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Title: The Knowledge Structure of the Commander in Asymmetric Battlefield: The Six Sights and Sensemaking Process

Topic: Cognitive Domain Issues, C2 Modeling and Simulation, C2 Analysis

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Abstract

The battlefield commander or the CEO of a company is "an intuitive statistician" and a cognitive information processor. The commander must first make sense of the complex information provided from different sources. While there are availability of information technology to help the commander in data processing and analysis, it is not surprising that in real-time operations, the commander falls back on what has been metaphorically called "six senses" (sights) while trying to make sense of a battle situation as well as making decisions to enact dynamic actions. In this paper, I present the six human sights---insight, hindsight, foresight, short-sight, and oversight, and show how each of the commander's "sights" moderate the sensemaking process. It is surmised that these sights represent the dynamic knowledge structures of the commander while developing plans for an on-going operation. It is believed that each of the sights are evoked by intuition-- a "vague feeling of knowing something without knowing exactly how or why."

Introduction:

Today's military conflicts generate battlefield that is termed "asymmetric" with non-traditional adversary (NTA). Under this situation, the combatants and the commanders must be aware of its surround in 360 degrees of its epicenter. The reason is simple—in then traditional force-on-force combat, it is easy to see and predict the enemy's positions and behaviors; whereas, in the current asymmetric situation, the enemy is not defined, and a potential attack can come from any geographic direction. These characteristics define a new dimension of warfare termed Fourth-generation warfare. As observed by Leedom (2005), this Fourth-generation warfare *"places unique demands on the commander's sensemaking process because it reflects a form of conflict and engagement that is significantly more complex and emergent, as compared with Cold War-era force-on-force combat."*

In view of this evolving battle system characteristics, the commanders are required (and must be trained) to demonstrate their cognitive expertise and to make decisions in complex and/or chaotic scenarios without having to go through tedious analytic reasoning process. In general, however, this requirement has been a norm rather than an exception. This is the reason the current military doctrines and standard operation procedures emphasize the training of cognitive skills (FM3-07).

Particular types of knowledge structures are needed for proficient problem-solving and decision-making by the military commanders. Much of this knowledge is conceptual in nature, as

opposed to operational or procedural. The presence of conceptual elements in the knowledge structures is the key to having a "deeper understanding" of the problem space. Particular types of cognitive processes are required for the acquisition of conceptual knowledge and the construction of useful knowledge structures. An example is illustrated in the Fire Chief Commander's knowledge descriptions: "*Command presence includes the incident commander's confidence, expertise, assertiveness, perceived ability to adapt to changing circumstances, and overall leadership capability. However, there is also something to be said about the physical "presence" of an incident commander and how it affects the function of command in the IMS" (http://firechief.com/tactics/command_course_presence_10282005/).*

As a matter of fact, the current information abstraction in the DOD's Intelligence Preparation of Battlefield (IPB) recognizes a three-tier hierarchy of physical, informational, and cognitive (Medby and Glenn, 2002) as shown in Figure 1. At the highest level of abstraction is the cognitive representations of scenarios, conscious instantiations of meta-knowledge, intuition, and instincts through various enactments of all the six sights. At the informational or symbol level, the commander relies on different types of intelligence from different agencies that include the media. Lastly, at the root level, the physical domain is represented by the "terrain", landmarks, and a geospatial map of the battlefield—including stationary and dynamically moving targets.

