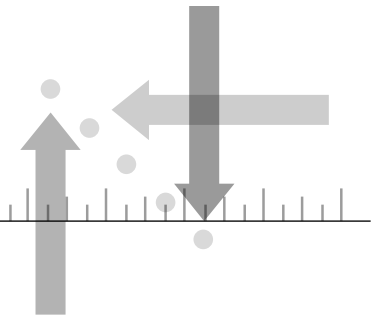

# COGNITIVE TASK ANALYSIS

## Purpose

The purpose of a cognitive task analysis (CTA) is to systematically define the decision requirements and psychological processes used by expert individuals (or performers) in accomplishing results.

## Needs Assessment Applications

A standard task analysis explains the processes and inputs that are being used at this time to accomplish results. As a consequence, a task analysis defines what individuals and teams either are doing or should be doing to contribute to current results. In the completion of a needs assessment, the task analysis is a vital tool for informing both the diagnosis of needs and the detection of potential remedies for improving performance.

In a CTA, however, cognitive analysis methods focus on the psychological processes underlying the completion of a task. For example, CTA may be used when one is trying to understand how master teachers are able to manage student behaviors in classrooms. CTA should be used whenever complex decisions are required (such as when multiple contributing variables and options must be weighed by the performer) and when few observable behaviors can be identified. Subtle cues from the performance context and the experience of expert performers are often discovered through the CTA technique. Of the many tools and techniques offered in this book, CTA is one of the more difficult approaches to undertake.

## Advantages and Disadvantages

### *Advantages*

- A CTA generates detailed, precise information on the nature of expert performance in a specific task of interest.
- When implemented correctly, CTA techniques provide highly valid sources of information on expert cognitive processes.
- A CTA provides systematic procedures (rather than hit-or-miss steps) for ascertaining expert cognitive processes.

### *Disadvantages*

- Analysis of the data gathered during a CTA can be time-intensive.
- CTA does not always capture other noncognitive attributes necessary for accomplishing results (such as physical capabilities, access to resources, and interpersonal relationships).
- The results of a CTA can be misleading when expert performers have performance capacities beyond that of others (for example, a CTA can be done with high-performing professional athletes, but implementation of cognitive processes alone will not duplicate performance).
- Completing a task analysis, especially a CTA, is usually more complex than completing the task itself. For complex tasks, you will likely want to use a task analysis expert to get useful results.

## Process Overview[1]

### *Collect Preliminary Knowledge*

To kick off the CTA process, identify some key cognitive tasks to study (for example, how master teachers manage classroom behavior) that are important elements in the achievement of particular results (for example, improvements in student performance on tests). In particular, identify those cognitive tasks that merit *detailed* study through CTA. As you proceed through the following steps, pay special attention to (a) tasks that are important, fre-

quent, and highly critical cognitive tasks within the job performance that you are studying and (b) tasks or problems that are within the job performance and that allow for discrimination between expert and novice performance (such tasks are referred to as *representative tasks*).

1. Develop some general understanding of the domain area (for example, training of teachers) in which the CTA will be conducted and of the common terminology used in that domain area. This understanding will make it a lot easier to conduct an effective CTA.
2. Identify experts who are good candidates (for example, master teachers) for serving as subjects of the CTA (ideally two or more experts should be identified for participation). Experts with recent experience in both performing and teaching the cognitive skill are generally considered to be good candidates for participation.
3. Identify the knowledge structures associated with the task area through one or more of the following substeps:
    a. ***Document review and analysis:*** Review any written materials that you can locate and that provide relevant information on the tasks you have identified as being of interest. Documents could include job descriptions, reports, training materials, and so on. By reviewing available documents and research, you are better prepared to conduct interviews with experts, and you are able to (later on) identify discrepancies between extant training (performance support materials) and expert performance.
    b. ***Observation:*** Observe an expert conducting the tasks and procedures of interest to the CTA (for example, teaching a classroom subject to high school students). Record the actions and conditions that are naturally a part of the process of executing the tasks that are of interest. Make special notes of points in the task-completion process where it seems that the expert is engaged in decision making, analysis, or other critical cognitive tasks.
    c. ***Unstructured interviews:*** When you are conducting an unstructured interview, it generally is helpful if you have been able to do a document analysis or observation beforehand. For the interview, your goal is to ask the expert direct questions that will give you more information about the tasks and to sort through preliminary questions that may help you in preparing for structured interviews that you complete later in the process. Because the interview is unstructured, you may opt to

take a "go with the flow" approach for the interview, or you may ask the expert to focus on a specific aspect or task related to the domain area.

