Studying Team Cognition during Collaborative Information Seeking: A Position Paper

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ABSTRACT

Team cognition concepts are important in the collaborative information seeking (CIS) community. Yet, while this importance has been recognized there is a lack of research on team cognition within CIS. We take the position that team cognition concepts and measurements can be very useful to CIS researchers. This paper provides an understanding of what team mental models and common ground are. We then present methodological measurements for studying team cognition during CIS. We conclude by highlighting the important relationship of CIS and team mental models and common ground.

General Terms

Experimentation, Human Factors, Measurement

Keywords

Collaborative information seeking, team cognition, common ground, team mental models, methods, design.

1. INTRODUCTION

There is a growing interest in understanding and supporting information seeking as a collaborative activity. One of the ways to better support collaborative information seeking (CIS) is through improving our understanding of team cognition during these activities. This paper will focus on two major concepts, team mental models and common ground. Researchers have identified the key role that these concepts play in improving team performance [9]. If teams develop a better team mental model and common ground, they have the potential to allow for improved shared information seeking and greater facilitation of information sharing during CIS activities.

Currently, the CIS community has focused more attention on interaction between participants during CIS activities than on the cognitive aspects of CIS. Methods within the community need to be developed for not only interaction, but cognition as well. A review of the literature by Shah [16] indicates the prominent and important role of interactional-based research within CIS. While the community acknowledges and sometimes uses cognitive perspectives, it is clear more focus is on interactional methods. We understand that studying team cognition can

be challenging, but we also believe that the knowledge gained from understanding CIS from this perspective could shed important insight into the process of CIS. The purpose of this paper is twofold: first, to raise the awareness level of the need for more cognitive perspectives within the CIS community, and second, to provide a broad overview of ways to methodologically measure team mental models and common ground within the context of CIS. Therefore, team mental models and common ground, as well as five different methods to measure these concepts will be discussed.

2. TEAM MENTAL MODELS AND COMMON GROUND

For the purposes of this paper, we are examining team cognition from the perspective of a team reaching common ground often through the development of a team mental model. We define the various concepts below.

Team Mental Model: Team mental models were first introduced in 1990 [1] to better understand and study implicit communication and coordination within a team. Since then, team mental models have been a very active research topic. Although there are multiple definitions of team mental models, we choose to use Klimoski & Mohammed's [8] widely acknowledged and accepted definition, which describes the model as "organized mental representations of the key elements within a team's relevant environment that are shared across team members."

Team mental models provide teams with many affordances. The opportunity to share and interpret information based on commonality (description), the ability to share assumptions and expectations of what will happen in the future (predictability), and the ability to understand together how an event happened (explanation) [14]. As Mohammed et al. [11] have noted, team mental models help a team acquire the knowledge of "what" is currently happening and will happen, and "why" it is happening.

Team mental models are generally viewed as being composed of two different categories: taskwork and teamwork [10]. Taskwork models usually focus on the actual work of the team, whereas teamwork models focus on the interpersonal relationships within the team and the emotional responses that are elicited.

Within both categorical types of team mental models, there are two main properties that help judge the effectiveness of the team mental model -similarity and accuracy. Similarity refers to how alike each team member's model is, indicating that they are consistent with each other, yet not identical [11]. Accuracy is how relevant and accurately representative the team mental model is to the real world situation or context. The important point is that if an accurate and similar team mental model is present, then a team's performance and effectiveness will increase [6]. Within CIS, there is a paucity of research that has examined team mental models within the context of CIS.

Common Ground: Common ground is considered a sub-construct within the broader concept of a team mental model. During CIS activities, individuals share information with each other. It is during the communication of shared information that common ground is often developed. The concept of common ground was primarily derived from social cognition and driven by the work of Herbert Clark. Clark [5] defined that collaborative activities require coordination of both the content of the activity and the process of communication that moves the activity forward. The ability for a group to move forward and coordinate is because common ground was established. Specifically, common ground is the set of mutual knowledge, mutual beliefs, and mutual assumptions that are shared within the group [4].

One could think of common ground as each collaborator "being on the same page" in regard to the content and process of communicating information. Common ground constitutes that agreement regarding knowledge, belief, and assumptions has been met, which then forms a shared understanding within the individuals who are collaborating [13]. The amount of shared understanding needed to reach common ground is dependent on that group and the context of that group. Development of common ground takes time, and is incrementally built through a series of joint activities between collaborators [3]. The agreement that leads to common ground is temporary, so continual efforts must be taken to maintain it [7].

