RAVENS: A Framework for Designing Human-Automation Collaboration to Enhance Situational Understanding for Emergent and Novel Contexts

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Odin used two ravens named Thought and Memory, to fly the world each day in order to inform him of what was happening.

Paraphrased from a Norse myth.

In the modern battlespace, the warfighter, from the commander and his staff down to the echelons, faces critical decisions in dynamic, novel, and highly uncertain environments. In addition, he or she has access to greater amounts of data and information being provided at a faster rate from multiple sources. Further, many critical decisions involve interaction and even collaboration with automation. Here, it is not only the performance of the automation that is important, but how well the human thinker and automation interact and the tools provided by automation or information interface to aid such interaction. While our technology and techniques for collecting information to support critical decisions has increased and become more sophisticated, the world that the warfighter is trying to make sense of has become more uncertain, dynamic, and risky. This requires a fundamental shift in how we approach the problem of understanding a situation.

Warriors going into new, unpredictable, and high-risk environments are certainly not new or unique to the 21st century (c.f., Boot, 2002). However, over the past two decades and for the foreseeable future, the missions and operations that the military has and will be involved in have changed so that these situations have become the "norm." Rather than going around cities, the battles are in the cities, and to a large degree "enemy" identification is ambiguous because they blend with civilians. Further, the military is not always engaged in force-on-force operations, traditionally defined as war. Military Operations on Urbanized Terrain (MOUT), Stability and Support Operations (SASO), anti-terrorist missions, peacekeeping and even humanitarian operations have become common. Deployment is rapid, cultures and languages may be divergent, the goal may be ill defined, and expertise may be limited. War is simple in its concept but complex in its execution. These current Military Operations Other Than War (MOOTW) are complex in both concept and execution (Pike, 2000).

Commanders and their staff or anyone else making decisions about what the enemy is going to do in these situations depend on timely and relevant analytical and predictive intelligence. The military intelligence (MI) system of systems involves human cognition collaborating with other humans and automation support. The products of these collaborations are then used by the decision-maker to understand the situation.

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With traditional war, this can be pretty straightforward as long as you are aware of the elements in the battlespace. In these rapid-deployment, dynamic and uncertain environments, situational understanding becomes a much bigger problem.

The question being raised here is how can the situational understanding of critical decision-makers be supported in these current operations? As information becomes greater and more complex, how can automated visualizations be employed to aid this critically human process? How can we promote adaptiveness (there are no school solutions) and rapid knowledge building? While this paper will not give firm answers to those questions, it does provide a perspective from which these questions might be usefully approached.

The purpose of this report is to propose a framework for approaching the problems that situational understanding of MOOTW missions raise. The intent is to extrapolate from that framework possible ways to design tools and decision aids that will better support the critical decision-maker in his or her efforts to make sense of the situation. An important emphasis will be made on storytelling (reflecting narrative cognition in the human) as a powerful human sense making ability that needs to be cultivated in the human decision-maker and needs to be supported by information automation. This framework is a refinement of previous ideas developed at the US Army Research Laboratory Field Element, Fort Huachuca, Arizona (Warner & Burnstein, 1996; Warner 2001).

First, I will focus on the concept of narrative cognition (storytelling), a key part of the framework and the importance of this concept for situational understanding in data-rich but knowledge-poor environments. This discussion is considered the central issue of this report because this is critical to sense making in emergent and novel situations, bringing the explanatory mode to the forefront.

Next, I will examine how this framework might be applied to decision support technology and information displays to aid the decision-maker, and particularly, how storytelling can be supported. Some methodological issues will be discussed here in terms of how to approach doing science and engineering with a concept such as storytelling. It is hoped that this discussion can become a springboard for future work.