### *Identify Knowledge Representations*

Using the results from the preliminary knowledge data collection, identify the subtasks and knowledge that are associated with each of the primary tasks that you are interested in studying further. Generally, an effective approach for visually organizing this information is by creating a visual representation of the relationship between the tasks, subtasks, and knowledge associated with the domain of interest. Concept maps can be an effective approach to visually representing the knowledge and task structures.

### *Use Focused Methods to Gather Information*

1. If the CTA will be conducted by someone other than you, identify someone to serve as the cognitive task analyst. Note that it is highly desirable to choose this individual carefully. Ideally, it is someone who can interact comfortably with the subject matter expert and who can learn domain- and task-specific terminology efficiently.
2. Choose one or more of the following methods to work with the expert(s) to identify, cluster, link, and prioritize the critical cognitive decisions that are routine in expert performance. All of these knowledge-gathering methods can be used with expert performers. If you intend to also gather information from novices, however, it is recommended that you select either *structured and unstructured interviews* or *concurrent verbal protocol analysis* as knowledge-gathering methods, because the other techniques assume a high level of domain knowledge.
    - ***Structured and unstructured interviews:*** One approach is to ask the expert (for example, a master teacher) to list (a) all of the steps involved in completing the subtasks (for example, how to call on students, how to deal with misbehaviors, and so on) that are part of the larger task (for example, classroom management) that you are studying; (b) key decision points, and when those decision points appear; (c) procedures that can be used to make decisions between alternate options; (d) conceptual knowledge required to tackle the subtasks; and (e) ways that the expert determines when the conditions call for beginning the process for completing the subtask(s).

- ***Concurrent verbal protocol analysis:*** To begin a protocol analysis, you should work with experts to identify a good "representative task" in the task area. An example could be how a master teacher would deal with a disruptive student. Develop a problem or scenario around that representative task, and ask several experts (such as master teachers) to review and modify the problem or scenario before using it for knowledge gathering.

  To begin understanding the task (for example, the process of dealing with disruptive students), you should schedule time with the expert in a quiet location where you have audio or video recording capabilities. Prepare and train the expert for solving problems aloud by giving him or her instructions on how to think aloud, as well as by giving the expert the chance to think aloud while solving at least two or three sample problems so that he or she can get comfortable with the verbalization process. Next, present the main problem or challenge to the expert. Record all of the verbal utterances of the expert as he or she solves the problem. It is very important that you avoid interrupting the expert at any time during the problem-solving process. If possible, gather verbal protocols from several experts for the same problem, and pay special attention to problem-solving steps and strategies used by all or most of the experts.

- ***Applied cognitive tasks analysis:*** In this approach, you conduct three structured interviews. Each interview generates a separate product. Through the first interview, you develop a *task diagram* that gives a broad representation of the task and specifically allows you to hone in on complex cognitive processes that merit further consideration. The second interview yields a *knowledge audit*, which probes the expert on the skills and knowledge applied to tackle specific component tasks or decision points in the overarching task process. The third and final interview involves presenting the expert with a specific and relevant scenario designed to elicit insight into the cognitive processes used by the expert in the scenario context. The compiled and analyzed results from the applied cognitive tasks analysis are represented in a *cognitive demands table*.

- ***Critical incident (or decision) method:*** This procedure begins with the expert identifying a situation in which he or she had to apply expertise to a critical and uncommon situation relating to the task area of interest (for example, a classroom where students were starting physical fights). The expert describes the incident, and the analyst works with the expert to create a time line for the incident. The ana-

lyst then works with the expert to try to identify key points on the incident time line when decisions had to be made (for example, when to intervene to prevent fights in classrooms). From there, the analyst closely questions the expert to identify perceptual cues and prior knowledge that were used in the decision making, as well as alternative decisions that could have been made. An understanding of those key decision points, as well as of the representative tasks that experts can perform and that novices have difficulty performing, is an important result of using the critical incident method.

3. Develop a protocol for each of the knowledge-gathering methods selected. Next are recommendations for the design of the protocols for each of the knowledge-gathering techniques:

   - ***Protocol for structured and unstructured interviews:*** Develop instructions and questions for interviews, focusing on key decision points, procedures for choosing between different options at decision points, and domain knowledge.

   - ***Protocol for concurrent verbal protocol analysis:*** Develop a protocol that provides participants with information on procedures for verbalizing thought sequences, as well as a few simple problem-solving tasks that can be used to practice the verbalization process. The protocol should conclude with the presentation of the main problem (based on the representative task).

