (AHRQ) and developed by Mathematica Policy Research under contract, with input from other nationally recognized thought leaders in research methods and PCMH models. The series is designed to expand the toolbox of methods used to evaluate and refine PCMH models. The PCMH is a primary care approach that aims to improve quality, cost, and patient and provider experience. PCMH models emphasize patient-centered, comprehensive, coordinated, accessible care, and a systematic focus on quality and safety.

I. Cognitive Task Analysis

Cognitive task analysis is a family of methods designed to reveal the thinking involved in performing tasks in real-world contexts and is especially well suited to understanding and helping improve several aspects of PCMH models. CTA methods can be used to uncover and describe the key patterns, variations, opportunities for improvement, and leverage points in the knowledge work—not just the physical work—of primary care staff and clinicians. Its results can then be used to help individuals and teams maximize the effectiveness of their implementation process by showing them where and how to focus their efforts. Moreover, many CTA methods were designed to understand how high performers (that is, experts) function, and thus identify contextually grounded best practices. These best practices can be used to inform and improve the training of individuals and teams in new roles such as care management, new clinical routines, and the meaningful use of technology.

CTA methods help us understand and improve people's performance on both clinical and organizational tasks because they identify the critical cognitive aspects of those tasks that would otherwise remain hidden. Identifying these cognitive aspects allows for more comprehensive, accurate, and effective formative evaluations, implementation planning and troubleshooting, and knowledge transfer (such as training and scaling up best practices). The cognitive aspects of tasks that are often not directly observable are the "macrocognitive" processes of clinical or organizational tasks that occur where individual knowledge and cognition interacts with group knowledge and cognition (Crandall, Klein, and Hoffman, 2006; Hoffman and Woods, 2000). Macrocognition is "the collection of cognitive processes that characterize how people think in natural settings" (Crandall, Klein, and Hoffman, 2006). These macrocognitive processes include how individuals, teams, and organizations make decisions, make sense of events and experiences (called "sensemaking"), use and share knowledge, plan and replan, coordinate, learn, monitor their work, detect problems, manage the unknown, and adapt to changing conditions. Although these processes are conceptually distinct from one another, they interact in all clinical routines and organizational change efforts that require thinking. CTA is useful in studying PCMH models because macrocognitive processes are central to the way the staff in a PCMH organizes the practice to deliver patient care.

Although CTA is an applied method designed to study macrocognition (that is, cognition in real-world contexts), it is informed by laboratory-based research on cognition. It is designed primarily to study thinking processes and structures, not to evaluate outcomes. That said, CTA can easily be combined with outcome-focused quantitative techniques using mixed methods. CTA methods have been used successfully for several decades in a wide range of settings requiring high reliability, such as military and civil aviation, air traffic control, naval ship command, nuclear power plant operation, and firefighting, but have only recently been used in health care (Crandall and Calderwood, 1989; Dominguez, Hutton, Flach, et al., 1995; Crandall and Grome, 2010). CTA comprises a wide range of qualitative techniques from disparate disciplines that have been adapted to the study of macrocognition. In fact, many researchers and practitioners do forms of CTA without calling it that. The advantage of drawing on CTA explicitly, however, is that the literature on what has been done in the past can help researchers more systematically and effectively choose and adapt methods to address their own research questions.

Regardless of the technique used, CTA consists of three main steps: (1) knowledge elicitation, (2) data analysis, and (3) knowledge representation (Crandall, Klein, and Hoffman, 2006). The choice of which method(s) to use to elicit the knowledge, conduct the analysis, and represent results depends upon the questions being asked, the context in which they are being asked, and the objectives of the project. Broadly speaking, CTA can be used to better understand the macrocognition in any clinical or organizational task, how and when it occurs, where it occurs, who is involved, and how technology and artifacts such as forms, emails, logs, and patient charts are (or can be) involved. Although we will focus on describing CTA methods that are suited to understanding and improving the typical types of organizational and clinical routines in a PCMH, additional CTA methods do exist should the reader wish to investigate the macrocognition of uncommon, critical events related to PCMH models (Crandall, Klein, and Hoffman, 2006).

II. Uses of Cognitive Task Analysis

In this section, we describe three commonly used CTA techniques, give examples, and discuss how they might benefit implementation studies of PCMH transformation projects and dissemination of successful approaches. All three techniques can be used when conducting on-site research.

