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Title: The Process of Sensemaking in Complex Human Endeavors

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This paper presents an approach to organizing the sensemaking process. The approach uses a set of cognitive constructs that translates tacit knowledge to the focal knowing of the objective world. The sensemaking process is also viewed as a robust method for developing training tools for the battle staffs critical thinking skills for various levels of problem complexities. At each stage of the sensemaking process, we have attempted to illustrate the efficacy of the available sensemaking constructs and paradigms. In addition to training application, the sensemaking process can be used to support knowledge representation for constructive modeling and simulation of sensemaking tasks.

1. INTRODUCTION

The Department of Army's doctrinal handbook, FM1 5-0.1 (2006, pp.1-18) summarizes the commander's role in exercising C2 in for ways which are all characteristics of human endeavor: (1) Visualizing the environment; (2) Describing their commander's visualization to subordinates; (3) Directing actions to achieve results; (4) Leading the command to accomplish the mission. Collectively, these endeavors are anchored on many cognitive processes that include, but are not limited to, sensemaking, situation awareness, and situation understanding.

Sensemaking is particularly important in information fusion and as an aid towards situation understanding the multidimensional information processing in asymmetric battlefields. Sensemaking is a process, a design, or a technique of fusing information in context to derive understanding from fragmentary pieces of information (Ntuen, 2003; 2006). Sensemaking can be viewed as a paradigm, a tool, a process, or a theory of how people reduce uncertainty or ambiguity; socially negotiate meaning during decision making events. Planning is a part of the sensemaking[1] process. Weick (1995) states that sensemaking refers to how meaning is constructed at both the individual and the group levels. Through the accurate construction of meaning, clarity increases and confusion

[1] David S. Alberts and Richard E. Hayes (2006). Understanding Command and Control. CCRP Publication Series (http://www.dodccrp)

decreases. For example, Leedom (2002) indicates that battle rhythms can best be understood through the sensemaking process. A poor sensemaking process often leads to poorly understood objectives, missions, and visions. This in turn can lead to poor framing of plans, and consequently, poor decisions. Sensemaking involves the collective application of individual "intuition"—experience-based, sub-consciously processed judgment and imagination—to identify changes in existing patterns or the emergence of new patterns (Weick, 1995).

Examples of situations or occasions that need sensemaking are ubiquitous in many command and control (C2) endeavors. For example, from the domain of a peaceful social structure to an unstable cultural war (e.g., Iraq); from a quite habitat of human species to catastrophic refugee immigrations orchestrated by natural calamities (e.g., Hurricane Katrina and the Gulf Coast residents in USA). The human system also interacts with multivariate ecological information to create a system transformation that may go from a stable state to a chaotic state or a state of calm to that of panic. Interestingly, these types of system state changes can be from human designs or as a result of natural phenomena. For example, we may design human organizations that are subject to stress and agitations. These may be political (e.g., recent outbreak of anarchies in Burma, Darfur, and Pakistan); economic such as the economic meltdown of South Korea in the early 1980's; socio-cultural (e.g., managing over 200 ethnic languages in Nigeria); or military, such as the on-going Iraq and Afghanistan wars. C2 can also be enacted when natural disasters occur. Hurricane Katrina in New Orleans and Tsunami in Asia are two obvious examples that define natural complexities, which in their own diverse characteristics can lead to further complexities in many facets of managing and controlling after effects—politically, economically, and socially.

The examples above illustrate sensemaking situations that can best be described by how much we can predict the informational state of the world. For example, in the military environment, Alberts and Hayes[2] note that *"Being able to pick a nontraditional adversary out of the noise and determine its capabilities and intentions is among the greatest challenges that we face in Information age (pp. 101)."*

While sensemaking is receiving some attentions recently because of the need to quickly analyze information and gain decision superiority, the process of sensemaking is still not well understood or formalized. The aim of this paper is to present a description of the knowledge components and a formal process of sensemaking. The result of this effort can be applied to many situations that may include: (a) modeling and simulating tacit knowledge; (b) understanding human intentions with respect to actionable knowing or world knowledge; and (c) determining how sensemaking occurs at various level of knowledge abstractions—cognitive (individual level), organizational (social level), and ecological (world out there).

