

# Tools for Facilitating Critical Decision Method during Tacit Knowledge Elicitation

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## ABSTRACT

Critical Decision Method is an interview technique commonly used for eliciting tacit knowledge in challenging and atypical complex situations. Despite having comprehensive interview guides from the literature, conducting CDM can still be a challenge as the interview process is highly dynamic and opportunistic. We present a visualization tool configured from Microsoft PowerPoint to facilitate the interviewing process by allowing the interviewers to create an event timeline of the incidents described by the experts easily. In this paper, we discuss the features of this visualization tool and how this tool can be used together with Cognitive Demands Table spreadsheet to facilitate the interviewing process by ensuring an accurate and comprehensive knowledge elicitation in the context of wargaming.

## KEYWORDS

*Cognitive Field Research and Cognitive Task Analysis; Military*

## INTRODUCTION

In order to understand how to perform the tasks effectively in specific professional fields, we rely on the respective Subject Matter Experts (SMEs) to provide us with the appropriate knowledge. One of the common approaches in capturing this knowledge is through self-reports. However studies have shown that self-reports from experts are often inaccurate and incomplete (Blessing & Anderson, 1996). The inability to articulate the procedures clearly is due to automaticity of knowledge (Feldon, Timmerman, Stowe & Showman, 2010). As the SMEs acquire expertise in a specific skill, less conscious monitoring is required in performing the skills, hence allowing them to perform the task quickly. While experts can verbalize the actions that they perform, it is difficult for them to articulate the conditions of when these actions should be done.

In view of the limitation, Cognitive Task Analysis (CTA) is increasingly recognized as an approach to ensure a comprehensive elicitation of expert's knowledge. CTA is a general term that describes an inventory of techniques to elicit the related knowledge, cognitive processes and goal structures of performing a specific task (Chipman, Schraagen & Shalin, 2000). Interview techniques with SMEs, particularly Critical Decision Method (CDM) (Klein, Calderwood & Macgregor, 1989) are most commonly adopted by CTA practitioners (Tofel-Grehl & Feldon, 2013; Cooke, 1999). The insights from CTA interviews are often used to develop training materials (Feldon et al., 2011; Feldon et al., 2010), decision aiding tools (Hoffman, Coffey, Ford & Carnot, 2001) and also to inform the improvement of work processes and system design.

The interviewing process is however laborious and complex. CTA practitioner has to constantly identify critical decision points from the SME's responses and probe appropriate questions to elicit useful information without influencing SME's perception. In addition, decision points are usually opportunistic. Upon detection of a critical decision point, the CTA practitioner would have to interrupt the intended flow of the interview and delve deeper into the underlying identified decision point to uncover the critical cues and strategies. After the required information has been elicited, the CTA practitioner would then have to return to the original set of questions to ensure the completeness of the information captured. The iterative knowledge elicitation process makes it challenging for the CTA practitioner to recall all the questions that he needs to ask. Without a proper knowledge documentation tool, the CTA practitioner might be overwhelmed with the massive and unstructured set of knowledge provided by the SME. Failure to acquire a complete and accurate set of information during the CTA interview might consequently impede the development of effective systems or training materials.