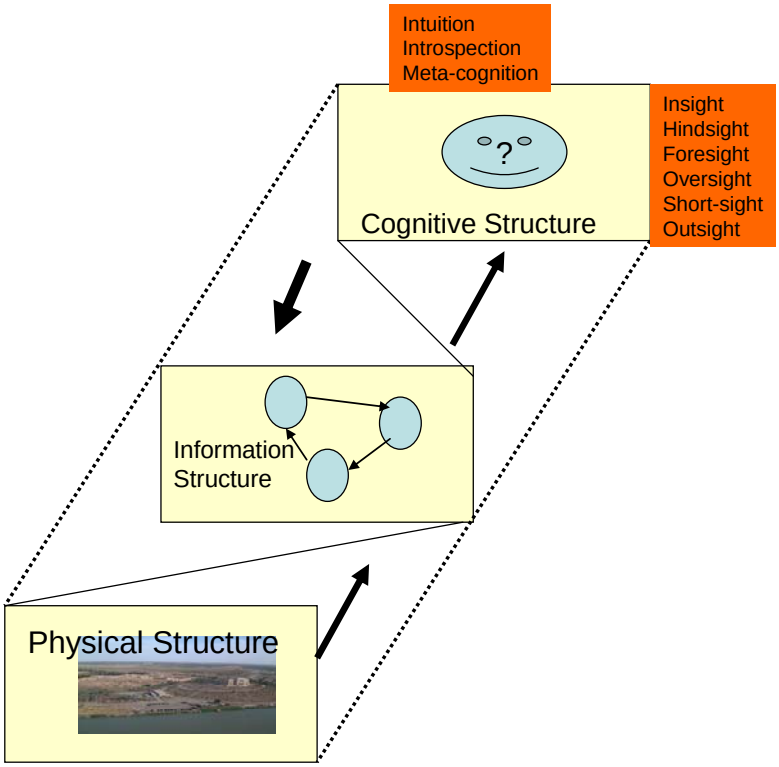

Figure 1. levels of information process abstraction for IPB

This stratification corresponds to Popper's (1972) world of knowing. Referencing Leedom (2005), Popper identified three classes of knowledge: World One is defined as the world of physics –the world of physical objects and forces that can be objectively measured and defined. This corresponds to the physical structure of terrain and geospatial maps. World Two refers to the psychological world of the individual –the personal world of feelings, dispositions to act, and all kinds of subjective experiences. This corresponds to the symbolic information

processing—signals, signs, and symbols. Finally, World Three refers to the conceptual products of the human minds. This corresponds to the cognitive information processing. This paper elaborates on some of the knowledge aspects of the cognitive knowledge.

In this paper, knowledge structure is used generically in the same context as cognitive architecture, but with specific reference to application to the sensemaking process. Terminologies such as knowledge map, linkage diagram, conceptual map, and cognitive maps can be used cautiously to describe the sensemaking process based on the analysis of the constituent knowledge and their relationships with each other. In cognitive architecture, the interest is to build computational and analysis tools to support cognitive simulation. Notes Grant (2005), "A cognitive architecture embodies the more general structure and mechanisms out of which could be made a model of individual cognition in a certain situation. The space of models and architectures has a number of dimensions, including: dependence on domain; level of specification; and extent of coverage of different phenomena (p.1)." For this discussion, my concept of knowledge structures is more opined to the "common sights" used by experts during problem solving and decision making. These sights, to be discussed later, are assumed to be an embodiment of perceptual, vis-à-vis cognitive constructs as illustrated in Figure 2.

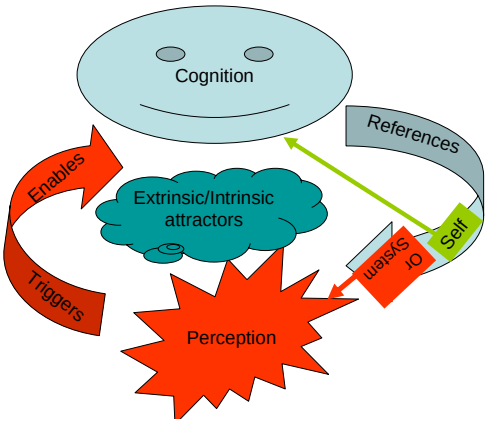

Figure 2. Cognition-perception loop with attractors as constraints

2. THEORETICAL RATIONALE AND EMPIRICAL SUPPORT

Klein (1988) has argued that in natural settings, the conventional sources of intellectual power (e.g., analytical reasoning) are not as useful as "the power of intuition, mental stimulation, metaphor, and story telling." He asserts that intuition allows individuals to size up a situation rapidly, while mental stimulations enable decision makers to imagine how a course of action might be carried out. Furthermore, metaphor enables people to draw on their experiences to compare the current situation to a situation that they have come across. These experiences are captured as mental models. The development of mental models is a product of experience and expertise. Experience lets people see a situation, even a novel one, as an example of a prototype.