Within CIS, Herztum [7] has proposed that CIS is the combined activity of both information seeking and collaborative grounding. Collaborative grounding, which leads to common ground, is defined as the "active construction by actors of a shared understanding that assimilates and reflects available information" [7]. From this perspective, CIS is looked at as the joint collaboration of information seeking at an individual level and then sharing of that information through collaborative grounding, which then leads to a common ground.

3. METHODS FOR MEASURING TEAM COGNITION

Below, we describe five methods that are potentially useful for measuring team cognition during CIS. While these methods are neither new nor innovative, they provide a repository of methods to consider when studying team cognition and CIS. This list is also not all inclusive but we

see these knowledge elicitation methods as being potentially very effective for capturing common ground and team mental models.

Concept Mapping: Often, concept mapping is thought of as being a method for learning, rather than a way to capture/measure cognition. Yet, many studies have shown the effectiveness of using it for cognitive purposes. Concept maps are defined as graphical tools for organizing and representing knowledge [12]. Concepts are generated and then enclosed within circles or boxes. Once the concepts have been generated, relationships between them are considered. If a relationship does indeed exist between concepts a connecting line is placed between them. To describe that relationship, a proposition is then placed near the connecting line. The proposition is usually a few words explaining how the concept mapper views the relationship. Often times, a concept map is shown in a hierarchal manner, where the most general or board concepts are at the top and the more specific and finite ones are at the bottom. Figure 1 shows an example of a concept map.
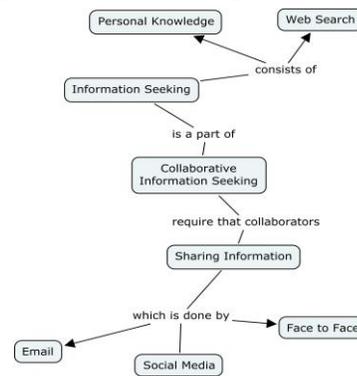

Figure 1: Example of CIS concept map

Concept maps can be produced with different levels of information density depending on how the map is aligned and explained to the prospective mapper. For example, a participant can "fill in a map" where everything from the concepts to the map structure are given, or they can "create a map from scratch" where they must generate the concepts and the structure [15]. In the context of CIS, participants within a team would be given a traditional CIS task, asked to work through it, and then produce a concept map based on the task. The concept map would then include concepts directly related to the CIS task and propositions connecting them. The concept map can be collected in a variety of ways: individual, team, or a combination of both. The value of this method from team cognition is that the participants are essentially mapping out their team mental model in relation to the CIS activity.

Paired Comparison Testing: This method is often regarded as one of the most popular team cognition methods. Participants are given pairs of statements in which they rate the degree of similarity between them. The similarity ratings are then configured using computer algorithms (examples: Pathfinder, Multidimensional Scaling). Once the ratings are available, the mean similarity rating of the team (all participants) can be

compared with individual similarity ratings. This comparison helps to further understand the relationship of individual and team mental models. Paired ratings would be given in regard to both the taskwork and teamwork team mental models. In the instance of CIS, statements regarding the CIS task would simply be given as highlighted in the example below.

Teamwork Paired Comparison Ratings:

1. Sharing information openly with all team members.
2. Trusting all team members.

These statements are directly related to the teamwork mental model. If one were actually using these paired comparison statements they would give both of the statements to the participants along with directions to rate on a scale of 1-5 how related the statements are. The goal of these statements is to understand the relationship between sharing information and trust. Once the comparison rating is derived from aggregating all team members' ratings, the researcher will then be able to understand how the team views trust and information within their team mental model and how that effects common ground.

Qualitative Methods- Observation and Cognitive Interviewing: Traditionally measurement and analysis of team cognition has been done through quantitative means. While quantitative measurement is very valuable, qualitative measurements must also be considered to provide a holistic perspective. Observation is often overlooked within cognitive research circles because it is looked at as method primarily focused on capturing interaction not cognition. A significant amount of cognitive activity can be learned from observation if it is paired with other more traditional measurements. There is great value in understanding if what is actually carried out matches up with the cognitive intent. This method is most valuable when one is seeking to understand if our actions (carrying out a CIS task) match up with our thoughts (CIS bounded team mental model). Cognitive interviewing is also a valuable qualitative technique. This is a specific approach to interviewing where the researcher first observes a critical activity, and then interviews the participant who was directly involved in that activity. Probing is done in such a way that requires the participant to describe to the researcher the activity and what they were thinking at that point in time. This interviewing approach demands that the participant use their recall and revisit cognitively what they were experiencing.