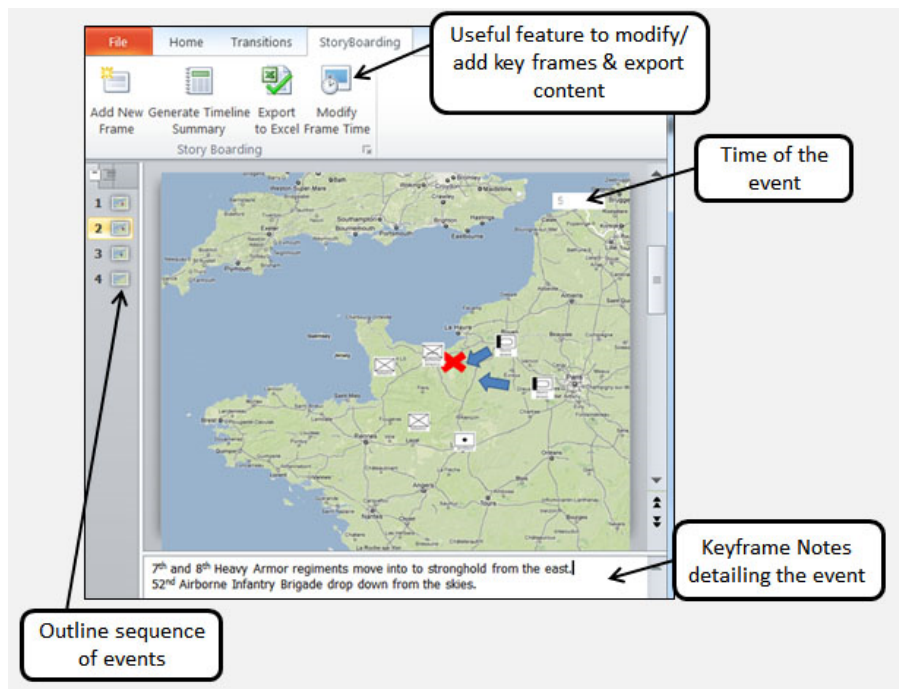
In view of the difficulties in conducting CTA interview, there is a need to develop knowledge documentation tools to facilitate these interviews. We present a visualization tool that we created by configuring Microsoft PowerPoint to allow the CTA practitioners to easily create a graphical event timeline of the incidents described by the SMEs. In this paper we will first describe how the visualization tool was developed and its unique features. Next we explore the feasibility of using this visualization tool together with a recommended template for knowledge documentation while conducting a series of CDM interviews in the context of wargaming.

## TOOLS TO FACILITATE KNOWLEDGE ELICITATION

There are several software tools developed to capture SMEs' knowledge. Radtke and Frey (1997) describes a procedure named "Sea Stories" that guides SMEs to "translate their conceptual knowledge and expertise into a representation" on a series of computer-based storyboards. The setback for this tool is that SMEs need to learn a set of procedures in order to use the tool effectively. Another limitation is that the SMEs will also have full control on what and how to translate their knowledge into an appropriate form. Granting full control to the SME would not be feasible because they might not be able to provide a complete description of the knowledge due to automaticity (Blessing & Anderson, 1996). An external intervention is required to probe deeper into the tacit knowledge.

### VISUALIZATION TOOL

The challenges faced by the CTA practitioners serve as the impetus to develop a tool to aid in their interview process. We designed a scenario drawing and visualization tool configured from Microsoft PowerPoint. Using macro programming and VBScripts within PowerPoint, new functional buttons and customized menu are developed for aiding CTA interview. Existing PowerPoint drawing tools and note-taking features are utilized with VBScripts so that all snapshots and notes can be compiled to create an event timeline. The scenario drawing tool uses the inherent drawing library in PowerPoint, which allows the CTA practitioners to quickly create snapshots of the critical events in the incident as described by the SMEs during the interview. Each snapshot exists as a slide and a customized duplicate slide function aids in the drawing of a series of events quickly. By creating the snapshot of the events, the CTA practitioners can better appreciate the incident as compared to an abstract verbal description by the SMEs. This snapshot feature also facilitates the interviewees' recall and verification of the events. After the snapshot of the events have been created, the tool can then compile all images and create an event timeline of the incident shared by the SMEs. The tool was originally designed for a series of CTA interviews in the context of military wargaming. However most of the features are context-independent and can be used in other domains as well. The tool interface is shown in Figure 1 and some of the key features are described as follows:



**Figure 1.** Features of the scenario drawing tool. The readily available maps, entity symbols and textbox allow CTA practitioner to quickly create the events together with the SME. Tagging a time to each event allows the tools to create an event timeline once all events have been described.

### Readily available maps and symbols

There is a set of maps and entity symbols that have been designed and installed in the tool. Both maps and symbols can be designed using PowerPoint or represented as a snapshot. For this version of visualization tool, the maps and symbols are designed specifically to the context of wargaming. During the interview, the CTA practitioner can immediately choose the map relevant to the incident and place it in the first PowerPoint slide. He can create a quick replication of the critical events by placing the entities on the maps according to the description of the SME. Subsequent events can be created easily by duplicating the previous slide and