Task Diagram

The goal of constructing a Task Diagram is to capture one or more aspects of macrocognition involved in a routine task. Building a Task Diagram involves getting a rich, multi-perspective description of the task by interviewing the range of people involved in it. In the first pass, the interviewer asks the interviewee (such as a physician, patient, or other practice staff) to break the task into four to seven large steps. In subsequent passes, the interviewer uses predefined (but open-ended) probes, guided by psychological and organizational theory, to elicit the macrocognitive processes within and between those steps. For example, CTA analysts might try to uncover: (1) the step(s) in which the most challenging decisions were made, (2) what made those decisions difficult, (3) what information was needed to make the critical decisions, (4) who needed the information, (5) how that information was obtained and transmitted, (6) what went wrong or fell through the cracks and why, and (7) how the team detected failures and problems in the task.

An important feature of these interviews is that respondents are asked to first identify a single, recent instance of the task in which they were involved (such as a specific patient's visit this week). They are then asked to keep that instance in mind when answering questions. Once that instance is described, the interviewer shifts the focus and tries to identify naturally occurring variations in the task. To do so, the interviewer asks respondents to identify other specific cases in which the task deviated from the norm, and tries to probe with plausible, hypothetical "what if" scenarios to reveal how the interviewees think they would perform their part of the task and why. Great care is taken to guide the interviewees away from general or decontextualized task descriptions. As the interviewer collects different interviewee perspectives on the task, the interviewer begins to develop a more complete and richer sense of the task and the characteristics of its macrocognitive dynamics. In the end, the Task Diagram method produces a depiction of the physical work flow with some of its critical macrocognitive processes uncovered and described. The result can be shown to members of the organization, who are often surprised at how accurate and informative it is. It can also be used as the basis for process redesign, or to identify areas warranting deeper investigation using other CTA methods.

Examples

Christensen, Fetters, and Green (2005) conducted Task Diagram interviews with experienced family physicians to understand the range of ways in which they structured visits, focusing on when computerized reminders for preventive and chronic disease management services could be inserted into the work flow. The purpose was to understand the cognitive—not physical—dimension of their work flow well enough that they could introduce computerized reminders while minimizing the risk of negative consequences, such as distracting from patients' primary concerns or increasing provider burden and stress. They discovered clear patterns in how physicians structured patient visits, which helped pinpoint stages at which reminders would be helpful, rather than disruptive. The findings allowed the team to design and implement an effective clinical reminder system that avoided producing "reminder fatigue" (Green, Nease, and Klinkman, 2009), the commonly observed decrease of response rates to reminders over time as a result of excessive reminders.

As another example, Shachak, Hadas-Dayagi, Ziv, et al. (2009) used Task Diagram interviews and observations to understand the cognitive aspects of physician electronic medical record (EMR) use. They focused on the benefits, errors, and patient communication problems associated with EMR use, and the role of physician EMR expertise in overcoming those communication problems. On the one hand, they found that physicians felt the EMR helped their decisionmaking, and thus improved patient care and safety, by making patient information more comprehensive, organized, and readable, and including decision aids and warnings of adverse drug interactions. On the other hand, they discovered that physicians were susceptible to EMR-specific errors, including making typos, choosing an option next to the correct one on pull-down menus, and entering data on the wrong patient's chart. They also found that physicians were aware that these errors were occurring, and, in some cases, routines had been put in place to better catch them (known as "problem detection"). Finally, they found that certain computer skills and spatial organization of offices helped physicians overcome some EMR-related patient communication barriers.

PCMH Application

Implementing PCMH functions in a practice requires improving clinical and organizational routines, and key aspects of those routines are macrocognitive in nature. The Task Diagram method focuses on revealing the macrocognitive aspects of practices' routine work flows, to offer important new insights into clinical and organizational process redesign. For example, it can be used for the formative evaluation of practices' change routines. We are currently conducting a study using Task Diagrams supplemented by Team Knowledge Audits (see below) for, among other things, studying and offering consultation on improving practices' change routines so that the practices can more effectively implement a health information technology (IT) system. We found great variation in how practices were approaching change implementation, but none had any change or implementation routines per se. They varied widely in their ability to engage in sensemaking, planning, communication, problem detection, and replanning. Identifying how practices address these macrocognitive functions during implementation gave us a more detailed understanding of their "change capacity." This, in turn, allowed us to make evidence-based and contextually tailored predictions about the future implementation difficulties they were likely to face, and make targeted recommendations, customized for each practice.

Concept Mapping

The objective of Concept Mapping is to understand and graphically depict how ideas (that is, concepts) on a given topic are related. In CTA, these ideas refer primarily to beliefs and values, which are connected in a network or "mental model." The beliefs and values in one's mental model of a topic and the connections between them define one's understanding of that topic. In CTA, Concept Mapping has traditionally been used to map the mental models of experts on critical tasks. Experts' mental models shape what they are aware of, what they pay attention to, what options and possibilities they consider, how they make sense of events and experiences, solve problems, make judgments, and ultimately make decisions and act. Taken together, these account for how well and consistently they perform both routine and exceptionally challenging tasks.