[2] Davis S. Alberts & Richard E. Hayes, Power to the Edge: Command and control in the information age. CCRP, (http://www.dodccrp.org), 2003.

2. THE STAGES OF THE SENSEMAKING PROCESS

Alberts and Hayes[3], notes that "*Sensemaking is much more than sharing information and identifying patterns. It goes beyond what is happening and what may happen to what can be done about it. This involves generating options, predicting adversary actions and reactions, and understanding the effect of particular courses of action (pp. 102).*" If we are to build a model that supports sensemaking as a human endeavor, the process of sensemaking must be understood. Based on our sensemaking studies—both theoretical and experimental (Ntuen & Leedom, 2006, Ntuen, 2003), we have identified eight macro stages of sensemaking. These stages are based on a cognitive information abstraction hierarchy model. Figure 1 is used to illustrate these stages with their interactions and feedbacks. The descriptions of these stages follow.

1.Situation Framing

In many situations that involve complexity and uncertainty, identifying the core of the problem is the most challenging task. We call this a perspective making problem—the first level of making sense of a problem situation. It is surmised here that perspective making is a pre-requisite to framing the structure of the problem situation. The problem of situation framing comes down to creativity and insight. Here lies one of the differences between the expert and the novices—in the way they build perspection codes of the situation. At this stage, sensemaking involves putting stimuli into some kind of framework (Starbuck and Milliken, 1988, p.51).When people put stimuli into frameworks, They can "comprehend, understand, explain, attribute, extrapolate and predict."

Consider the recent bombing of Times Square in New York (CNN News Report, March 4, 2008), the C2 decision elements involved (the Police, FBI, CIA, etc.) started with an assertion that the bombing is likely the work of terrorism. This assertion is an example of imposing beliefs and history on a framing problem. There are many other ways in which people impose frames on an ongoing situation and link the frames with the situation cues for the purpose of discovering meanings in context.

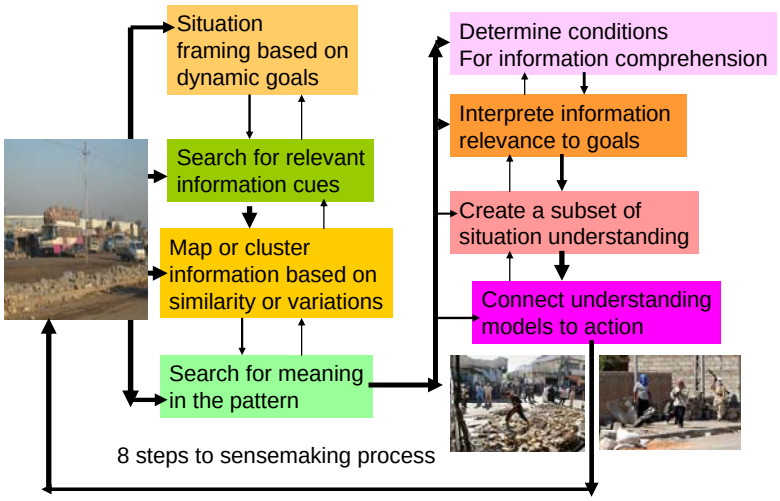

Figure 1. Stages in the sensemaking process

[3] Ditto Alberts & Hayes, 2003

Framing can begin with beliefs and take the form of arguing and expecting. Or, it can begin with actions and take the form of committing or manipulating. In both cases, sensemaking is an effort to tie beliefs and actions more closely together as when arguments lead to consensus action during team problem solving. Various performance shaping factors that are relevant to measuring situation framing outcomes may include, clarified expectations; confirming actions for effect-based objectives; justification for matching sensemaking outcomes to desired actions; or explanations for assumptions and hypotheses about a situation of interest. Failures in framing a set of hypotheses about a context can be attributable to atypical beliefs, bias, and stereotypes. These attributes can block our ability to see things in the same fixed frame of reference.