Within the discourse in knowledge structures and how it is used, many studies have attributed knowledge to the theory of expertise—a result of training, skill, and experience on the job. It is recognized that expertise gravitates around the domain or situational factors and not the features of the problem to be solved (Chi et al., 1981; Adelson, 1984). This domain or situational factors are what control how mental models of the system is built as cognitive codes in the mind, and how it helps the expert to deal with novel situations.

Other studies have acknowledged that expert knowledge structures are influenced by skill, ability, and competency. Proficient sensemakers utilize knowledge structures that extend

beyond those of less proficient ones. For example, proficient sensemakers explore effects and consequences of their sensemaking outcomes. Klein and associates (1998) have emphasized how experts recognize cues and patterns and use them to elaborate through priming the linkages or associations leading to the desired goal.

Schema theories have also been associated with expert knowledge structures. Hintzman (1976) identifies three types of schemata: functional, cognitive, and conceptual. A functional schema holds the knowledge humans use to cope with everyday task. Above the functional schema, is the cognitive schema which operates as atypical knowledge, that is, knowledge based on beliefs and stereotypes. For example, people express their goals and intentions based on prototype beliefs anchored on strongly held information about a context. The contextual schema is used as a meta-cognition schema, that is, as an executive supervisor to the cognitive schema. Meta-cognition schema organizes knowledge based on high level concepts, percepts, and categories (Scholl, 1987).

Pirolli and Card (1999) studied an expert intelligence business analyst and observed that a schema structure was developed for each dimension associated to the type of information required to make decision. For example, a schema for market survey and analysis, report types, and market penetrations. Through interviews and protocols with intelligent analysts, they found the evidence of schemas used to organize information to support the cognitive tasks of planning, reasoning and evaluation about alternative courses of action (COAs). The cognitive structure of the intelligent analyst with respect to sensemaking task is represented by Pirolli and Card (1999) as: Information→ Schema→ Insight.

Because of the above assumptions, a schema-based organization of knowledge links automatic inference with mental models of the context stored in the human memory. This characteristic allows a schema to be applied in many situations involving information organization. Smallwood (1967) has used schema slots to describe the internal models held by pilots during instrument monitoring. Downs and Stea (1977) and Scholl (1987) have used schema organization of information to develop computational models of cognitive maps. Geiselman and Samet (1980) and Noble (1989) have applied schema theories to summarize military information and to elicit situation awareness information from the memory.

3. THE COMMANDER'S KNOWLEDGE STRUCTURE

3.1 The Guiding Paradigms of Principles

Historically, we can trace studies in human knowledge structures to early psychologists that believe that we make decisions introspectively. Thus, one way of understanding the commander's sight is to go back to introspection—a study of how people contemplate their own thought or inner feelings. Introspection depends on conscious experience, and each individual's conscious experience is by its nature personal and private (Eysenck & Keane, 1995; pp. 19) despite this, it is often assumed that introspection can provide evidence about some mental processes.

Each person has its private knowledge. Polyani (1967) refers to private knowledge as tacit. Polanyi is repeatedly cited and credited for the definition of tacit knowledge and how it influences the sensemaking process. According to Polanyi, tacit knowledge is what is known but cannot be told. The reasoning behind the statement is that the knowledge has become so personal in the unconscious mind and therefore it cannot be expressed because there is no access to it through the conscious mind. Polanyi said "we know more than we can tell." Polanyi's concept of tacit knowledge is reflected in three main theses (Leedom, 2005): (1) true discovery cannot be accounted for by a set of articulated rules or algorithms; (2) while knowledge is public, it is also to a very great extent personal or constructed by humans; and (3) the knowledge that underlies explicit knowledge is more fundamental.