SITUATIONAL UNDERSTANDING IN EMERGENT AND NOVEL ENVIRONMENTS: THE VALUE OF A GOOD STORY

"RAVENS" was selected as a name for this framework for a number of reasons, including the fact that Ravens are storytellers in many cultural traditions and the fact that Ravens are sometimes associated with MI. However, it was turned into an acronym standing for "Rapid Adaptive Visualization of Emergent and Novel Situations," which refers to the goal of the framework as much as the application of it. Note that "visualization" should be interpreted broadly as any means that helps one clearly represent and think about the battlespace. Visualization in this sense encompasses any or all perceptual modalities or even non-modal techniques such as modeling. Unfortunately, while "visualization" seems tied to the visual modality, there are no really good alternate terms.

The operational goals and missions of the U.S. and other allied military partners have changed greatly over the past few decades, starting with the collapse of the Soviet Union in the late 1980s, most symbolically represented by the demolition of the Berlin Wall. One of the key things that changed was that the U.S. found itself as, both economically and militarily, the only superpower. That meant (and the gulf war helped emphasize) that any attempt by a formal nation-state to oppose U.S. forces strength-for-strength in a force-on-force linear engagement was going to have only one result (Paparone & Crupi, 2002). Thus, we are

no longer being attacked by nation-states but by more amorphous groups, attacks may not always appear as military attacks and that uncertainty has greatly increased. In addition, the military is increasingly involved in missions that include goals other than engaging the enemy such as SASO and is often operating as part of a joint-force and international coalitions. Finally, the military is less often engaged in linear battles involving large numbers of troops fighting away from urban environments and more often uses smaller forces fighting in urban terrain.

The result is that in the modern battlespace, the soldier faces critical decisions in dynamic and uncertain environments characterized by a wide possible range of threats. These operational environments include civilians, police and local security, the international press, terrorists, paramilitary groups, other friendly or neutral forces, and even political and diplomatic considerations that can impact the operation both strategically and tactically. Thus, I refer to these types of operational environments as *emergent* and *novel* because the situation evolves rather than unfolds much more dynamically and with much more complex interactions. Further, each operation may be quite different from other operations, even those with similar goals, making expertise a difficult thing to attain. These new environments often involve unfamiliar cultures in which some may be allies and some may be foes, low frequency languages, and rapid deployment, a difficult combination for developing reliable intelligence. These environments are what I will call "data rich but knowledge poor" in that there is a lot of complex information that can be gathered and the military is getting very good at collecting and distributing large amounts of information, but the more critical task of building knowledge or intelligence out of that data for the decision-maker is much more challenging.

Because of this, previously fuzzy distinctions between *situational awareness* and *situational understanding* need to be sharpened and there is a growing need to focus on sense making (Weick, 1995). These new types of operations, likely to be with us for the foreseeable future, require differentiation between situational awareness and situational understanding.

Situational awareness (sometimes referred to in the literature as simply "situation awareness" – cf., Endsley, 1995) has been an important topic in human factors and cognitive psychology (under the guises of studies of attention and perception, including social perception). It has largely been studied in the context of closed supervisory control systems used by humans and interfaces designed to help humans in their supervisory control tasks. The term, situational awareness, can also be extended by analogy to much broader, open environments such as the decision-maker observing a battlespace and planning strategy and tactics.

Here, I propose a three-level distinction that maps fairly well to a similar distinction made by Endsley (1995) but tweaked to emphasize issues of building knowledge and understanding in a battlespace. Endsley developed a model of situational awareness for performing operator control tasks in dynamic systems. Endsley defines "situation awareness" as

> *...the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.*

Endsley (1995) argued that it was important to separate situational awareness as a construct from other constructs that influence it such as knowledge, attention, stress, decision-making and performance. She thus views situational awareness as a state of the operator within the context of a dynamic system. However, using Endsley's own arguments, it seems important to separate out notions of "awareness" versus "understanding" rather than treating understanding as a "level of awareness" because, while it is probably impossible to have understanding without awareness, it *is* possible to have situational awareness without understanding. Further, understanding in an open system may arise from partial and selective awareness or even be emergent from a chaotic gestalt that alters awareness.

