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STUDYING TRANSFORMATION: THE USE OF CMAPTOOLS IN SURVEYING THE INTEGRATION OF INTELLIGENCE AND OPERATIONS

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Abstract. The analysis of qualitative data in the social sciences is notorious for inviting criticisms of non-standardization and lack of "rigor." While many approaches to collecting qualitative data have been described, the follow-on stage of discovery and analysis is often underspecified, and can result in the appearance of haphazard or incomplete study.

This paper reports on the use of CmapTools for supporting the analysis of qualitative data. The real-world setting for the approach was a worldwide "survey" of United States Department of Defense Combatant Commands. The qualitative data analyzed was collected during interviews conducted by a team of researchers using forms of Cognitive Task Analysis (CTA) methods. The data was analyzed by another group of researchers. CmapTools was selected to enable inspection of the data because the application provided automated support for merging, organizing, and producing a variety of representations for analysis. Analytic and operational advantages of the approach, as well as dangers, are presented here.

1 Introduction

Within the social sciences, debate has long raged about the proper methods for understanding social phenomena. In the related domains of cognitive psychology, human factors, and organizational research, the debate focuses on two general schools of thought and practice. In one school, laboratory-based, tightly "controlled" methods are the tools of trade, and preferred for their production of statistically-manipulable data. In another school, "cognitive task analysis" (CTA) approaches to understanding naturally occurring phenomena are the methods of choice. The CTA approaches, while often more insightful than laboratory methods, produce qualitative data that is less structured and not uniformly manipulable. Naturalistic researchers, thus, often face criticism from laboratory-based researchers regarding the "rigor" of their approaches. Yet the critiques disregard their strongest appeal – bringing under inspection the natural world in all of its disparate occurrences and ostensibly "messy" forms.

To be sure, some of the critiques of CTA-based approaches are deserved, as they have historically provided detailed guidance in the collection of data yet underspecified their analysis methods. Researchers often feel themselves drowning in a sea of data and insight without the life-preserving benefits statistical analysis can bring. But it is not the absence of a standardized technique that causes the sea-sickness. Indeed, Blumer (1965) has pointed out that the process of inspection – not standardization of technique – is the *sine qua non* of scientific investigation of social phenomena:

> By "inspection" I mean an intensive focused examination of the empirical content of whatever analytical elements are used for purposes of analysis, and this same kind of examination of the empirical nature of the relations between such elements…such analytical elements may refer to processes, organization, relations, networks of relations, states of being, elements of personal organization, and happenings…The procedure of inspection is to subject such analytical elements to meticulous examination by *careful flexible scrutiny* of the empirical instances covered by the analytical element…The prototype of inspection is represented by our handling of a strange physical object; we may pick it up, look at it closely, turn it over as we view it, look at it from this or that angle, raise questions as to what it might be, go back and handle it again in the light of our questions, try it out, and test it in one way or another. This *close shifting scrutiny is the essence of inspection*.

What CTA-based researchers need are methods to support inspection.

This paper reports on the use of CmapTools (Cañas, 2004) for supporting the inspection of qualitative data. We worked with a team of researchers to inspect very large sets of CTA-based data, and in the process learned a number of lessons that are of value to researchers facing analysis of similar data. Thus, we believe the paper has a wider application than the CmapTools user community.

2 Application of CmapTools

In early 2006, the United States Joint Forces Command (USJFCOM) marshaled a team of researchers and experienced operators from across the intelligence community to conduct a survey of the nine Combatant Commands' (COCOM) efforts at transforming their intelligence operations, or their Joint Intelligence Operations Centers (JIOC). The number of interviews at each COCOM varied by available and appropriate personnel, time to collect, and other time-consuming activities. At the time of writing, over 175 interviews had been conducted at eight COCOMs and one subordinate command. The survey team was comprised of a group of 14 -18 collectors who traveled to each COCOM to conduct interviews with key personnel involved in intelligence operations (hereafter, the "forward team"), and a group of 12 analyzers, four of whom were the primary analysis team (hereafter, the "rear team"), who worked in Norfolk, Virginia. We comprise three of the four rear team.