Ericsson and Lemann (1966) recorded instances of intuition in problem solving and decision making. Intuition is knowing without the use of rational analytic process; immediate recognition through automatic information processing and knowledge of perceptive sight. Ericsson and Lehman (1966) noted that experts don't just automatically extract patterns and retrieve response directly from memory. Instead they select relevant information and encode it in special representations---that allow planning, evaluation and reasoning about alternative courses of actions. Intuition is therefore, an important aspect of the expert's knowledge. Hayashi (2001) notes that *"a decision is guided by intuition if the decision maker ascribes it to a "vague feeling of knowing something without knowing exactly how or why"* (Hayashi, 2001, p. 60). The ubiquity of reference to intuition in most aspects of organizational science and problem solving literatures indicates that they regard intuition as a valid guide for decision making.

3.2 The Sighted Knowledge Structure

In this paper, I shall use the word "sight" to be synonymous to Emmanuel Kant's (1783) concept of experience of knowledge and their influences on our understanding through what is intuitive. Because of its relationship to knowledge and experience, sight can be defined and/or described in terms of cognitive substrates, expertise, skills, and other human abilities that are associated with mental models. The human mind is then pivotal to my concept of "sight."

As shown in Figure 2, there is a continuous interaction cycle between cognition and perception enabled by environmental stimuli. These stimuli trigger cognitive knowledge elements that make reference to itself (meta-cognition) or to sources where the stimuli is situated. Relevant to the expert commander, sight is recognized as comprising of six sub-structures according to the contexts of use and their interactions with the task environment. The six sub-structures are (a) foresight used for envisioning and anticipating future states of the system; (b) hindsight, the sight used as reflexive knowledge from lessons learned or an after the fact knowledge; (c) insight, the sight based on our tacit knowledge; (d) outsight, a term I use to describe the sight for thinking outside the box; short-sight, the knowledge structure that focuses on short-term goals; and (e) oversight, the sight that overestimates or underestimates the states of system and leads us to erroneous conditions.

The description of each "sighted" knowledge structure follows (Figure 3). At the epicenter of Figure 3 is the commander. In the modern conflicts situations, this commander is surrounded by all the doctrines designed for operations-other-than-war, stability operations, peace keeping, and emergency relief operations. For stability and relief operations, the commander must understand how to run a civil affairs office using the SWEAT-MS (sewage, water, electricity, academic, trash, medical, and security) paradigm. As a warrior, he must be fully knowledgeable of METT-TC (mission, enemy, terrain, time, technology, and civilian) doctrine. Along these dimensions of doctrines and paradigms, are the understanding of how to deliver effect through the mapping of DIME (Democracy, information, military and economic) to the PMESII (Political, military, economic, social, information, and infrastructure) factors. When the adversary behaviors are included, these factors are considered the triggers of the commander's "sight"

3.2.1 Insight

This is our ability to discern the true nature of a situation—the ego-centric approach to situation analysis through the exhibition of tacit knowing. There are two definitions of insights from literature. The first refers to a state of understanding—understanding a principle, a concept, a problem, and so on (Smith, 1978). In this regard, insight can be achieved by incremental acquisition of knowledge. The second definition is phenomenological and describes insight as a sudden emergence of an idea, i.e. the "Aha!" experience.