In the RAVENS framework, Endsley's (1995) three levels are uniquely identified and characterized by the kinds of questions that can be answered by the decision-maker at each level. These questions illustrate the usefulness of each state considered on it's own, even though it builds on and interacts with the other levels. The questions are not framed in terms of a supervisory control task but in terms of learning things about the world so that one can make decisions and respond to present and future events. Thus, the change is not a criticism of Endsley's approach, but a shift in the approach because of the shift in emphasis to intelligence analysis for the decision-maker as the domain of interest.

The first construct, s*ituational awareness*, refers to being aware of what elements (actors, events, objects, conditions) are in the environment and their configurations (motion vectors, how they group, locations). It allows you to answer questions such as "What is it?", "Where is it located?", and "How soon will xyz converge on point B." In terms of knowledge being applied, situational awareness requires only syntactical (structural and configural information) and simple associative semantics. You can act and react on the basis of situational awareness, but it is not sufficient for planning, more integrative reasoning, or projection of intent.

The next is s*ituational comprehension*, which refers to interpretations of meaning in terms of the here and now. In this case, you are not just aware of objects and actors, but of their roles and behaviors within the unfolding events. It allows you to answer questions such as "What are xyz doing right now?", "Do their movements appear to present an obstacle to my plan?", and "What is the strength of a given organization of enemy fighters." Here, meaning is being assigned within the framework of one's current goals, plans. While this meaning can be complex and some intent may be inferred, this level can be achieved without a complete model of the battlespace and the "world" in which it sits. In terms of knowledge, it is richly semantic but not entirely pragmatic. One can react and do near-term planning quite well using situational comprehension, but to the degree that the here-and-now situation fails to reflect all aspects of the "world," it is insufficient for reliable projection and prediction.

Finally, there is s*ituational understanding*, which refers to being able to fit the objects and actions, their roles and behaviors, into a theme based on a fairly well bound model of the overall situation and "the world." This allows you to answer questions such as "What will the enemy do next?", "How will the population react if we change our plans to do X?", and "What seems to be the long term goal of units xyz." Planning and decision-making is most effective when made with sufficient situational understanding. With situational awareness, you can react; with situational comprehension you can manage. However, when you have good situational understanding, you see the big picture, which is not just a picture but also a dynamic model. With understanding comes knowledge of causality and, thus, the decision-maker is no longer looking for the most effective synthesis but is ready to make decisions based on knowledge. As Hayes (2001) put it, "Understanding is the beginning of decision-making."

Having established the above distinction, I want to talk about how we achieve situational understanding, particularly in these dynamic and uncertain environments we have been discussing. It is exactly in these situations that situational understanding becomes an issue and requires our most powerful cognitive abilities. The human decision-maker must make sense of any situation, i.e., sense making, especially situations that are very uncertain. As humans, we are compelled to do this, to take any surprise, anomaly, or unexpected behavior and make it fit smoothly with what we know. In traditional war, this is easier because the expectations and set of alternatives are much narrower, and situational comprehension may even be sufficient to support situational understanding. In those situations, however, when key relationships are not always clear, particularly causal relationships, we resort to a cognitive process I will refer to here as *storytelling* or sometimes, more formally, as *narrative cognition*. Ideas about human storytelling and story being a powerful, even preferred, means of representing and understanding situations and leaning about the world from them is

not a new idea. It has been taken quite seriously by the humanities, including history, by anthropology, law, education, and even management and artificial intelligence (AI), human-computer interface design and constructionist-based psychotherapy (Brunner, 1990; 2002; Harre & Gillett, 1994; Hirokawa, DeGooyer, & Valde, 2000; Klein, 1998; Murray, 1995; Pennington & Hastie, 1993; Rossiter, 1999; Shank, 1990; Snowden, 2000; Weick, 1995).

