



COGNITIVE TASK ANALYSIS

PURPOSE

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

NEEDS ASSESSMENT APPLICATIONS

A 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 are either doing or should be doing in order to contribute to current results. In completing a needs assessment the task analysis is a vital tool for mutually informing the diagnosis of needs as well as the detection of potential remedies for improving performance. Cognitive analysis methods focus on the psychological processes underlying the competition of a task. Use cognitive analysis whenever complex decisions are required (such as when multiple contributing variables and options must be weighed by the performer) and few observable behaviors can be identified. Subtle cues from the performance context and the experience of expert performers are often discovered through this analysis technique.

ADVANTAGES AND DISADVANTAGES

ADVANTAGES

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

DISADVANTAGES

- Analysis of the data gathered during a cognitive task analysis can be time-intensive.
- Cognitive task analysis does not always capture other non-cognitive attributes necessary for accomplishing results (such as, physical capabilities, access to resources, and interpersonal relationships).
- The results of a cognitive task analysis can be misleading when expert performers have performance capacities beyond that of others (for example, a cognitive task analysis can be done with high

performing professional athletes but implementation of cognitive processes alone will not duplicate performance).

GENERAL PROCEDURES¹

COLLECT PRELIMINARY KNOWLEDGE

To kick off the cognitive task analysis process, identify some of the key cognitive tasks related to the completion of results within your results framework. In particular, identify those cognitive tasks that merit detailed study through cognitive task analysis. As you proceed through the steps below, pay special attention to (a) tasks that are important, frequent and highly critical cognitive tasks within the job performance that you are studying, and (b) tasks or problems within the job performance that allow for discrimination between expert from novice performance (these tasks are referred to as "representative tasks").

1. Develop some general understanding of the domain area in which the cognitive task analysis will be conducted, and develop a sense of the vocabulary that is associated with the domain. This will make it a lot easier to conduct an effective cognitive task analysis.
2. Identify experts who are good candidates for serving as subjects of the cognitive task analysis (ideally 2 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 subs-steps:
 - **Document review & 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 extant documents, you will be better prepared to conduct interviews with experts, and you will also be able to (later on) identify discrepancies between extant training/performance support materials and expert performance.
 - **Observation:** Observe an expert conducting the tasks and procedures of interest to the cognitive task analysis. 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.
 - **Unstructured interviews:** When doing an unstructured interview, it generally is helpful if you have been able to do a document analysis and/or observation beforehand. For the interview, your goal is to ask the expert direct questions that will give you more information about the knowledge domain, and to sort through preliminary questions that may help you in preparing

for structured interviews that you complete later in the process. Since the interview is unstructured, you may opt to take a "go with the flow" approach for the interview, or you can 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 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.

APPLY FOCUSED KNOWLEDGE ELICITATION METHODS

1. If the tasks analysis will be conducted by someone other than yourself, 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/task-specific terminology efficiently.
2. Choose one or more of the methods below 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 elicitation methods can be used with expert performers. If you intend to also gather information from novices, however, it is recommended that you select either *interviews* or *concurrent verbal protocol analysis* as knowledge elicitation methods, since the other techniques assume a high level of domain knowledge.
 - **Structured & unstructured interviews:** One approach that you could use when doing interviews is to ask the expert to list (a) all the steps involved in completing the subtasks that are part of the larger task you are studying, (b) the key decision points, and when those decision points appear, (c) procedures that can be used to make decisions between alternate options, (d) the conceptual knowledge needed to tackle the subtasks, and (e) how the expert determines when the conditions call for beginning the process for doing the subtasks(s).
 - **Concurrent verbal protocol analysis:** To begin a protocol analysis, work with experts to identify a good "representative task" in the task area. Develop a problem/scenario around that representative task, and ask several experts to review and modify the problem/scenario before using it for knowledge elicitation. To begin the knowledge elicitation, schedule time with the expert in a quiet location where you have audio/video recording capabilities. Prepare and train the expert for solving problems out loud by giving him/her instructions on how to think aloud, and by giving them the chance to think aloud while solving at least two or three sample problems so that they can get comfortable with the verbalization process. Next, present the main problem/challenge to the expert. Record all of the verbal utterances of the expert as he 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/strategies that all or most of the experts use.

