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Extending CA with AI COAs for Wargaming

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COGNITIVE ASSISTANCE WITH AI COAS - RADICAL RETHINKING OF HMT MISSION WORKFLOWS & DECISION-MAKING AS AI ASSUMES A PEER RELATIONSHIP WITH OPERATORS EXECUTIVE SUMMARY

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Project Summary

This study researched the factors of situational awareness (SA) as it relates to decision quality in tactical decision making. This is an ongoing issue for the Marine Corps Headquarters (MCHQ), Plans, Policy, and Operations (PP&O) with lethal consequences. First, the stages of the evolution of human-machine teaming (HMT) mission workflows were assessed. Stages focused on transitioning automation tasks from humans to machines. It began within the context of interdependency analysis (IA), a technique which is used as part of a co-active design in the process of digitization of mission workflows such as fire support coordination (FSCn). We also studied the evolution of HMT to include various tools used to determine courses of action (COAs) for decision making with artificial intelligence (AI) and what role natural language processing (NLP) plays. In addition, this study explored the viability of an IA matrix and NLP in HMT peer-to-peer COAs generation paradigm as opposed to other approaches.

The main research questions included 1) What is the best approach for a cognitive assistant (CA) to learn mission workflows? 2) How can a CA switch between modes of automatic, advisory, or monitoring? and 3) What are the conceptual considerations that must be understood to make decisions, as well as the ability to switch contexts?

This research resulted in a comprehensive literature review covering topics in AI, command and control, cognition, cyber, decision-making, decision support systems, fire support coordination, HMT, human systems integration, knowledge management, naturalistic decision-making, situational awareness, and wargaming. Upon reviewing the literatures, a more nuanced and detailed phenomena emerged. The top-level issue may be a lack of SA. However, the causes of decreased SA can be reduced to factors of noise such as environmental, physical, or technological. A deeper investigation identified a potential dependent variable of 'ignorance' with an independent variable of decision quality.

Keywords: *human-machine teaming, HMT, automation, artificial intelligence, AI, courses of action, decision making, decision support systems, fire support coordination, situational awareness, SA, cognition*

Background

This research studied a conceptual framework for a novel decision support system that centralizes the user in the system. A cognitive assistant (CA) is a combination of hardware and software that augments human intelligence (Engelbart, 1962 & 1995). A CA does not replace the human decision-maker, rather a CA enhances human capabilities. The idea of augmenting human intelligence has been researched dating back to the 1940s (Dreyfus & Dreyfus, 1986).

Key aspects of this new conceptual framework will focus not only on human decision making, but computer-aided decision making. The novel contribution of this work is that a CA would gather information, learn SA and share COAs with humans while allowing multiple modes of operation of the system namely, the ability to monitor, provide advice, or have full autonomy within parameters. The system will utilize AI and machine learning (ML) algorithms to process information from multiple data sources. The CA represents the system framework that can automate tasks to improve FSCn and corresponding SA. To illustrate the CA, this research focused on the MCHQ PP&O Fire Support Coordination Center (FSCC) planning at the tactical decision-making level. Beyond this first conceptual framework, the theory-testing and development and proposed solution should be generalizable to higher levels such as operational and strategic planning.

The goal of this research extended the design principles for intelligent CAs so that human decision-makers are equipped with decision support tools that provide a tactical edge in command-and-control situations. A CA that can learn SA and provide COAs would result in lower cognitive load of FSCn unit personnel, improve speed and quality of decision-making, decrease decision-making errors, and ultimately, reduce fratricide, unintended civilian casualties and/or excessive physical destruction.

This study took a comprehensive review of multiple literatures including AI, command and control, cognition, cyber, decision-making, decision support systems, fire support coordination, HMT, human systems integration, knowledge management, naturalistic decision-making, NLP, SA, and wargaming.