The scope of the survey was broad. The intent of USJFCOM was to gather information regarding the COCOMs' current and future intelligence operations that indicated how they were arranged (i.e., Organizational Structure), what their missions were (i.e., Functions), how they accomplished these missions (i.e., Processes), and what sorts of information technology systems and related policies they employed (i.e., Systems and Policies). The USJFCOM was also interested in the relationships between COCOMs and other organizations. The overarching purpose of the survey was to identify best practices and their caveats, gaps and redundancies, overlaps between COCOMs, and comparisons between the COCOMs and concepts thought to be transformational. These findings, in turn, served as the basis for candidates for experimentation in future USJFCOM transformation efforts. The entire scope of the survey was captured in a concept map form, using CmapTools, shown in Figure 1.

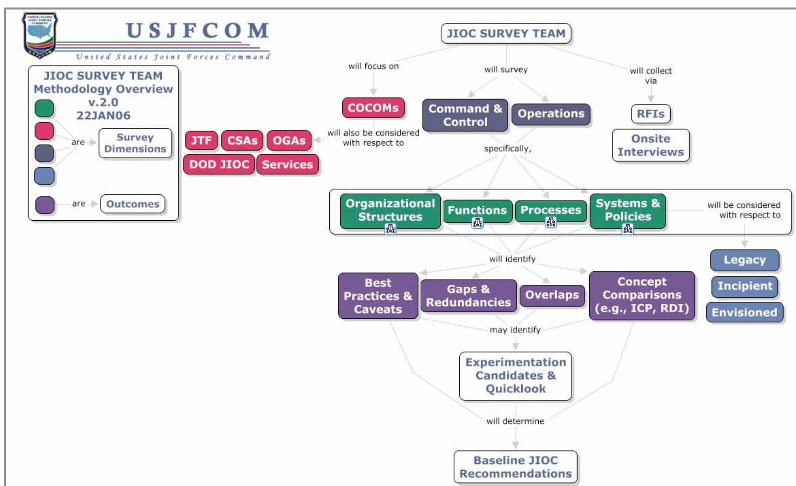

Figure 1. USJFCOM JIOC Survey Team Methodology Overview

The forward team received training in cognitive task analysis methods for conducting the interviews. The primary methods were Wagon Wheels and the Critical Decision Method. (Crandal, 2006). The Wagon Wheel is useful for dissecting information flow and identifying roles and functions, information requirements, types of information passed between team members, sources of information, decision and course of action impacts, criticality of information, and the impact of poor information flow. It can be used with highly experienced and novice subjects, in distributed and co-located teams, and in both one-on-one and group data collection sessions. As Moon (2004) suggested, it also lends itself to analysis in Cmap format. The CDM is highly useful for capturing deep, detailed data around processes of cognitive work (Crandal, 2006). Together, the CTA methods provided the interviewers with means to organize the interview sessions, flexible formats to collect in, and means to capture data in a variety of collection settings – i.e., collectors were not tied to standardized survey instruments.

The forward team organized into teams of two during interviews. One interviewer led the interviews by asking questions with regard to the areas of interest and CTA methods. The second interviewer captured the interview by hand in text format, and participated in the interview by asking questions. Following the interview, the second interviewer captured the findings in an electronic text document that covered the entire scope of the interview.[1] Formats for the text documents were provided to the team; however, in practice, the team members also developed their own formats. Figure 2 shows the basic roles in each interview.