   - ***Protocol for applied cognitive task analysis:*** Develop instructions and questions for each of the three interviews. For the task diagram, come prepared with paper, sticky notes, markers, or a computer to diagram the tasks. For the knowledge audit, come prepared with some idea of what the possible knowledge and skills would be so you are able to probe for more information. For the third interview, prepare scenarios for the expert to discuss.

   - ***Protocol for critical decision method:*** Develop instructions and questions, focusing on key decision points, procedures for choosing between different options at decision points, and domain knowledge in use in the critical incident identified by the expert.

4. Apply the knowledge-gathering technique. It is highly advisable that you record the knowledge-gathering session in either audio or video format (video format is justified in cases where the task includes psychomotor actions). Make sure that you have the expert's permission in

advance to record the session. Because people generally do not feel immediately at ease with being recorded, and because the knowledge-gathering exercise may be unfamiliar to the expert, it is highly recommended that you run through with the expert an example session of the exercise before conducting the actual knowledge-gathering session. This suggestion is particularly relevant if you choose to implement a concurrent verbal protocol analysis, an applied CTA, or the critical decision method.

### *Analyze and Verify Data Required*

1. If you have recorded the knowledge-gathering session(s), transcribe the recorded information into a text-based format.
2. Prepare the transcripts for further categorization and synthesis by coding them. Pay special attention to diagnosing and characterizing key decision points on the basis of the techniques used, the cues signaling the decision points, and the inferences made.
3. After coding has been completed, organize the data from the transcripts into a format that summarizes and categorizes the data.
4. Provide a copy of the formatted results from the knowledge-gathering session to each of the experts from whom you gathered data. Allow the experts to make any suggestions for changes or clarifications.
5. Integrate edits and adjustments recommended by the experts.
6. Compare the formatted results for each of the expert knowledge-gathering sessions, and verify that the formatted results reflect the knowledge representation for the task area.

### *Format Results for Intended Application*

1. Using the formatted results from the expert knowledge-gathering sessions, create a single model task analysis, representing all the skills, knowledge, and strategies used by the experts when functioning in the task area.
2. Write a summary report of the findings from the CTA.
3. The task analysis is an essential ingredient of a needs assessment and should be used as a point of comparison with other assessment data (for example, surveys, interviews, focus groups) to inform your decisions.

## Tips for Success

- Strive to be very systematic in your analysis.
- Remember that actions speak louder than words; it is better to observe individuals performing the task than to simply ask them what they do.
- Also remember that expert performers have often internalized or made habitual many of the key decisions that go into performing the related steps within the task. This internalization makes completing a cognitive analysis challenging. Aid expert performers in communicating their cognitive processes by using techniques such as card sorting, process tracing, or concept mapping.

## Note

1. Based in part on Clark et al. (2008). Also available at http://www.cogtech.usc.edu/publications/clark_etal_cognitive_task_analysis_chapter.pdf.

## References and Resources

Clark, R. E., D. Feldon, J. J. G. van Merriënboer, K. Yates, and S. Early. 2008. "Cognitive Task Analysis." In *Handbook of Research on Educational Communications and Technology*, 3rd ed., edited by J. M. Spector, M. D. Merrill, J. J. G. van Merriënboer, and M. P. Driscoll, 577–94. Mahwah, NJ: Lawrence Erlbaum Associates.

Watkins, Ryan. 2007. *Performance by Design: The Systematic Selection, Design, and Development of Performance Technologies That Produce Useful Results*. Amherst, MA: HRD Press, and Silver Spring, MD: International Society for Performance Improvement.

Witkin, Belle Ruth, and James W. Altschuld. 1995. *Planning and Conducting Needs Assessments: A Practical Guide*. Thousand Oaks, CA: Sage Publications.

### *Websites*

"Applied Cognitive Task Analysis (ACTA)" (by Militello and Hutton) is available at http://www.class.uidaho.edu/psy562/Readings/Militello&Hutton(1998).pdf.

"Cognitive Task Analysis" (by Clark, Feldon, van Merriënboer, Yates, and Early) is available at http://www.cogtech.usc.edu/publications/clark_etal_cognitive_task_analysis_chapter.pdf.

"Cognitive Task Analysis" (from NATO) is available at http://ftp.rta.nato.int/public//PubFulltext/RTO/TR/RTO-TR-024/TR-024-$$ALL.pdf.

"Cognitive Task Analysis for HPTers" (presentation slides generated by Stone and Villachica) is available at http://www.dls.com/1090_CTA_Panel.pdf.

"Protocols for Cognitive Task Analysis" (from the Institute for Human and Machine Cognition) is available at http://www.ihmc.us/research/projects/CTAProtocols/ProtocolsForCognitiveTaskAnalysis.pdf.