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Relevant Topics:

C2 Experimentation
C2 Decision Making and Cognitive Analysis
C2 Assessment Tools & Metrics

COLLABORATIVE CRITICAL THINKING

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Abstract

Command and Control (C2) organizations must operate decisively and synchronously, and do so in highly uncertain and dynamic settings. Individuals succeed in these settings in part by thinking critically about their assessments and plans. We argue that individual team members collaborate in their application of critical thinking in a process called "collaborative critical thinking." We are developing this concept of Collaborative Critical Thinking (CCT) within C2 teams from three research threads concerning 1) individual critical thinking, 2) team process and architecture, and 3) human performance in information age warfare. This paper describes our CCT framework and the tools and training we are developing to improve CCT among team members.

Introduction

A fundamental goal of the military is to ensure that Command and Control (C2) organizations operate decisively and synchronously in highly uncertain and dynamic settings. Individuals succeed in these settings by thinking critically; that is by critiquing their understanding of the situation at hand, refining their knowledge, and adapting their decision making and planning to the problems at hand. This project purports that individual team members collaborate in their application of critical thinking in a process called "collaborative critical thinking."

There is, to our knowledge, no theoretical framework to help warfighters learn, measure, and manage collaborative critical thinking (CCT). However, aspects of this topic are addressed by recent programs of research concerning critical thinking, team processes and architecture, human performance in information warfare.

A theory about how individual warfighters make decisions under uncertainty has been validated through research concerning *critical thinking*. This recognition-metacognition framework (Cohen, Freeman, et al., 1996, 1997, 1998) speculates that expert warfighters *monitor* for opportunities to critique their assessments and plans, *identify* sources of uncertainty (i.e., gaps, untested assumptions, and conflicting interpretations), and *reduce or shift* that uncertainty by doing such things as gathering information, testing assumptions, and forming contingency plans before taking action.

Research conducted under ONR's A2C2 program and other Air Force Research Laboratories human engineering projects concerning *team process and architecture* have produced a rich body of measures concerning the processes by which teams coordinate their activities. This team coordination may occur either explicitly, that is, through explicit communication, or implicitly, through reliance on shared information, shared interpretations of information patterns, and standardized responses to those patterns.

Recent theory and fieldwork studying individual and collaborative cognition in command and control and other information-intensive organizations has provided insights into *human performance in information warfare* by studying the processes by which team members may interpret data to develop *information*, build *understanding* that informs *decisions*, and *collaborate* to ensure that information and knowledge are shared in support of synchronized *action* to shape *events*. Alberts, Garstka, Hayes, and Signori (2001) have developed a framework that clearly defines these (italicized) constructs as primitives of performance in information age warfare.

In a research and development project for the Office of Naval Research, we are weaving these threads together to create a theory, validated measures, tools and training that will help us to understand and support team critical thinking.

This paper addresses the theory development as well as initial ideas about the tools that will be developed based on this theory.

Collaboration Framework

Collaboration is the process of shared creation (Rawlings, 2000). During collaboration, people with complementary skills interact to create a shared understanding of the situation that is more complete than would have been achieved with any individual alone. The framework in Figure 1 was created in an attempt to better understand the entire collaborative process.

As this framework suggests, collaboration is not always needed; in fact, when all the important information resides in one person and time is short, the collaborative process is less optimal than a quick, autocratic decision (Vroom & Jago, 1988). If expertise is distributed among multiple people, and resources and responsibilities are divided between people as well, collaboration is needed. These "factors generating the need to collaborate" affect not only the importance of collaboration, but also the goals of collaboration, which will vary with the responsibilities allocated to collaborating parties.