- **Applied cognitive tasks analysis:** In this approach you conduct three structured interviews. Each interview generates as separate product. Through the first interview, you develop a Task Diagram that gives a broad representation of task and that 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 the tackle specific component tasks or decision points in the overarching task process. The third and last 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 Decision Method** (also referred to as "Critical Incident Technique"): This procedure begins with the expert identifying some situation in which he/she had to apply his/her expertise to a critical and uncommon situation that relates to the task area of interest. The expert describes the incident, and the analyst works with the expert to create a timeline for the incident. The analyst then works with the expert to try to identify key points in the timeline when decisions had to be made in the incident. From there, the expert is probed by the analyst to identify perceptual cues and prior knowledge that were used in the decision making, as well as things such as alternative decisions that could have been made. One of the key things that can be yielded through the critical incident method is an understanding of those decision points and representative tasks that experts can perform and that novices have difficulty performing.
3. Develop a protocol for each of the knowledge elicitation methods selected. Below are recommendations for the design of the protocols for each of the knowledge elicitation techniques:
- Protocol for structured interviews & 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 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 elicitation technique. It is highly advisable that you record the knowledge elicitation 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 to audio/video record the session in advance. Since people generally do not feel immediately at ease with being recorded, and since the process to be used may not be familiar to the expert, it is highly recommended that you run the expert through an example session of the knowledge elicitation prior to conducting the actual knowledge elicitation session. This is particularly relevant if you choose to implement a concurrent verbal protocol analysis, an applied cognitive task analysis or the critical decision method.

ANALYZE AND VERIFY DATA REQUIRED

1. If you have recorded the knowledge elicitation 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 decisions points based on the techniques used, cues signaling the decision points, and the inferences made.
3. Once 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 elicitation to each of the experts from whom you gathered data. Allow the expert to make any suggestions for changes or clarifications.
5. Integrate edits and adjustments recommended by the expert.
6. Compare the formatted results for each of the expert knowledge elicitations 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 elicitation 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 cognitive task analysis.
3. The task analysis is an essential ingredient to a needs assessment and should be used a point of comparison with other assessment data (e.g., surveys, interviews, focus groups) in order to inform decisions.

TIPS FOR SUCCESS

- Strive to be very systematic in your analysis.
- Actions speak louder than words; it is better to observe someone performing the task than to simply ask them what they do.

- Expert performers have often internalized or made habitual many of the key decisions that go into performing the related steps within the task. This 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.

REFERENCES AND RESOURCES

Watkins, R. (2007). *Performance By Design: The selection, design, and development of performance technologies that achieve results..* Amherst, MA: HRD Press, I.

WEB SITES

Cognitive Task Analysis (by Clark, Feldon, van Merriënboer, Yates and Early):

http://www.cogtech.usc.edu/publications/clark_et al_cognitive_task_analysis_chapter.pdf

Cognitive Task Analysis (from NATO):

[http://ftp.rta.nato.int/public//PubFulltext/RTO/TR/RTO-TR-024/TR-024-\\$\\$\\$ALL.pdf](http://ftp.rta.nato.int/public//PubFulltext/RTO/TR/RTO-TR-024/TR-024-$$$ALL.pdf)

Protocols for Cognitive Task Analysis (from the Institute for Human and Machine Cognition):

<http://ihmc.us:16080/research/projects/CTAProtocols/ProtocolsForCognitiveTaskAnalysis.pdf>

Applied Cognitive Task Analysis (by Militello and Hutton):

[http://www.class.uidaho.edu/psy562/Readings/Militello&Hutton\(1998\).pdf](http://www.class.uidaho.edu/psy562/Readings/Militello&Hutton(1998).pdf)

Cognitive Task Analysis for Human Performance Technologists (presentation slides generated by Stone and Villachica):

http://www.dls.com/1090_CTA_Panel.pdf

¹ Based in part on "Cognitive Task Analysis":

http://www.cogtech.usc.edu/publications/clark_et al_cognitive_task_analysis_chapter.pdf