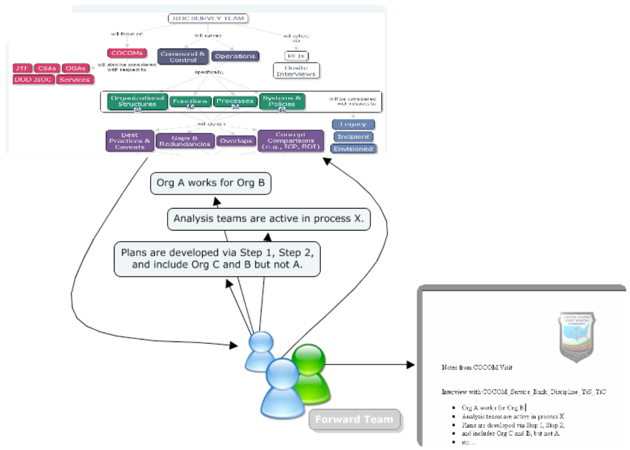

Figure 2. Basic roles of the forward team

As the survey progressed, the forward team provided their text-based data to the rear team. Upon receipt, the rear team manually converted the text documents into concept maps, shown in Figure 3. This required the rear team to interpret the forward team results, and document them in a "propositionally coherent" (Hoffman, 2006) format – that is, by creating node-link-node triples that in turn form stand-alone propositions. In most cases, and because the CTA techniques lent themselves to concept map representation and because concept maps are an effective form of knowledge representation, the translation was straightforward; yet some data points required reformulation of the forward team's data. The reformulation also enabled the rear team to disregard a small portion of data that was deemed not useful for analysis. Generally, a single rear team member concept mapped an interview from the forward team; however, in some cases, multiple rear team members worked against the same set of data, or revised the first rear team member's concept maps.

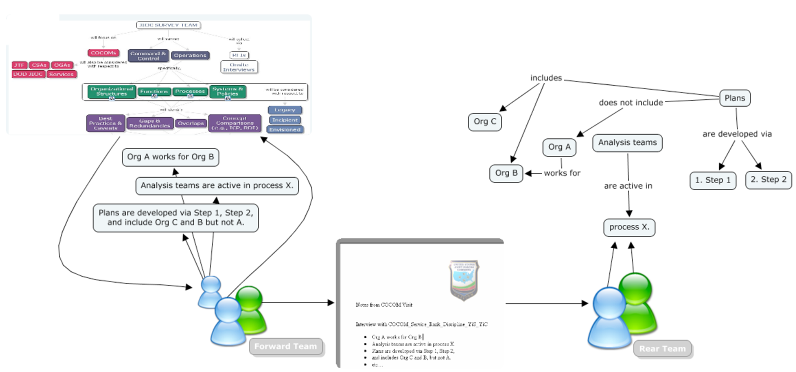

Figure 3. Data conversion to concept maps

Ultimately, the survey team was interested in knowledge models by which the interviewees reasoned and which guided their practice (Hoffman, 2006), as well as a "collective" model of each COCOM. Each interviewee at the COCOMs varied in their knowledge regarding the COCOM's current and future intelligence operations, and thus had different views on the same aspects of the operations. Any given interview resulted in the capture of any given

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[1] Due to the classified nature of some of the data, the forward team was required to enter their data into a portal on a classified network. The portal corresponded to the areas of interest – e.g., Organizational Structure, Functions, Processes, and Systems and Policies. Forward team members were given the option of entering data directly into the portal, which could then be exported, or posting text documents to the portal. In either case, all survey data was collected into this central repository.

aspect of the COCOM's intelligence operations. Thus, multiple interviews may have provided convergence on particular aspects, while some interviews provided the sole collection against other aspects. The intent of the survey team was to provide a COCOM-wide perspective on each COCOM, which could then be used for comparison and to give a Department of Defense-wide view of intelligence operations. Thus, as the forward team progressed, the rear team continued to generate concept maps of their interviews, and the multiple maps were subsequently merged into "master maps," as shown in Figure 4. Rear team members varied in their preferences for the workable sizes of their maps – e.g., some preferred to map *all* of a forward team members' data from a given COCOM, while others elected to create maps on *each* interview. All, however, aimed to create propositionally coherent maps.