Card Sorting: Known as a highly psychological method, card sorting is a well-known team cognition measurement. Participants are given cards with critical components of a situation on them, and the participant must then sort those cards into groupings based on how they seem them as being related. Once the groupings of cards are sorted, the participant is then asked to name each grouping. This allows for the researchers to understand both the content and cognitive structure of the mental model. The individual mental model card groupings are then measured throughout all members to see which groupings are most similar and accurate, thus providing the team mental model groupings. Much like concept mapping, card sorting can be aligned directly to a CIS task. In this context, the cards would simply be named after the critical components within the CIS task. An example of card sorting within the context of CIS follows.

Teamwork Cards:

1. Nonverbal Interactions, 2. Social Media, 3. Web Search, 4. Personal Knowledge, 5. Others Knowledge, 6. Experience, 7. Sensory input, 8. Word of Mouth, 9. E-Mail, 10. News

These cards with concepts would be given to each member of the team and they would then be asked to separate them into groupings based on concept similarity. So, hypothetically, the participant took the cards above and grouped cards 1, 2, 7, 9 in one group and 3, 4, 5, 6, 8, 10 in another group. Now that the following cards have been sorted into groups the participant must name the groupings. For this example, the participant names the first group information sharing and the second group information seeking. The results across all team members will then be aggregated and analyzed to understand the structure and content of the team mental model and common ground.

Analytical Methods: Verbal protocol analysis (VPA) is one of the most widely used analytical methods for measuring team cognition. While VPA is a method for capturing cognition, it is also a way to analyze the data. For this measurement, traditionally the researcher would ask the subject to think aloud while they are performing a task. This works well for an individual, but when a team is present it can be more complicated. One can't expect each member of the team to think aloud while they are also communicating with their teammates. An approach to get around this problem is to not even ask them to think aloud, rather just let them communicate normally with their team. Cooke et al. [2] has made the argument that because they are in a team they are already thinking aloud to a degree. If members of the team didn't think aloud, then teammates wouldn't understand what each is thinking and no ideas or solutions would be developed.

Verbal protocol analysis has mainly been used within the Human Factors community as a way to make cognitive inferences from content found within discourse[19;18]. As previously mentioned, the "content" is a written transcript derived from participant's verbal communication during a task. The content can then be further coded by words, sentences, and themes. The content that has been coded is then categorized based on a pre-defined categorization theme. The thought process behind VPA is that because the subject is thinking aloud their cognition is directly related to their spoken word. As a subject continues to think aloud, the researcher will then be able to derive how they cognitively developed thoughts and outcomes. For the purposes of team research, one will be able to make inferences on how each member of the team thought and verbalized their cognition to the rest of the team. Analyzing each team members spoken thoughts allows the researcher to come to an understanding of a how a team mental model was developed.

In regards to the context of CIS, these analytical methods can prove to be very useful and easily implemented in current CIS research studies. Since many CIS studies consist of a team undertaking a CIS bounded task, the only thing the researcher would have to change is ensuring that they capture the verbal communication during the task. Once the communication is transcribed, coding can then begin based on VPA or content analysis.

5. CONCLUSIONS

CIS is an important step within team decision-making. If a team fails to gather the adequate information from the onset, it will most likely result in problems throughout the whole team decision-making process. Therefore, understanding team cognition is critical to better understanding CIS. If team mental models and common ground are successfully developed, teams have a much better chance to succeed in seeking and retrieving information. For these reasons, we feel that the CIS community should take note of these concepts, and work to understand them within the context of CIS. Consequently, the primary purpose of this paper is to raise the awareness level of team cognition within the CIS community. The concepts and methods discussed in this paper have a rich history in other domains, and we believe that they can be utilized to better help understand CIS. Understanding CIS from both a cognitive and interactional perspective will allow us to develop better systems to support CIS activities.

6. ACKNOWLEDGMENT

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