2 Searching for Cues

Using the Times Square bombing problem presented in stage one, the C2 decision makers would likely be searching for evidences or clues as to how the bombing happen, when did it happen, and who is responsible for it. Evidence provides a cue to problem contextualization, and thus serves as the focal base for human reasoning strategies and the focus in which a problem space is grounded. Here, a clue can start as a signal guided mapping where the sensemaker basically starts with a hypothesis and looks for data to confirm an assumption. On the other hand, a cue-guided search can be used--a bottom-up search which uses information cues as an initial data frame. From here, the sensemaker seeks linkages and patterns in the available information or data, and make classification according to saliency of the cues in order to develop some sense of patterns and correlation likely to lead to a first level nominal awareness. Klein's (1989) concept of recognition decision making (RPD) process falls closely into this phase. A recognition-primed decision relies on the decision maker's ability to recognize cues or familiar objects. It also requires recalling information relevant to a context in which these cues were applicable. It requires an extensive a memory resources. The extent to which the process uses cognitive resources depends on how much adjustment the decision maker decides to make in response to evolving contexts and information changes. This is a function of familiarity, a topic widely discussed in skill acquisition and expertise theory.

During the process of looking for clues from the provided cues, we are likely to encounter a confirmation failure—information processing state whereby the existing information space does not match or correlate with the information in our memory. For example, in the Times Square bombing case, if a typical belief of associating the bombing to terrorism is maintained, important evidences or cues can be missed—e.g., it could be that a disgruntled citizen with Iraqi war might have been responsible, which, by seeing an army recruitment office triggered an act of aggression that led to the bombing act. Also, when we make the wrong assumptions or hypotheses which are contradictory to the existing evidence, we are in essence subjecting sensemaking process to a first level fault which can later manifest into a serious decision making failure.

3. **Information Mapping**

The next step in sensemaking process is information mapping. Here, the available information cues are used by the expert sensemakers to develop a map or a relation topology where clusters of similar information stimuli are arranged in the form of patterns or taxonomy trees. In the Times Square bombing case, chemical evidence of

smoke and gunpowder, biometric footprints, and eye witness accounts can be used to develop a crime map from a national database. The result may point to the types of bomb used, whether the culprit is a male or a female, and whether a pattern of such crime has occurred some else (either geographically dispersed or near). The purpose of such information mapping is to gain a spatial understanding of the relationships in the available information space so as to create ontology or place holders for fitting new information patterns during scenario changes. The mapping process can include link maps, conceptual maps, free body diagrams, decision trees, and semantic diagrams. This makes information mapping a classification problem. So, mapping an information object to a wrong cluster can lead to potential errors. This can lead to misguided mission in the C2 process.

4. Search for Meaning in Information Pattern

What do the chemical components of the gunpowder in the bomb or the finger print at the Times Square crime scene tell us? In other words, what does this information mean? Sackman (1991) views sensemaking as the mechanisms that organizational members use to attribute meaning to events. Such mechanisms include the standards and rules for perceiving, interpreting, believing and acting that are typically used in a given cultural setting (p.33). Meaning is therefore tied to a specific context and search of how one concept relates to, influences, or allows sensemakers to gain a first level interpretation of the big picture. As an epistemological construct, meaning is a subtle, loose, and diverse assignment of definition to a knowledge token, object, or artifact. In this respect, Berkeley (1710) notes that meaning exists in one's mind, and is often difficult to explain it—an observation that leads to the paradigm that "we know more than we can tell" (Polyani, 1966). Polanyi describes the semantic aspect of tacit knowing, how meaning tends to be displaced away from ourselves, and toward the external. This is observed in the perception of using a tool, in which the meaning of the use of the tool becomes evidenced in the external impact of the tool, not in its immediacy in our hands while using it. Meaning is also realized through the process of how we describe things, objects, events, and so forth—hence, meanings are embedded in language through description (Macdonald, 1995)--implying that meaning cannot be absolute or objective in the positivist sense (Ambrosini, 1998).