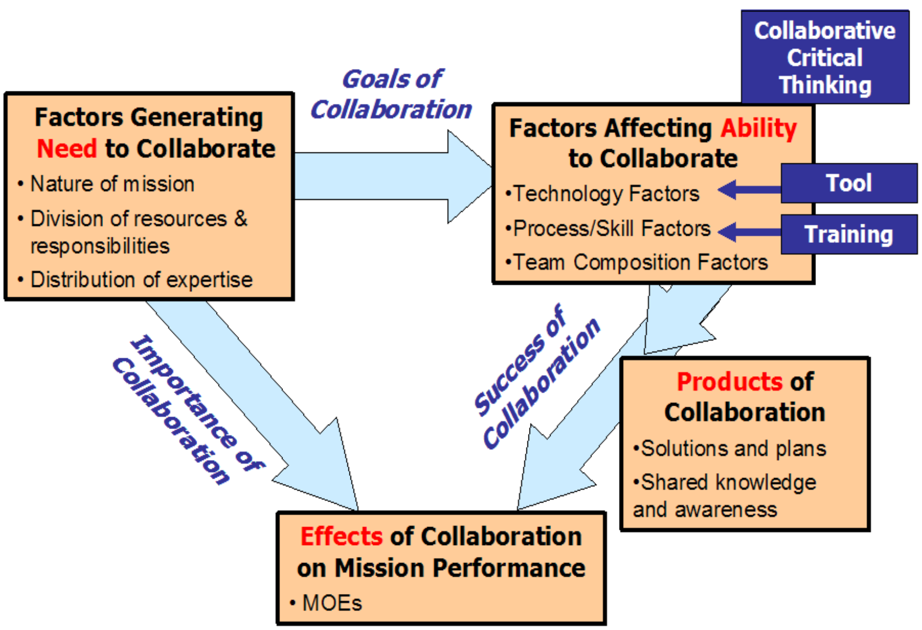

Figure 1. Collaboration Framework

A team's ability to achieve its collaboration goals depends on a number of factors such as available technology, team members' collaboration skills, and team composition factors.

Technology. The distribution of teams in time and/or space requires the use of technology to enable the information sharing necessary for effective collaboration. Such "technology" currently ranges from telephones and email to video-conferencing. New technologies are being developed that claim to assist team collaboration and information sharing even more.

Process/Skill Factors. Although really effective teams can make collaboration look easy, collaboration is not innate. Effective collaboration requires specific skills such as negotiation and active listening.

Team Composition Factors. Collaboration is strongly affected by the composition of the team. For example, teams composed of members with homogenous backgrounds find early collaboration to be much easier than heterogeneous teams; however, heterogeneous teams eventually make decisions that are of a higher quality than those of homogenous teams.

These "factors affecting the ability to collaborate" directly affect the quality of the collaboration products (e.g., the assessments and plans) as well as the effects (Measures of Effectiveness, or MOEs) of team performance.

Collaborative critical thinking can be thought of as one factor that affects the team's ability to collaborate (see navy boxes in Figure 1). The next section of this paper describes this in more detail.

Collaborative Critical Thinking

Cohen developed a framework for understanding critical thinking that he and colleagues validated in studies of individuals and teams, largely in air combat (Cohen, Freeman, and Thompson, 1998) and commercial air settings (Freeman, Cohen, and Thompson, 1998). This model posits that critical thinking monitors, tests, and refines recognitional decision making (the phenomenon described in the literature on "naturalistic decision making" (Klein, 1993)). This framework specifies several cognitive functions that constitute critical thinking; monitoring, critiquing, and actions. *Monitoring* tests for the need and opportunity to critique assessments and plans. When the decision maker senses uncertainty and the stakes are high, there is a need to engage in critical thinking; when time is available to do so, there is an opportunity. *Critiquing* ferrets out specific sources of uncertainty, such as gaps in knowledge, untested assumptions, and the existence of conflicting interpretations of events. *Actions* such as gathering information and formulating contingency plans manage – and may even reduce – uncertainty and attendant risks.

Individuals engage in critical thinking within team settings. This is well established (Freeman, Cohen, and Thompson, 1998). We hypothesize that analogs of these critical thinking functions exist at the team level, as well. That is, high functioning teams encourage productive, timely, critical dialogue between team members. As markers of collaborative critical thinking, we look for the following behaviors:

Team leaders and members use disagreement within the group as an indicator that conflicting interpretations should be resolved, that the relevancy and accuracy of assumptions and paradigms should be tested, and that uniquely held information should be shared. Disagreements are pointers to uncertainty in the assessments and plans the team generates. Proficient teams use disagreement as an indicator when they *monitor the need to engage in collaborative critical thought*.

Team leaders and members prioritize activities to ensure that time and efforts are invested in addressing the most critical sources of uncertainty and risk. Thus, they *monitor the opportunities* to engage in collaborative critical thinking, and attempt to control them.

Team leaders and members engage in dialogues to identify the sources of uncertainty that might weaken their assessments and plans, and they devise ways to reduce that uncertainty (e.g., by gathering information) or compensate for it (e.g., by developing contingency plans). In this way, proficient teams *critique* their work.

Proficient teams *act* in coordination to gather and disseminate information as they manage uncertainty.

To document these hypotheses, we are conducting empirical research with Michael Coovert and his colleagues at the University of Central Florida. To support CCT – particularly the functions above – we are developing tools and training. Both are designed to help distributed team members critique their assessments and plans. Both employ questions designed to support monitoring, so that teams can spot opportunities to engage in collaborative critical thinking (and avoid needless debates).

CCT Tool

The tool being developed will help teams monitor for opportunities to engage in CCT, support CCT when it occurs, and thus improve the products of team collaboration.