Concept Mapping a mental model involves choosing a topic, eliciting an individual's beliefs and values about that topic, identifying how those beliefs and values are related, and then graphically depicting the parts of the model and their relationships. For practical purposes, topics typically address: (1) how some category of things is organized, (2) how a system works, or (3) how to perform some task properly. The first type of mental model tends to be typological, whereas the latter two tend to have sequential and causal links. Models can vary in a number of ways, including their completeness, their internal consistency, their sophistication, and their ability to account for phenomena. For example, consider how differently the mechanisms of diabetes are understood by a molecular biologist, a family physician, a diabetic educator, and a patient.

Concept Mapping has evolved over time so that, in addition to being used to capture experts' mental models, it is now used to measure group consensus (Trochim and Kane, 2005), team mental models (Burtscher and Manser, 2012; Mohammed, Ferzandi, and Hamilton, 2010), and cultural mental models (Sieck, 2010).

Example

An example of one of the newest forms of Concept Mapping is Rasmussen, Sieck, and Smart's (2009) "cultural network analysis" (CNA), which they used to reveal and explain key cultural differences between American and British military conceptions of effective planning. In mapping out the network of officers' concepts, values, and causal beliefs about effective planning, they discovered that, in British military culture, effective planning consists of communicating the plan's intent so that it can be flexibly implemented in the field as circumstances change. In contrast, effective planning in American military culture aims to reduce the need to make decisions in the field by working through various contingencies ahead of time. These findings were used to improve joint British-American military planning operations.

PCMH Application

One of the cornerstones of a PCMH is to improve patient care by developing more effective coordination among providers, staff, and organizations involved in a given patient's care. Providers and staff inevitably identify with different personal, professional, and organizational cultures. This means that, for a PCMH model to succeed, it is important to identify and address important tacit differences in their mental models of such organizational and clinical functions as planning, coordination, cooperation, remuneration, disease management, self-management, and even what it means to be a PCMH (see Hoff, 2010). As demonstrated in the example of military planning, (cultural) mental models need not be identical for coordination to succeed. However, understanding differences in mental models, as well as the effect of these differences on social interactions, helps one calibrate and reorganize complex interactions so that they are more effective.

Team Knowledge Audit

The Team Knowledge Audit (TKA) is derived from the well-studied Knowledge Audit (KA) CTA tool (Klein and Militello, 2005; Militello and Hutton, 1998). The KA was developed using insights from the literature on expert-novice differences in decisionmaking (Ericsson and Smith, 1991), and is designed to probe for macrocognition functions in routine knowledge work. The TKA is the KA extended to focus on macrocognitive functions between, as well as within, individuals on a team (Klein, Pliske, and Thordsen, 1999; Militello, Kyne, Klein, et al., 1999). Much of a team's expertise is contained in tacit understandings of how it performs macrocognitive functions, and key knowledge may be distributed (held across team members) or dispersed (portions held by different members) (Becker, 2004). Like the highly automatized knowledge of individual experts, the team's expertise is often employed with little conscious awareness.

The TKA focuses on identifying the specifics of how members of a team carry out macrocognitive functions, rather than on how they understand them (that is, team mental models), as would be revealed by the Concept Mapping method. TKA uses mainly semi-structured interviews, but commonly includes observations of team interactions and analyses of forms, logs, patient charts, and other artifacts. Each interview begins with a set of probe questions that are structured to elicit the tacit knowledge of the team. Multiple team members are interviewed independently to elicit both distributed and dispersed knowledge and distinguish the two. The probes focus on how the team executes macrocognitive functions related to the task and context. Similarly, observations and artifact analyses focus on uncovering macrocognitive functions.

The TKA typically builds on a Task Diagram, and develops additional detail about the execution of each step and the coordination between steps. Not all categories of macrocognition are necessarily informative for any given task, so the interviewers will often increase or decrease their use of various planned probes as the interviews progress. As in the Task Diagram method, interviewees are guided to relate how tasks are carried out with specific examples in mind, and are carefully dissuaded from answering in the abstract. Finally, the TKA usually focuses on how teams currently carry out their tasks, though it can be used for studying past routine tasks.

Examples

The TKA has been applied successfully to develop a training program for surgical teams to make optimal use of newly introduced, very complex patient status and management plan displays in cardiothoracic surgery suites (Crandall and Grome, 2010). Detailed mapping of the teams' planning, problem detection, coordination, and replanning revealed patterns that resulted in marked changes from the initial design of the displays themselves and the training program for introducing them. As a result of this process, improvements were introduced before the training began, avoiding potentially costly and disruptive revision.