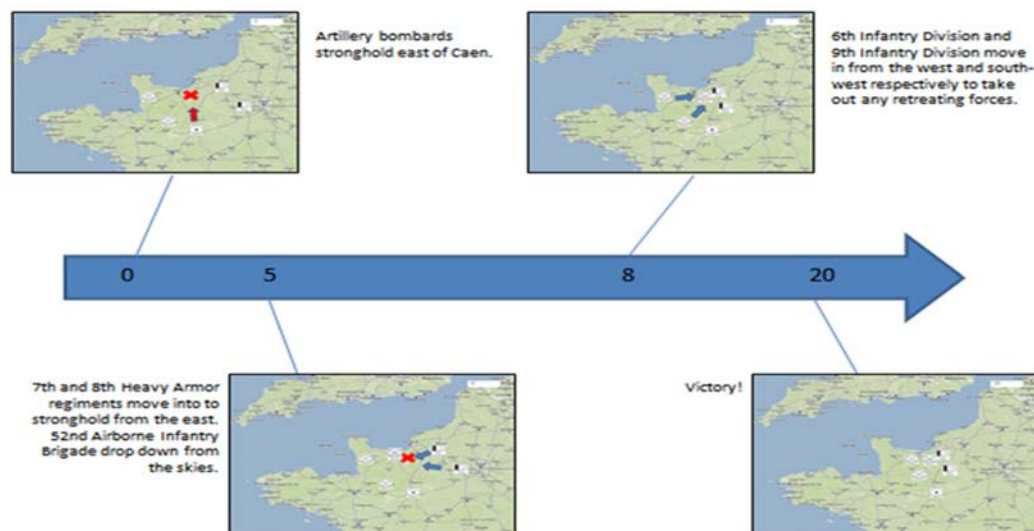
repositioning / adding / removing elements that differ from previous event. The CTA practitioner can also create and save new entity symbols during the interview. Each of these critical events can also be time-stamped, so that the slides can display the flow of the entire incident visually. This feature is extremely useful because the sequential slides contain much richer detail as compared to the typical hand-drawn image by the SME on paper, where one image is often used to depict the entire incident.

### Textbox to allow detailed description of events

Textbox is also provided in the tool so that the CTA practitioner can make comments or observations that are difficult to represent in the scenario drawing tool. The information is normally a specific description of the particular slide. It is recommended to keep the comments short so that when the slides are compiled, the notes will not clutter the event timeline.

### Automated generation of event timeline

The tool allows the CTA practitioner to document the time of critical events mentioned by the SME during the interview. With the time provided for each event, the tool can immediately generate an event timeline of the incident in a slide. The timeline can then be presented to SME for discussion and verification during the interview. The benefit of using the tool to create the event timeline is that the CTA practitioner can make any refinement or changes immediately without messing up the event flow: the CTA practitioner can just return back to the slides and make the necessary amendments and create a new event timeline by compiling the slides again. The scenario drawing tool and visualization of the event timeline is shown in Figure 1 and Figure 2 respectively.



**Figure 2.** Auto-generated event timeline. The images of the key events will be presented in a timeline together with the notes that were written for each event.

## FACILITATION FOR CTA PRACTITIONERS

The finalized version of the visualization tool was implemented in a series of actual interviews conducted by a group of CTA practitioners (Tan, Tee & Soh, 2014). A total of six CTA practitioners were involved in these interviews. At least two CTA practitioners were assigned to each interview. The objective of the study was to elicit the warfare knowledge from experienced officers, and translate the knowledge into a set of training content and scenarios in a training simulator. A total of 40 incidents were captured from 27 experienced officers. In addition to the visualization tool, key information documented during the interviews was organized directly using the Cognitive Demands Table (CDT).

### Critical Decision Method (CDM)

In this study, CDM was adopted by the CTA practitioners as the main interviewing method. CDM is an incident-based interview where the SME is asked to recall a highly challenging or unusual event that he experienced (Klein, Calderwood & Macgregor, 1989). In essence there are four broad phases in the interview. SME is required to share a personal incident that he felt was challenging at that time. If the incident is deemed appropriate and aligns with the objective of the CTA interview, the next phase is to elaborate the incident further by creating a timeline of events. The third phase is to probe into the critical decision points to identify the perceptual cues and alternative options when making a decision. These dimensions are aligned with what experts typically find difficult to articulate during self-reports. If time permits, the CTA practitioner will ask

hypothetical “what-if” questions to understand how the decisions might change with varying conditions or situations. Guides in conducting CDM are well-documented by Crandall, Klein and Hoffman (2006).