This is an ability that humans possess to adaptively build knowledge about and make sense of the world, to transfer this understanding to others and, in so doing, allow others to do a better job of reading our minds (that is, inferring our intentions). Storytelling can be a tool for sense making in the face of less-than-perfect and incomplete data because it does not depend entirely on truth and logic. It rather fits the data to what you know and have experienced and even to your sense of self in the world. As we will discuss later, this can have some drawbacks, but it is not a flaw as some have suggested (most notably, Kahneman & Tversky, 1973). Brains are not limited to syllogistic and Boolean rationality as digital computational devices are and as a result, people do not make the decisions on the basis of well-formed if-then statements and calculated probabilities. This, I will argue, is mostly (but not always) a good thing. It really depends on what your objective is and what you have to work with.

What is the construct of story or narrative and why is it so powerful? Defining "story" is difficult, in part because what constitutes a story is both obvious and developed with little or no consciousness on the part of the teller. In fact, we may often have difficulty distinguishing what was generated in the storytelling and what actually is veridical to the "real world" being modeled. We all know what a story is when we see it, but many would be hard pressed to agree on an essential set of characteristics. However, we need something a little more formal and operational here, at least as a starting point.

According to the dictionary on my desk (Merriam-Webster, 1990), a story is "An account of incidents or events or a statement regarding the facts pertinent to a situation in question." This identifies a particularly important aspect of story as a knowledge structure – that it is rooted to a particular situation, that it reflects time, place, intent, behavior, and goals. This also implies that a point-of-view (POV) or experiencing self is as important to gathering intelligence as it is to any situated work of fiction. This makes storytelling pragmatic (Fiske, 1993; Warner & Burnstein, 1996).

For our purposes, I will define *story* as

> A thematically organized and coherent representation or model of actors, roles, behaviors and goals and their relationships to one's self or POV and one's previous knowledge of the world.

Let me first elaborate a few of the terms used in the definition so as to be as clear and concrete as possible. *Thematically* refers to an essential property of stories, that they have a central subject or "thing in the world" that they are modeling. It is this theme that gives the relations, particularly causal relationships, between the essential elements (actors, their roles, their actions in those roles) not only meaning but consequences in the model. *Coherent* refers to what has come to be called sense making, which is the act of taking the unexpected and normalizing it with regard to our knowledge and experience. This may be done by altering the model or by changing our expectations. Finally, the terms *self* or *POV* (these are interchangeable) refer to the "narrative center of gravity" (Bruner, 1990) that drives the model, provides the emotion, defines the consequences as well as the goals, and provides this knowledge "structure" with its adaptability and dynamism.

Given this definition, the other related terms fall easily into place. If the story is thought of as a mental simulation that mediates between our expectations (plans) and the unexpected (outcomes), then s*torytelling* is

the "running" of that model. This does not always mean telling to another, as a storyteller would do; it may also be done internally, going through the story until some criterion of reduced uncertainty is met.

This framework takes a constructivist approach to situation understanding. Constructivist approaches to psychology assume that we do not simply sense and perceive photographically veridical exemplars of "what is out there" and store them in memory, like photos in a filing cabinet. Rather, we extract essential features of reality and use them as a "good enough" version of the original (Fiske, 1993; Kintsch, 1998; Klein, 1998). This abstracted structure (sometimes referred to as a *schema*) is then imposed on reality where it acts as a kind of filter for both perception and memory. In our attempts to maintain coherence, either perception or memory may be changed to get the "best fit" to the overall structure. Thus, both perception and memory, the things we think about, are constructed in real time, not just stored and retrieved. Storytelling is, in fact, the ultimate constructive process as the result is not just a representation but also a constructive simulation. The advantage of a constructive cognitive system is that it is efficient – a lot can be done, with sufficient experience, with expectations about the world without verifying every pixel of reality. A disadvantage is that, once constructed, you really do not know what part of your "good enough" representation was based on expectation and what part was based on verification. For example, I may get halfway to work and wonder if I locked my door before I left. I may in fact have a memory of doing so, but if that daily routine has become automatic and I was not paying a lot of attention, I will not know if that memory reflects having done it, having done it other days, or having simply thought about doing it in my head. In most cases, this is not a big problem because, in negotiating the world in a shared and familiar culture, you do not need absolute veridicality – hence, the term "good enough." There are special cases, however, when this can become a problem. For example, this underlies the fundamental unreliability of many eyewitness reports used in police investigations (Loftus, 1996).