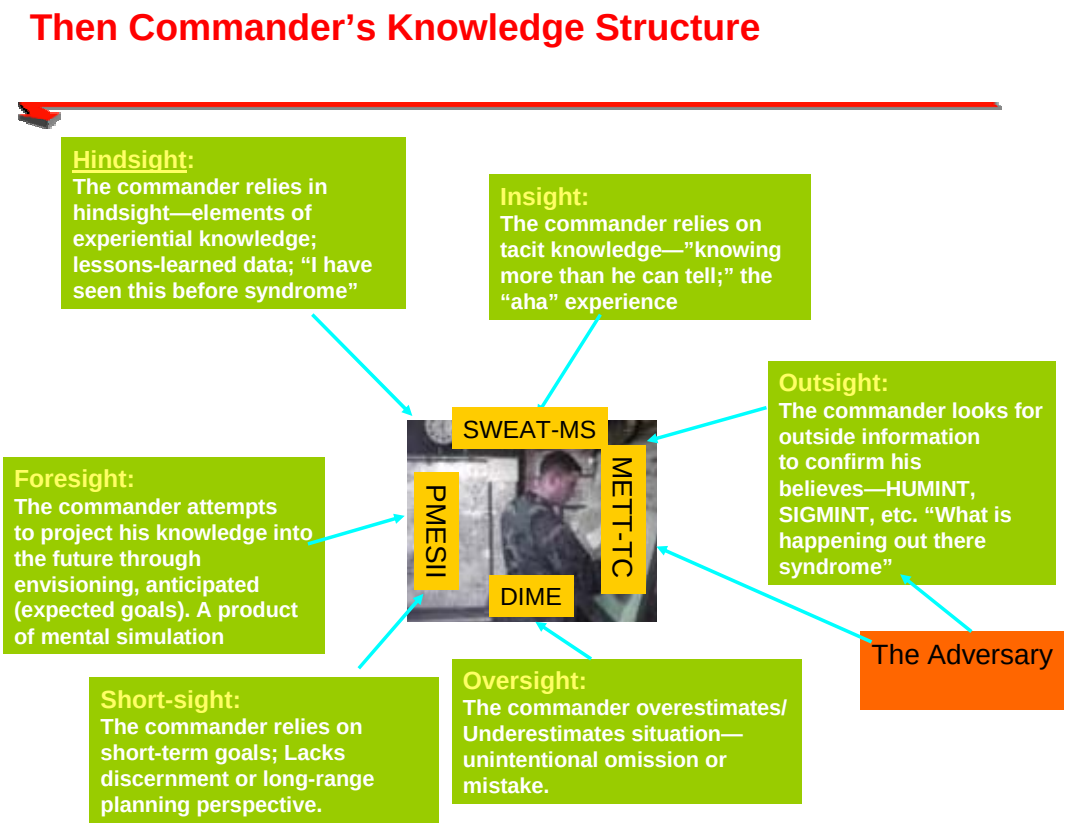

Figure 3 . The commander's sighted knowledge structure

3.2.2 Hindsight: this is the perception of the significance and nature of events after they have occurred. It is "a flashback experience for using what we know to get what we want." Hindsight is all about experience and not necessarily expertise. The decision maker with hindsight thinks back in time, recalling events, episodes, actions, and consequences. History is the arbiter of hindsight, and quite often, people make decisions "to avoid the past mistake." For example, people tend to remember the worst experience in life or significant days in their lives, such as wedding. Similarly, military commanders use past history to deal with new and similar situations, or even extending their knowledge to cover novel situations. They do so to minimize risks or other undesirable consequences.

3.2.3 Foresight: Foresight is a cognitive structure that contains level 3 situation awareness elements defined by the projection of the future actions, at least in the near term (Endsley, 1995). Thus, foresight allows the sensemaker to anticipate, envision, and form notional expected goals about the situation or context of interest. The process of foresight is constructive and may involve such tasks as: Scanning the environment to identify significant changes in the system states; Trend analysis can be used to examine patterns of behaviors over time and space; this also requires a continuous monitoring of the activities or events and trend projections; and Historical analysis which involved some lessons learned in the past. For example, the U.S. invasion of Iraq in 2003 has been compared by some commentators to the Vietnam War, with the implication that the Iraq War would also prove disastrous.