**Cognitive Demands Table**

As part of the recommendation by the Applied Cognitive Task Analysis framework by Militello and Hutton (1998), Cognitive Demands Table (CDT) is used to document elicited information from the CTA interviews. Given that not all information provided during the interviews will be important, the format provided by the CDT helps the CTA practitioners to quickly filter out irrelevant data. The CDT provides a standard set of headers that CTA practitioners can use to categorize the information gathered from their interviews. The headers are namely “Difficult Cognitive Elements”, “Why difficult”, “Common errors”, and “Cues and strategies used”. However the CTA practitioners do not necessarily have to adhere to this set of headings, given that the purposes of CTA interviews can be vastly different. The CTA practitioners are allowed to alter according to the information they would need in order to translate the CTA findings effectively.

While CDT proves to be an effective tool for knowledge representation during the interviews as well as for analysis purposes, the knowledge is mainly represented in the form of text. Text-based representation makes interpretation difficult, especially when there is a need to understand the incidents quickly. For instance during follow-up interview, the CTA practitioner and the SME might have to spend some time reading through the text during the interview to ensure that all critical events have been covered. In situations like this, some form of visualization of the events would potentially improve the usability of CDT, and subsequently enhance the workflow of CTA practitioners. For this purpose, the visualization tool would serve as a complementary tool to CDT.

**Evaluation of facilitation tools for CDM interviews**

The implementation of both visualization tool and CDT was useful to the CTAA practitioners during the interviews. The advantages of both facilitation tools are described as followed:

*Accurate representation of events using the scenario drawing and visualization tool*

By creating images of the events during the interviews, the CTA practitioners had a better comprehension of the incident described by the SMEs. Misunderstanding by the CTA practitioner was also easily resolved as the SMEs could immediately point out any incorrect representation of the event. As the timeline provided a visual representation of how the events transited, the CTA practitioners could easily identify any gaps between the events that might be critical and probe further.


*CDT provides affordance on the areas to deepen*

Information elicited during the interviews was typed into the respective CDT columns. As decision points were identified, the CTA practitioners sometimes might skip the current set of questions and delve into the identified decision point. The information that hadn’t been asked was hence left blank. The empty spaces served as an affordance for the CTA practitioner to identify which area/s required further deepening. Therefore CDT helped by relieving the CTA practitioners from having to remember the questions that he had to ask.

*Knowledge easily understood and interpreted*

We added an additional column in CDT to include the images of the events created by the scenario drawing tool. During the analysis phase of the interview data, the images certainly helped the CTA practitioners to quickly recall the incidents without having the read through the text. It was also easier for the SMEs to recall what incidents they shared when the CTA practitioners sent the CDT spreadsheet to them for clarification and verification. An example of the CDT is shown in Table 1.

**Table 1.** Example of Cognitive Demands Table (CDT): The event image created from the scenario drawing tool is added into CDT to better understand the incident. The empty cells in CDT help the CTA practitioners to identify areas that have not been addressed during the interview.

| Events  | Storyline and Decisions  | Strategies                               | Challenging Cognitive Demands | Expert-Novice Differences                 | Lessons                                   |
|---|--|--|-------------------------------|---|---|
|  | 6 <sup>th</sup> and 9 <sup>th</sup> infantry Division move in from the west and south-west respectively to take out any retreating forces. | Adversary starting to retreat eastwards. |                               | Novice might perform X instead because... | (Keywords highlighting the lesson learnt) |

Empty cells indicate areas that have not been addressed.

## CONCLUSION

The process of conducting CTA interview is laborious and cognitively demanding. With the increasing demands of CTA for expert knowledge elicitation, there is a need to develop tools to facilitate the interviewing process to ensure comprehensiveness and accuracy in the information collected. The scenario drawing and visualization tool aims to facilitate the communication between the CTA practitioner and the SME so that the information described by the SME can be represented quickly in a visual form. Coupled with CDT, the interview process is less cognitively demanding as both tools allow the CTA practitioner to identify topic of interest during the CDM interviews as well as for analysis phase.

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