The original hypothesis stated that a CA could improve SA for FSCn personnel. A visit to 29 Palms, California provided an opportunity to observe the training exercises for FSCn personnel. Data was collected by attending the pre-brief meetings to understand the scenarios, who was responsible for different types of decisions, and observing the exercise unfold. To ensure reliability of the data collected, photographs were taken, and audio recordings were obtained so that any observational notes taken could be compared to the actual events. The data collected was organized and sorted for a high-level analysis to find themes and patterns. The themes and patterns were then distilled into factors that affect SA, such as, environmental, physical, and technological. These key factors drove a deeper investigation into understanding types of decision errors, styles of decision-making, and other cognitive factors. These areas were studied to extend our understanding of cognitive load and situational awareness to apply it towards a CA.

Findings and Conclusions

Upon reviewing the literatures, a more nuanced and detailed phenomena emerged. The top-level issue may be a lack of SA. However, the causes of decreased SA can be reduced to factors of noise such as environmental, physical, or technological. A deeper investigation identified a potential dependent variable of 'ignorance' with an independent variable of decision quality. The key issue of SA is not knowing what one does not know and not knowing to ask for new or different information. This is where a CA can parse through large volumes of data from multiple sensors and sources to 'make sense' of the environment and push additional insights to the operators thus augmenting the operators SA to ask questions they do not know how to ask or formulate.

The research questions evolved to consider: Where do errors enter and propagate? What is the effect of decision errors on the mission and lives?

With a CA, it is hypothesized SA would improve but a new question arose: with conceivably more or 'better' information, at what point would decision quality decrease regardless of SA due to a limit of cognitive load on humans? Higher levels of SA may improve decision quality to a certain point, but more may not always be better. Rasmussen (1986), as cited in Hutchins (1996), argued that human processing capabilities have "remained almost static for thousands of years." So, even with perfect SA, human processing capabilities reach a peak limit, and beyond that peak, are diminishing returns. Once a decision maker reaches peak saturation of SA, more information will only contribute to higher cognitive load. It is at this nexus of SA and decision quality that a CA can provide the tactical edge for our military to outperform our enemies.

The challenge is the breadth and depth of the problem. This research will attempt to select the best-of-the-best and synthesize the components into a general framework that can be broadly applied to any complex, dynamic, and critical, decision-making environment. In doing so, other conclusions drawn from the literature reviews revealed that NLP may be a viable approach to designing a CA, but it is not sufficient as a theoretical application. As such, this resulted in additional theoretical frameworks studied and identified to situate the research appropriate for military applications. Two theories identified were General Systems Theory (GST) and Naturalistic Decision Making (NDM) Theory. GST provides a framework for measuring/testing key elements such as feedback in an open, complex system. NDM Theory is concerned with "how people make decisions in complex real-world settings that can include dynamic, uncertain, and continually changing conditions, and can require real-time decisions in urgent situations with significant consequences for mistakes" (Naturalistic Decision Making, n.d.).

The potential impact of creating this framework would change the rules for the U.S. to have a system providing a competitive advantage against hostile nations and intrinsically provide information dominance in the battlefield.

Recommendations for Further Research

Further research on this study will address and support the current Force Design 2030 challenges in alignment with the strategic guidance from The National Defense Strategy. This includes completing this research towards "iterative wargaming, analysis, and experimentation" (Force Design 2030, 2020). Utilizing an expeditionary advanced base operations as a scenario and collaborating with the Joint Artificial Intelligence Community, the conceptual framework that will be developed from this research can be tested and analyzed. In addition, considering a general framework broadly applicable to rapid decision-making environments, the researchers plan to have discussions with Dr. David Ferrucci, creator of IBM Watson and CEO at "Elemental Cognition"—a start-up focused on human-machine-interaction collaboration based on natural language processing understanding. Continuing these discussions between other government agencies and industry will deepen our understanding not only of the theoretical possibilities but the technological capabilities available to enable "new capabilities for doing things differently" (Force Design 2030, 2020).

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Acronyms

AI	artificial intelligence
CA	cognitive assistant
COAs	courses of action
FSCn	fire support coordination
FSCC	Fire Support Coordination Center
GST	General Systems Theory
HMT	human-machine teaming
IA	interdependency analysis
MCHQ	Marine Corps Headquarters
ML	machine learning
NDM	Naturalistic Decision Making
NLP	natural language processing
PP&O	plans, policy, and operations
SA	situational awareness