3.2.4. Outsight: This sight is about understanding the ecological niche and how it influences the commander's sensemaking process. It is seeing the world from what is happening "out there"--the ability to look outside one's self to determine what and how environmental stimuli influences the general thinking process; e.g., how the information ecology drives the enactment of tacit knowledge or how experiential knowledge from hindsight is used to determine the patterns and linkages of system behaviors. An example is the PMESII doctrine used in today's military to deal with stability operations. Gibson (1979) believes that the information provided by the visual environment (*outsigh*t) is allegedly sufficient to permit the individual to move around and interact directly with that environment without the involvement of internal processes and representations (Eysenck and Keane, 1995; pp. 73). This theory of direct perception as known by Gibson, although in conflict with constructs in cognitive theories, still has relevance in how people organize information in response to the environment. In the military lexicon, the "terrain" , "citizens", and the "enemy" are some of the determinants of the METT-TC that are consequential to the "outsight" knowledge.

3.2.5. Short-sight: This is the sight that controls the short-term decision making by the expert. The expert does not see beyond immediate spatio-temporal dimensions—every planning and actions are time and knowledge limited. The short-sighted sensemaker does not see the "big" picture; hence all thinking is local for an immediate effect-based operation. In most cases, it lacks feedbacks and follow-ups. For example in the early stage of 2003 Iraqi war, the strategic sensemaking failed to deal ruthlessly with the insurgents because they did not want to offend the religious leaders, leading to more escalations and growths in the number of insurgent organizations in Iraq. Al-Zarqawi, the Jordan-born terrorist could have been killed earlier, but due to short-sighted decision making of the policy makers.

3.2.6. Oversight: An oversight knowledge structure is used by experts to review and assess errors that occur during problem-solving or decision-making. The error may be an unintentional omission or mistake—having the thinking overshooting or projecting beyond or below expectations. An oversight condition occurs because the meta-cognitive knowledge used by experts is limited and liable to information processing errors such as pattern matching, and misjudgment of situations. Overwhelming and complex information fusion or attempts to estimate intelligent from sparse data may lead to overestimation or underestimation errors. Oversight knowledge also allows the sensemaker to perform either a self-feedback- or a system-level -feedback evaluation to determine the necessary corrective actions.

The summary of the "sighted" knowledge and their explanations are shown on Table 1.

4. APPLICATION IN BATTLEFIELD SENSEMAKING

A key to sensemaking is attempting to understand the nature of the knowledge that humans bring to the sensemaking process, and the way in which that knowledge is used, shared, tested and evolved during the process. How sensemaking occurs, and how knowledge is used, is strongly dependent on how we think and how we understand the world. Herein, lays the importance of commander's knowledge structure.

Table 1. The summary of "sighted" knowledge and their applications

Sighted (cognition)	Knowledge Type	Explanations/ Applications
Foresight	Fore knowledge Predictive knowledge Mental simulation	Envisioning, forecasting, anticipating, and predictive causal maps for situations and/or events. Applied to anticipatory planning, goal expectations and intents; perceiving dimensions of system failures at the conceptual stage; Useful in constructive (predictive) simulation models for future system state analysis and preparedness planning.
Insight	Tacit knowledge	Supports meta-cognition using experience-based mental models, cognitive maps, and heuristics generated from experiential knowledge. Useful in constructing mental simulation models for explorative/proof-of-concept on expertise; Derivative knowledge of familiar situations embodied in ego-centric goal description –intentional knowledge explications.
Hindsight	Lessons-learned knowledge embodied in historicity	Heavily bounded on reflexive knowledge of past events. Long-term memory plays a major role.
Oversight	Diagnostic knowledge	There is an overshoot caused by the gap in knowledge between reality and model-based situation assessment. The interest is to diagnose causes and consequences of error during the sensemaking process. Gap analysis, error correction, and feedback. Helps in diagnosing causes and consequences of errors during sensemaking process.
Short-sight	Myopia knowledge	Spatio-temporal reasoning and planning; short cycle system analysis; short-term goals and plans; lacks the vision of a big picture—leading to constraints and bottle-necks or strategic errors.
Outsight	Ecological knowledge	Thinking outside of the box. Uses all forms of doctrines, procedures, and intelligent—HUMINT, SIGMINT, and so on to determine adversary terrain information.