The tool being developed has two major users: the team members and a person acting as facilitator. The team members are asked questions at crucial points during the collaboration process that give insight into the current state of CCT (Figure 2 shows a prototype). Answers are made anonymously, to encourage candor – a precious but scarce commodity in some settings. Each question consists of a rated item and an optional comment. The system analyzes the rated items and distributes descriptive analyses plus comments to the facilitator, who then decides whether action should be taken (Figure 3). Alternatively, they may be distributed to the team to foster awareness of the team's state.

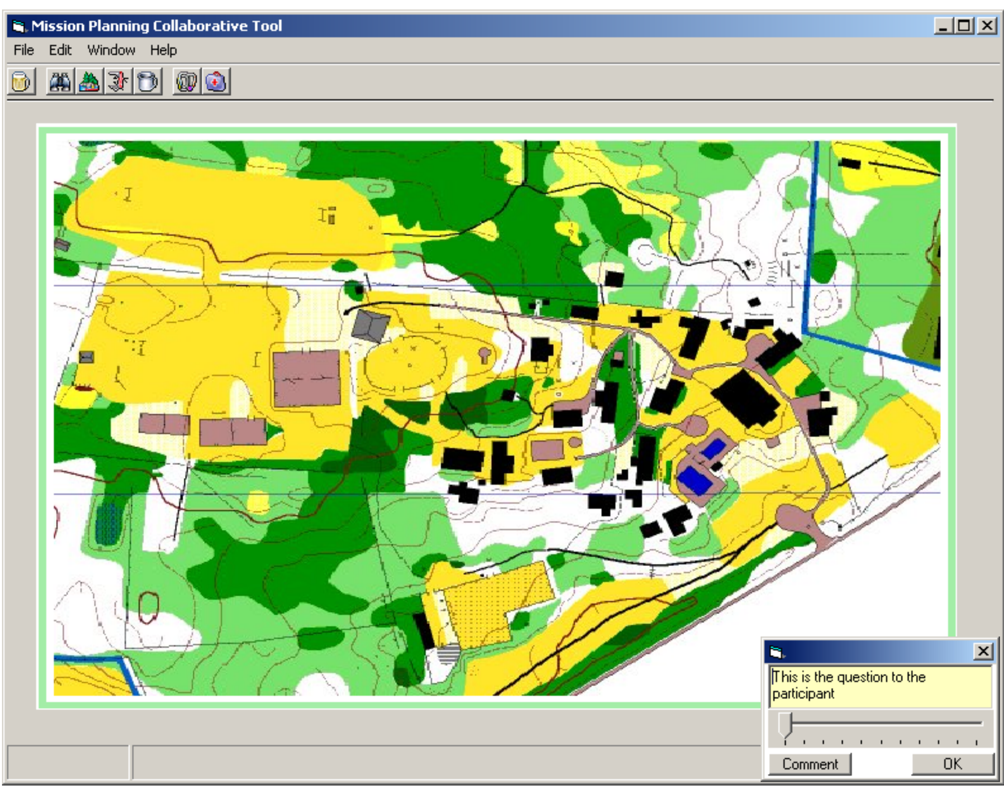

Figure 2. Screenshot of initial team member interface

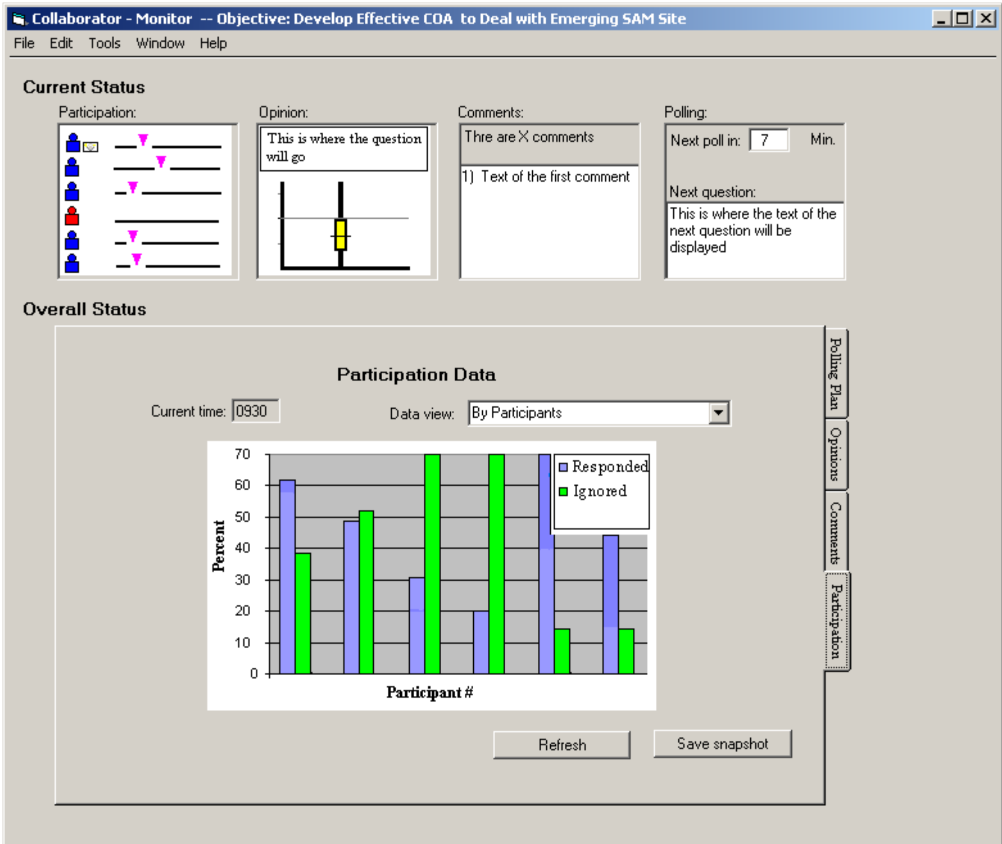

Figure 3. Screenshot of facilitator's interface

What questions might this system present to users that would support collaborative critical thinking? Consider a decision, made during planning of an air campaign, whether to gather battle damage assessments using special forces on the ground (a tactic that produces highly accurate reports at high risk to warfighters) or by other means, such Predator UAVs (an approach that can produce less accurate reports in some weather conditions but does not expose human warfighters to threats). While the team researches the targets and enemy defenses, and discusses these options, the team leader polls the members, asking, "Are you confident in the plan to use ground observers?" Respondents answer this question by selecting a rating on a Likert scale anchored on one end by "No" and the other by "Yes." Low variance in responses to this question (whether the ratings are high, low, or at the mean) suggest that there is little uncertainty to be resolved on this question. High variance indicates, of course, that there are differences within the team that may, if discussed, expose potential problems in the use of ground observers, relative to other solutions.

We can also employ a second order question in this circumstance. "Is there consensus within the team concerning the use of ground observers?" Ratings gathered from team leaders in response to this question give insight into their awareness of the team state when considered in light of team member responses to the question above. Leaders' awareness of team state is accurate when estimates of consensus are low and team member confidence varies widely, or when leaders' estimates of consensus are high and confidence exhibits little variance. Team leaders may waste the time and tax the patience of team members in unneeded discussions or research when they estimate that consensus is low though variance in confidence is low. Conversely, leaders may fail to identify and address critical problems when they estimate that consensus is high when confidence varies widely.