Information mapping has no meaning unless it results in pattern recognition. The finger print evidence in the Times Square bombing scene has no meaning unless we can correlate it with particular biometric information in the national database and make an inference about a likely suspect with an upgraded probability and confidence level of significance. This is a pattern recognition problem that provides the meta knowledge for searching for meaning in context of evolving information. It is the act of taking raw data and making an action based on the "category" of the pattern. A remarkable property of humans (and other living beings) is our ability to recognize patterns. Examples include face and sound recognitions. Recognizing patterns in a cluster of grouping also enables such tasks as diagnostics, search, monitoring, and inspection. Thus, the characteristics of the groups or clusters formed by information patterns have some useful knowledge for sensemaking and decision making. Such knowledge is a result of some derived statistical and syntactical properties such as features, error estimations, and grammatical inferences. When patterns are irregular in form, or when we can not predict the conditions when and

where an information pattern repeats itself, we can encounter gestalt type errors leading to sensemaking failures. An example may be arresting a wrong person in the bombing case and latter exonerating the person with better evidence from DNA analysis.

5. Information Comprehension

Comprehension is a meta-cognition task explicated in the context of a work domain. In a sensemaking task, comprehending a situation is synonymous to "being aware" of the situation. It involves developing rules to fit or map information from one source or new situation to another source or situation. Information mapping rules are based on repetitive behaviors in which a set of production rules (in the form of "If X then Y") are used to associate specific meanings and interpretations to system goals. When we comprehend a situation, in a nominal sense, the abstract frame of reference is concretized through associations with specific rules of behavior or schema. During a comprehension task, *"changes in the environment will often be met by an updating of the current schema by a subconscious reaction to cues or a consciously expressed intention (Rasmussen, 1986; pp.151)."* Let's take the Times Square bombing case again. Assume all sensemaking activities in stages 1-4 above have been completed successfully; we are now in a position to visualize subroutine of multiple behaviors emerging. The expert investigators can now bring to bear the relevance of their retrospective information to the current situation. Rules of association can be developed to serve as competing likely courses of actions or competing alternatives. The crime investigators can now comprehend the situation because of the availability of the compelling evidence based on their personal constructs of self awareness. Kelly (1955) defined this phenomenon in terms of personal constructs, an individual's organization of unique mental models (in the form of rules) of the world that are both shaped by prior experience and are used to interpret new experiences.

6. Interpreting Information Relevance to Goals

In the Times Square bombing case, we have gathered a preponderance of evidence; each expert investigator is now disposed to all information. It is time to give an individual opinion on what might have led to the bombing. Interpretation reflects an approximation of these individual opinions. Interpretation leads the sensemakers to discover the possible knowledge states required for intended actions. Feldman (1989) views sensemaking as an interpretive process that is necessary for *"organizational members to understand and to share understandings about such features of the organization as what it is about, what it does well and poorly, what the problems it faces are and how it should resolve them*." The act of interpretation may take the form of explicit sensemaking through communication; it may also take place through the transformation and integration of representation of selected information within the defined context (Suthers, 2005). The key challenge is, however, is minimizing the variance in a diversity of meanings accorded the object of interest with its different interpretative viewpoints (Malhotra, 2001). This is because, the art and science of interpretation is subjective to all forms of subjectivity—opinions, estimates, guess, and so on; leading to the so called problem of equivocality or diversity of viewpoints.