Coherence or sense making relies on this "best-fit" idea implied by constructive theories. As long as what we experience fits within a tolerable range of variability to our expectations, they will be incorporated into our model of the situation. This means the situation will continue to be coherent and we will not require a lot of extra cognitive resources to maintain coherence. It is exactly when expectations are so different from outcomes that they can no longer be accommodated by the same model that storytelling is invoked.

This brings me to the second very important question I raised a few paragraphs ago. What purpose does story and storytelling serve? What makes storytelling so powerful and so useful that stories seem to be a preferred way of assimilating and passing knowledge and culture (Bruner, 2002)?

First, stories are much richer and deeper than most other forms of verbal communication, making them more compact (Gershon & Page, 2001). Consider the following "story" example (from Gershon & Page):

> *Jim felt too sick to attend the meeting later that morning. After three hours of unanswered email and phone and pager messages, he finally got a message that the meeting was postponed until next week.*

According to Gershon and Page (2001), this simple story has embedded in it and conveys the following information (I have abbreviated their original list to omit secondary inferences):

- Jim is using technology (pager and the internet)
- Jim relies on technology
- Jim is responsible; he tries to contact his colleague; he does not want to infect others
- Jim is dedicated: while sick, he tries to communicate with his colleague

- Jim is persistent
- His colleague was busy, did not get the messages, or was slow to respond
- In his work, Jim meets with people
- Jim is sick but not incapacitated

As indicated, this list is longer in the source, but this seems sufficient to make my point. I could show you the bulleted list and you would know a number of things about Jim. You might not necessarily know how to put them together, and it also might be more difficult for you to remember some of these things about Jim later, especially as the list gets longer. Further, it takes a lot more text to convey this information. The story, on the other hand, conveys all this information and, more importantly, it relates all this information because it is generated (the constructive, reconstructive, and even reinventing nature of narrative cognition) by a model of the world.

Let me create one more example to really illustrate the generative aspect of storytelling: the absolute compulsion to thematically organize and make sense out of anything. Here are two sentences that are linked only by pronominal reference.

> Clarence heard the cream truck.
> He ran inside to get his wallet

Nonetheless, I am fairly certain that as soon as you read them you had a story about the situation that contained something like the following information:

> Clarence likes ice cream. When he hears the music of the ice cream truck, he decides to buy some ice cream. He left his wallet inside (his house, his office, whatever) and has to go get it because he has no money on him. He is in a hurry because the ice cream truck may not stick around.

This representation is generated from a model of how the world works, making the two sentences "hang together" and make sense even though the two ideas need not be connected. The fact is there is a lot more ambiguity in the world than we ever realize, even in fairly normal daily activity. We do not notice it very much because we are compelled to make sense of our experience. I will come back to this point later as this figures importantly in deciding how to support storytelling in the decision-maker.

Second, stories are tools for and invoked by dealing with unexpected outcomes. It is no accident that stories as entertainment turn on conflict and difficulty. Narrative structure, because it is richly semantic (carries meaning) and pragmatic (relates that meaning to ones goals, point-of-view and emotions), allows one to make projections about the future (plans) and decisions. That is, narrative is an ideal way to discover and represent causal chains. When something unexpected occurs, one of two things can happen, depending on factors such as the importance of the event (pragmatically), how great the mismatch with expectations, the consequences of the difference for achieving the goal and other factors. One possibility is that the narrative structure imposes itself on the unexpected outcome or event and forces a fit in the model.