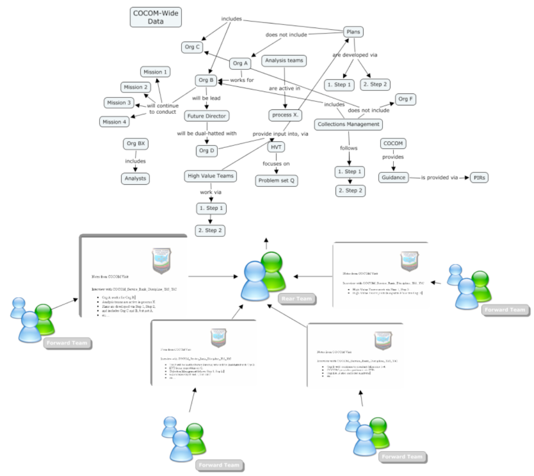

Figure 4. Merging multiple maps

The master map of one COCOM is shown in Figure 5, with the content of the concepts hidden from view due to its classified nature. The largest map, it contains 727 propositions, 495 concepts, and 580 linking phrases. It demonstrates the use of the rear team's color coding scheme to represent the temporal nature of findings. Interviewees provided data for each aspect with respect to legacy, incipient (i.e., newly formed or emerging), and envisioned aspects of operations. Findings (i.e., concepts) were color-coded by this temporal dimension.

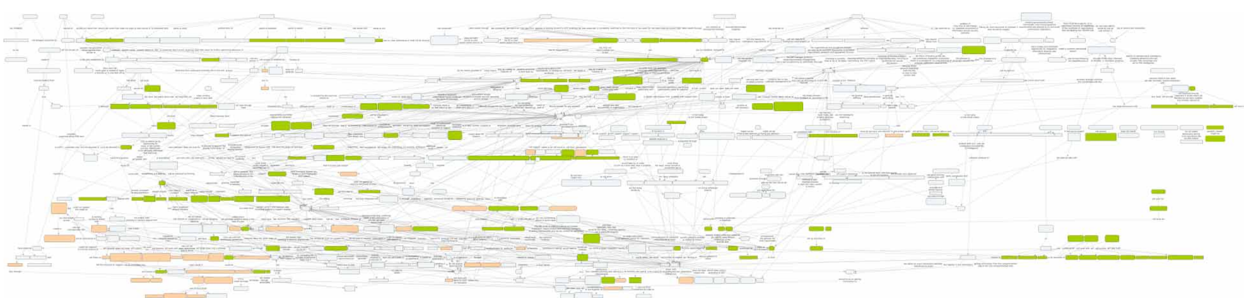

Figure 5. COCOM master map

Once all data from a COCOM was mapped, we used the CmapTools "Merge" capability to support automated merging of matching concepts. Other merges were made manually, as forward team collectors made varying references to like phenomena by the use of acronyms and other shorthand descriptors. For example, the "intelligence planning team" was referred to as "intelligence planning team", "intel planning team", "IPT", "IPTs", etc., none of which could be automatically merged. In this fashion, all related concepts could be grouped, either explicitly in by use of Nested Nodes, or not explicitly by spatial organization. Links, however, were never merged, as each was required to remain independent to ensure the propositional coherence. All links and non-merged concepts were spatially grouped to bring the entire map into a workable size, as shown in Figure 6, which is the re-organized version of Figure 5.