7. Creating a Subset of Situation Understanding

Understanding a situation means that we have a grasp of the relevance knowledge spectra about the situation. In addition to being situation aware, we also possess meta-cognitive structures that allow us to solve problems that are not familiar—those problems that evolve according system changes, relatively unfamiliar and with novel characteristics. Take the case of the Times Square bombing. We are working backward from an atmosphere of chaos to a situation where we can understand a partial subset of knowledge required to solve the problem. Information that is processed into knowledge is useful only if it can be understood in terms of the implications for action or goals. We can identify the suspects with increased probability; we have interrogated the suspects and gained some insight into the reasons to the bombing behavior; we can now estimate some other future targets and the social network groups involved in the attack. We can now plan some deterrence and decisive courses of actions. As complexity, dynamics, or uncertainty increase, situation understanding models become useful to the decision makers. The principal resource available to the sensemaker for perceiving the situation and understanding it is his or her experience and judgment. If a certain pattern of information has been encountered previously the sensemaker will likely recognize that pattern and make the connection quickly. Accordingly, Polanyi's (1967) definition of focal knowledge can be used to infer how individuals assign meanings to what the see and feel. As echoed by Malhorta (2001), *by understanding a situation, we 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 (Malhorta, 2001; pp. 120).*

8 The Stage of Actionable Knowledge

The purpose of sensemaking is to connect situation understanding to action or to derive some actionable knowledge. Crothy (1988) observes that *"all knowledge and therefore all meaningful reality as such, are contingent upon human practices, being constructed in account of interaction between human being and their world (pp.42)."* The focal knowledge posited by Polanyi (1966) forms the theoretical basis for describing the enactment of sensemaking process into an actionable knowledge. According to Polanyi focal knowledge is a form of articulated knowledge or a situation understanding model that can be used in selecting and executing courses of actions. This can take place in one or many ways that include, but are not limited to

1) knowledge that provides an understanding of the task and assigning priorities to actions;
2) using recognizable cues to perform actions automatically;
3) providing plausible cause-effect explanations to diagnostic problems;
4) recognizing the specificity of knowledge and their changing requirements in applications. This is echoed by Nonaka (1995), that "what makes sense in one context can change or even lose its meaning when communicated to people in a different context").

3. CONCLUSION

Sensemaking is a cognitive task and a human endeavor. In decision making, rational processes (sometimes with dichotomous decision variables) are used to develop preference recipes to problems with two or more courses of actions. Sensemaking does not enjoy that privilege of dealing with "yes" or "no" choice decisions. It is a knowledge intensive process that involves many multivariate activities; these include, e.g., data mining, information fusion, diagnostic reasoning with explanations, and so on. Additionally, sensemaking deals with work systems with asymmetric dimensions where information changes occur dynamically based on contexts, time, and space. These dimensions can create mushroom of uncertainties, complexities, and sometimes, chaos. The sensemaker does not have a formal process per se to deal with or cope with these dynamic and evolutive information situations.

While sensemaking has received some attentions recently as a way to understand problems in complex and asymmetric battle space, the process of sensemaking is still not well understood or formalized. This paper has presented an approach to organizing the sensemaking process. The approach uses a set of cognitive constructs that translates tacit knowledge to the focal knowing of the objective world. We have used the process to develop visualization and cognitive simulation games applied to Stability and Security Operations (SASO). The model environment known as Sensemaking Support System (S3), see, Ntuen (2007) and Ntuen and Gwang-Myung (2007, 2008), is developed by architecting sensemaking information flow at three macro hierarchical levels of abstractions; consisting of the individual or cognitive level, organizational level, and ecological levels; respectively. At each level of abstraction, the stages of sensemaking process are applied. The lessons learned from the S3 modeling effort is that, as with any human cognitive exercise, the ontological representation is highly abstract and constructive. The sensemaking process is also viewed as a robust method for developing training tool for battle staffs critical thinking in complex asymmetric problem scenarios (Ntuen and Leedom, 2007).

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