In time-critical missions, it may be useful to encourage sensitivity to the time available for decision making (and, thus, for collaborative critical thinking) and to elicit estimates of available decision time from team members with different perspectives on the problem or different levels of expertise. Uniformly high estimates of available time indicate that there may be opportunities to critique assessments and plans. High variance among estimates indicate either that some team members have time constraints not understood by their team members, or that some team individuals misperceive the time course of the mission. These are not rare or trivial failures. To avoid them, experts in anti-air warfare, for example, maintain an awareness of the available decision time so that they can use it well when the stakes are high, and even buy time when possible (Cohen, Freeman, and Thompson, 1998). This sensitivity to decision time varies with expertise. An experimental test of decision making by airline pilots (Freeman, Cohen, and Thompson, 1998) revealed that there is marked difference in the sensitivity to time (but not accuracy of time estimates) as a function of experience. Pilots with more than 20 hears experience used all of the available decision time (rarely much less or much more) to gather information and make a decision whether to divert to an alternate airport; pilots with less experienced were more likely to make hasty decisions when time was available, and tardy decisions when it was not. Evidence such as this suggests that teams may benefit from tools or training that help them to monitor the available decision time and use it well.

To complement questions such as these, which support monitoring, we are designing questions that help teams to ferret out problems, identify actions to resolve problems or compensate for them, coordinate those actions, and apply what they learn to improve their assessments and plans. The system will help leaders to develop these questions by presenting question templates that leaders specify to the problem at hand.

To guarantee that the users get the optimal benefit from the CCT tool, training is being developed that will help the users leverage these tools. An effective training program, such as the successful Team Adaptation and Coordination Training (TACT) Program (Entin and Serfaty, 1999), includes four components: lecture, demonstration, practice, and feedback. We plan to build on our aviation experience with cockpit resource management (i.e., narrative-based realistic operational scenarios) to create stories that illustrate critical elements necessary in CCT. We will incorporate these stories into a training program that will build the necessary CCT skills and facilitate the tool integration. The validation planned for this intervention should show that teams with both CCT training and the CCT tool achieve a better shared situation awareness, produce more robust plans, and execute missions with greater synchrony and success than teams that do not receive these CCT interventions.

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