In another project, we are combining a Task Diagram and TKA to understand how practices implement care management for chronic diseases, and relating the findings to quantitative changes in quality indicators. In yet another, we are using the TKA to examine macrocognition process differences in whether and how primary care practices accomplish the changes necessary to implement a PCMH functionality of their choosing (such as, test tracking and followup, patient registries, or care management) in a setting where they have financial and organizational incentives to do so.

PCMH Application

The TKA has been used extensively in other fields for knowledge transfer, that is, to understand what high-performing teams are doing accurately enough to instruct new or lower-performing teams and improve their performance (see, for example, Klein and Militello, 2005). In a PCMH context, the TKA offers a structured, rigorous approach to yield more comprehensive and contextually detailed "best practices." These best practices can distill the skills developed and used by practices doing well with PCMH activities to help those doing less well. TKAs also can be conducted within organizations with teams within practices that differ in levels of success, enabling them to share knowledge to increase overall effectiveness. Finally, TKAs and other CTA techniques can also be used to understand and improve the ways best practices are disseminated.

III. Advantages

Macrocognition is rarely studied in health services research or addressed in practical primary care applications, and yet is at the heart of complex, interdependent knowledge work such as the teambased care that PCMH models require. Below we list three advantages of using CTA to understand and improve PCMH implementation.

Helps uncover the thinking and decisionmaking involved in PCMH models. A key advantage of CTA is that its structured approach to elicitation and its focus on macrocognition reveal important phenomena that are often missed by traditional methodologies (Ryder and Redding, 1993; Schneider, 1985). CTA arose in part because attempts to implement findings from behavioral task analysis resulted in errors and poor performance (Schraagen, Chipman, and Shute, 2000), leading to a realization that observation and more traditional interview approaches produced incomplete information. Macrocognitive processes often are not observable, and introspection in un- or semi-structured interviewing does not often bring them out spontaneously. Skilled teams usually carry out macrocognitive functions and processes so automatically that the methods and reasons behind them go unnoticed or are misperceived unless specifically and skillfully elicited. CTA's specific focus on eliciting macrocognitive functions and processes helps ensure that they will not be overlooked.

Provides results that can be used to improve training and transition processes. The power and flexibility of CTA methods to help understand a variety of relevant features in a given cognitive landscape has yielded benefits in individual and team training, quality improvement and safety, and change efforts more generally. Each of these, in turn, serves to decrease the risk of being blindsided by unanticipated consequences when implementing a PCMH, which keeps costs down, and quality, productivity, and collective self-efficacy high.

Supports efforts to obtain organizational buy-in. The existence of a large, practical, applied body of CTA literature and respected consultants with portfolios of successful work for prominent clients provides reassurance and credibility to teams anxious about change and looking for guidance.

IV. Limitations

Requires a fairly high level of skill to execute properly. Investigators who possess a clear understanding of how the different macrocognitive and organizational theories bear on their objective (in this case, PCMH models) yield better results. Both interviewers and analysts (if they are not the same) benefit greatly from understanding how the techniques are grounded in the cognitive sciences, as this affords the necessary flexibility to adapt and blend CTA methods to one's purposes, including "on the fly" during interviews. For this reason, CTA is not amenable to scripted interviews conducted by student research assistants.

Involves time-consuming processes. Though it need not be excessively so, using CTA methods can be time-consuming. With training, practice, and a sufficiently focused objective, a CTA can be designed, conducted, and analyzed in a week's time. An example of a smaller CTA project might be mapping an exceptionally good care manager's mental model of effective communication with and engagement of providers.

Better suited to process than outcomes studies. Like other qualitative methods, CTA is not especially good at testing hypotheses (although, Crandall, Klein, and Hoffman [2006] do describe how to use CTA in an experimental design). Ultimately, CTA is best suited for uncovering, describing, and explaining how thinking happens in a specific and complex context.

V. Conclusion

CTA's benefits are showcased by its decades-long track record of success in delivering tangible benefits where stakes are high and failure is very visible, including for high-profile organizations such as the U.S. Armed Forces, the national air traffic control system, nuclear power plants, and intensive care unit and operating room teams in major health care systems (Crandall and Grome, 2010; Crandall, Klein, and Hoffman, 2006). CTA is a powerful addition to methods for studying the implementation of PCMH models and identifying and disseminating contextually grounded best practices. It is used to understand how cognitive tasks are carried out—how the knowledge work of a PCMH is done—by primary care clinicians and staff. Ultimately, this richer understanding facilitates the transfer of what is essential in best practice skills to other staff and organizations implementing PCMH models.

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