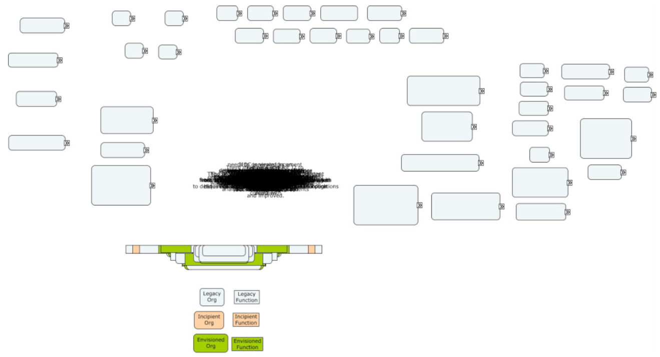

Figure 6. Reorganized COCOM master map

The value in the CmapTools-based organization of the data lied in the use of the Cmap List View, which provided a means to view all Concepts, Links, and Propositions in an Outline or alphabetically sorted lists. The View, shown in Figure 7, enabled the extraction of subsets of the COCOM datasets. In this format, a single rear team analyst had ready access to and quick and flexible manipulation of an entire COCOM dataset. The subsets lent themselves to closer inspection *within the context of the entire dataset*, descriptive modeling, comparison within and between COCOMs, and conversion of the dataset into a text document via copying. The subsets were selected and formatted using the Autoformat feature. Typically, we organized the data in the Horizontal Hierarchy. For larger subsets, we manually organized the data, spatially placing closely related links and concepts for review in context. Submaps were saved into new maps, which were then linked to analytic products, providing other organizational structures.

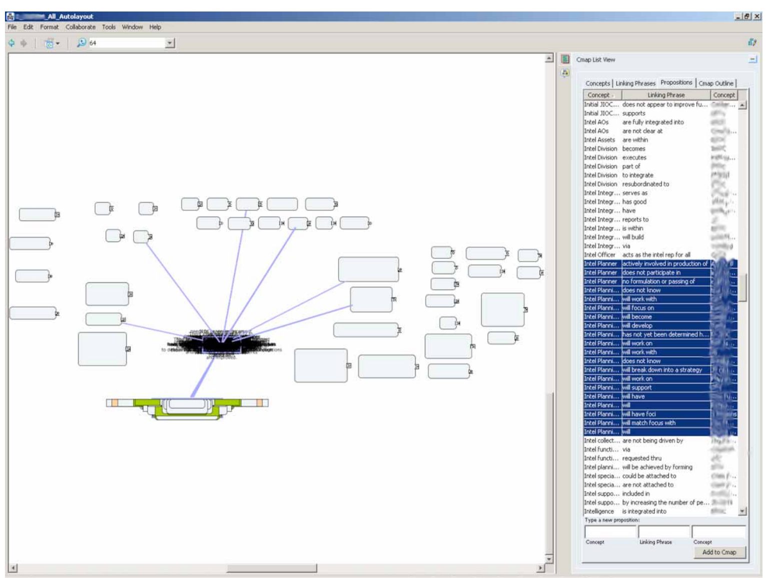

Figure 7. Reorganized COCOM master map in Cmap List View

3 Analytic and Operational Benefits and Challenges

The primary analytic benefits of the use of CmapTools in conduct of the survey lied in the merging of multiple datasets into a master copy, and the subsequent capability to select subsets of data for manipulation. We were able to consider organizations, functions, and processes in the context of *all the data collected about them*. Thus, what discoveries were made in one interview could be considered in light of other interviews. Representing the survey data in concept maps for manipulation in CmapTools enabled the sort of careful flexible inspection that Blumer calls for – we could examine our data at different levels of subsumption, group our data, freely “move” our data to examine its relations to other data, and select subsets of data for closer inspection.

Yet, as Berkowitz (1997) has rightly noted, while computer-based qualitative analysis packages can be “helpful in marking, coding, and moving data segments more quickly and efficiently than can be done manually, the software cannot determine meaningful categories for coding and analysis or define salient themes or factors. In qualitative analysis…concepts must take precedence over mechanics: the analytic underpinnings of the procedures must still be supplied by the analyst.” This sentiment agrees with Klein’s Data/Frame model of Sensemaking (Klein, 2004). The act of sensemaking – i.e., the process of fitting data into a frame and fitting a frame around the data – does not proceed upward from data. Rather, frames – or explanatory structures that define entities by describing their relationship to other entities – help account for the data and guiding the search for more data. Frames reflect a person’s compiled experiences. In order to make sense of the data, the rear team required some guidance from the forward team in the form of frames, or tentative hypotheses, about what the merged data ultimately reflected. Given the shear size of the master maps and even with the automated aids – e.g., Cmap List View and Autoformat – the rear team found it difficult to “gist out” the meaning of the data. This was particularly difficult for the rear team member who was less familiar with intelligence operations. As Hoffman (personal communication) has noted, even the most well constructed concept maps take time to digest and understand. To make sense of megamaps, the forward-team-provided-frames ultimately guided the search for sense, and the *rigor* involved should not be underestimated.