On the nature of knowledge, Quine (1951) discusses empiricism, which assumes there is an external world which we perceive through stimuli affecting our senses. We detect patterns in those stimuli, which are subsequently stored in memory as knowledge. The external stimuli are

thus the source of all knowledge which is consequently universal, and objective (Killin and Hickman, 1986).

Consider a situation in Iraq at the city of Al Kut (See Figure 4). The commander and his staff in charge of the region, and operating from his TOC, have received a message that there is sporadic firing from a mosque in that city. The parole platoon has called for reinforcement without knowing whether this is a civil unrest, a terrorist attack, or an on-going military confrontation with the enemy. For this problem, the situations were "sights" are relevance will allow the commander to ask some important questions, such as

(a) What is the specific event or fact observed? (*Outsight knowledge*)
(b) What does it mean to you? (*Insight knowledge*)
(c) How much familiarity to this event or situation? (*Hindsight knowledge*)
(d) Should the Iraqi security be sent to control the situation? (*likely Oversight/ Short-sight*)

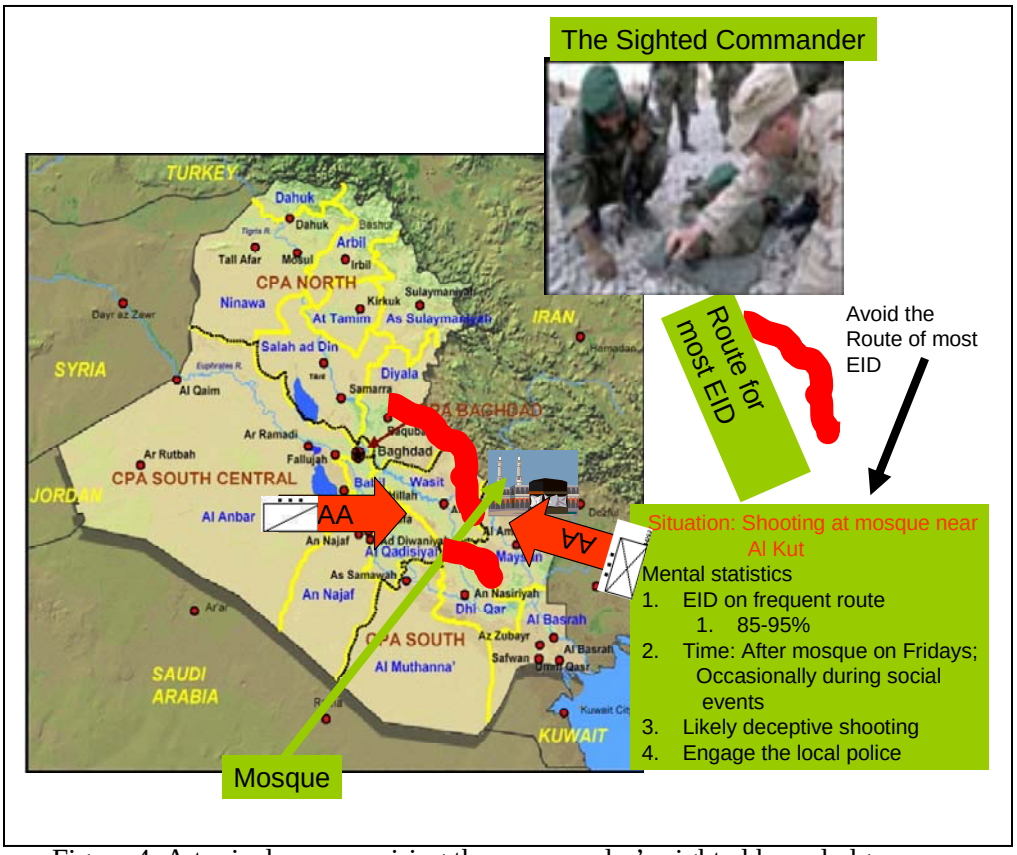

Figure 4. A typical case requiring the commander's sighted knowledge

The commander's knowledge structure is useful in this case only if it can be understood in terms of the implications for action. As complexity, dynamics, or uncertainty increase, the use of the knowledge can become a burdensome and labor intensive process. The principal resource available to the sensemaker for perceiving the situation and understanding it is his or her sightful knowledge expressed in the form of experience trigger and expertise quasi-analytic intuition. If a certain pattern of information has been encountered previously and always represented a clearly defined situation, the sensemaker will likely recognize that pattern and make the connection quickly. As echoed by Malhotra (2001), by understanding a situation, the expert can form the conceptual link between information available and the expected result or anticipation of task

outcomes. It could also help us to understand the gap between performance expectations based on information in context (Malhotra, 2001; pp. 12). Table 2 is a summary of situation applications for mapping the sightful knowledge to different sensemaking situations.

Table 2. Sample applications of the sighted knowledge structure

Selected Problem Situation	Sighted Knowledge Influence
Problem analysis: Constructing a problem representation	Insight; Outsight.
Conceptual analysis: Using primitive concepts to reconstruct meaning	Hindsight; Short-sight.
Representational analysis: Determining different ways of interpretation and meaning assignment	Oversight; Short-sight.
Complex analysis: reducing problem to manageable size and applying heuristics that ignores complexity—make sense of complexity and chaos	Insight; Hindsight; Short-sight
Comparing and contrasting evidence: Identifying patterns based on qualitatitive/quantitative similarity metric	Hindsight; Oversight.