Another analytic benefit lied in the capability to represent many types of meaning in diagram form. We represented bilateral and multilateral relationships, processes, horizontal and vertical organizational structures, simple propositions, and temporal aspects. Our goal was to represent the knowledge captured in the interviews. Each of these types was, for the most part, understandable and clearly visible in the concept maps we created of individual interviews. However, in cases where multiple links were used to convey a complex relationship or steps in a process within a stand-alone map, those secondary links and processes could be lost when merged with other concepts and maps unless steps were taken in creating the stand-alone maps to specifically mitigate those effects (e.g. numbering steps or “freezing” links within nested nodes).

We cannot underestimate the advantages of the accessibility of our data in the Cmap List View. The capability to bring our data into a manageable size – i.e., as shown in Figures 6 and 7 vice Figure 5 – enabled us to overcome the formidable challenges inherent in digesting such a large and heterogeneous dataset in textual format – e.g., keeping names and acronyms straight, resolving contradictions, recognizing patterns. Each proposition could be examined in the context of the master map, and, by and large, each represented stand-alone expressions. Data expressing meaning about the same concept could be readily grouped and considered. In this format, however, we sacrificed one of the key differentiating features of concept maps. Hoffman (2006) has proposed several features that differentiate concept maps from other diagrammatic representations that use text and graphic elements, to include explicit yet unrestricted links, hierarchy-like morphology, morpho-semantic interactions, and dynamic state and representation. We rarely represented our maps in a hierarchical shape. Most of our Autolayouts were Horizontal Hierarchies, with no particular relations being more important or subsumed under others. For larger submaps, we spatially grouped concepts and links to encourage meaning-making, and we captured some levels of subsumption through merging and nesting nodes. Yet we were not as concerned with creating the familiar morphology as we were in gleaning meaning of the bilateral and multilateral relationships. We viewed this departure from ‘standard’ concept mapping as unimportant.

Regarding operational advantages Berkowitz noted, “since it takes time and resources to become adept in utilizing a given software package and learning its peculiarities, researchers may want to consider whether the scope of their project, or their ongoing needs, truly warrant the investment.” While one of us was considered an expert user at the outset of the analysis phase, the other members had no experience concept mapping or using CmapTools. The ease of use of CmapTools during the survey allowed more time for relatively inexperienced users to focus on processing data and developing maps rather than learning to use software. The understanding of CmapTools’ basic functions does not necessarily lead to the creative use of its functions to represent complex relationships. Indeed, while the ease of use of the CmapTools allowed the rear team to continue without much ado, and while most of the interview data was coherent and generally understood to mean the same thing by all who read it, the representation of that meaning in concept map format differed depending on the talents of the user. Further complicating the matter were the varying talents of the forward team for representing their discovered knowledge in text format. At times it was necessary for the analyst to reword statements for visual appeal or ease of understanding. The ability to relate information economically without misstating or omitting the information turned out to be problematic in certain circumstances. For instance, the team devised color codes to denote the chronologic categories of Legacy, Incipient, and Future. This temporal aspect was not always obvious in the context of the interviews and was left up to the interpretation of the rear team analyst. Accounting for that interpretation caused some friction. For our purposes, however, we believed the analytic benefits of merging all of the data outweighed the inter-mapper differences, and mitigated potential mistranslation of the interview data. We saw great power in the ability to create and display – both to the forward-team collectors and our eventual customers – the audit trail from our data to our conclusions.

4 Summary

Through the context of our efforts on a major data collection and analysis effort, we have presented an application of CmapTools for enabling the analytic process of inspection. CmapTools amplified the sensemaking process of inspecting by providing capabilities to capture, merge, organize, sub-select, and display very large datasets. Researchers using qualitative data may benefit from exploring and expanding our approach with other types of qualitative data.

5 Acknowledgements

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