Interpreting situations: For example, using object location in maps to determine enemy position or dangerous zone.	Outsight; Hindsight; Insight.
Self evaluation: Such as evaluating one's performance, or identifying bottlenecks in problem situations.	Insight; Oversight.
Self-awareness: Determining physical, informational (symbolic) and cognitive states and their risks during combat.	Insight; Hindsight; Outsight; Short-sight.

CONCLUSIONS

In every battlefield sensemaking situations, it is likely that the commander will look back at history, his mental model, and reflexive knowledge in order to compare the decisions made in the past to the features of the present problem; use the results from the past decisions to envision the possibilities of the future. Hume (1748) succinctly captures this observation thus: "In reality, all arguments from experience are founded on the similarity which we discover among natural objects, and by which we are induced to expect effects similar to those which we have found to follow from such objects…From causes which appear similar we expect similar effects. This is the sum of all our experimental conclusions."

In general, then, the commander's "sightful" knowledge becomes an indispensable commodity for sensemaking. The commander must first make sense of the complex information provided from different sources. While there are availability of information technology to help the commander in data processing and analysis, it is not surprising that in real-time sensemaking situations, the commander falls back on his six sights while trying to make sense of a battle situation as well as making decisions to enact dynamic actions. In this paper, the six human sights---insight, hindsight, foresight, short-sight, and oversight have been discussed. It is also shown how each of this commander's "sights" influences and moderates the sensemaking process.

It is also argued that extracting information and knowledge contained in "sightful" knowledge of the commander is situation specific and thus varies according to the complexity of the situation. In time-critical sensemaking process, it is likely that the commander may use some

or all the "sights" simultaneously without knowing. In general, the level of experience and expertise determine at what problem instance is a particular sight is useful. In difficult situations, sensemaking may translate to a knowledge discovery process. This requires the commander to use his sights to navigate the continuum of intuition-analytical mode of thinking--substituting intuition for analytical models, and vice versa. As observed by Wong and Wang (2003), *"The speed of the pattern and rule extraction process is often crucial to a decision making process. This is true, not only because of the imminent response often required for a quick decision , but also that interactive processes are often needed in the incremental information and knowledge extraction process for a comprehensive decision…. In many situations, based on what they learn or discover from the explicit patterns …., they could make a judicial decision or they may like to look further into the data to discover more supporting evidences (pp.115)"*.

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