For example, imagine someone who has an acquaintance that he or she regards as being a prankster of sound mental health. Later, this same friend exhibits suicidal behavior. A first reaction would be to simply regard this event as a prank, fitting it neatly within the causal relationships represented in the model. This is very efficient. Human perception and cognition cannot keep pace with "redrawing" the world in every moment. Narrative creates a stable and rich network of semantic, pragmatic, and causal relationships that form a "good enough" model of the world that is while remaining flexible and non-specific enough to coherently

incorporate new experiences. Once you have this rich, good enough model, you only need to detect differences. However, returning to our example, other, more forceful observations and events may come along which force a major change, essentially assigning the actor a new role and even a thematic shift in the model of this person's world. He or she comes to realize that his or her friend is, in fact, undergoing a mental breakdown and personal crisis. This requires a change in the narrative structure itself, the story changes. We do not like changing our stories, it is cognitively demanding and risky, but in fact the same aspect of narrative – deep and rich connections – that make it so normalizing also makes it ideal for adaptability. Because causality is represented in the narrative structure, even incompletely, the consequences of the change can propagate through the model pruning newly inappropriate relationships and re-weighting others. What is still "good enough" does not need to be discarded and rediscovered, but there is a perspective shift and relationships realign accordingly. This may affect goals or it may simply affect the strategy you use to obtain them.

Third, stories are easily shared, if imperfectly. That is, to the degree that our models of the world overlap and are mutually coherent, stories can be passed from one person to another. The advantages of this are enormous. It means that one person can pass not just information but his or her understanding of that information to another. This is no small accomplishment. Because stories are constructed from actual perceptual information and from one's personal experience and POV, each person's story is somewhat idiosyncratic. This range of individual interpretation is somewhat bound by culture and domain, but not as much as you might think. We often misunderstand each other, but it is much more surprising how often we do not misunderstand each other. If someone narrates a situation for another and they share enough experience, culture and domain in common, the person receiving that story should be able to go away with a "good enough" understanding of the situation as the narrator understands it and may even be able to "read" the narrator's mind – that is, being able to understand the intent of a request from the narrator even though the request lacks sufficient detail in its surface form (Klein, 1998). This is very difficult to do with almost any other kind of information presentation.

Together, these three aspects of narrative make storytelling a powerful method for rapidly building knowledge, adapting to change and achieving understanding even in new and uncertain environment.

SENSE MAKING: BUILDING UNDERSTANDING IN THE DECISION-MAKER

Previously, the case was made for storytelling as a unique human ability for the essential human need to make sense of the world. It was suggested that conveyed culture and domain stories make it easier to accomplish this sense making task. Nowhere is sense making more vital than in MI. However, this is the task that has become so much more difficult when operations and their contexts change from mission to mission. How then can we support the human with technology and knowledge management to aid the decision-maker in his or her narrative sense making? Can decision support technology and human engineering be used to support storytelling in order to provide more rapid coherence and situation understanding?

One fruitful area to consider is the idea of narrative information visualization (Gershon & Page, 2001). This can be explored at a number of levels. Foe example, recall the pervious definition of story:

> *A thematically organized and coherent representation or model of actors, roles, behaviors, and goals and their relationships to one's self or POV and one's previous knowledge of the world.*

Most information in a database, which is where the visualized information is drawn from, tends to be typically organized in an object-oriented manner. This hierarchical inheritance structure is useful for the kinds of knowledge we can agree on, objects and ideas that are well defined within the culture or domain, such as

general knowledge and domain knowledge. However, it is not the structure that will help you construct a story, though in fact you may draw usefully on such a structure. What is needed is a way or organizing information thematically. What is the current situation about, who are the major players, and what roles do they seem to be acting, given their behaviors? This suggests visual animations and mini-worlds with sidebar and mouse-over information made available. It also suggests having access to simulations based on these theme and role assumptions and collaborative story comparison among staff or different levels of echelon. This kind of story-like external representation and simulation tool suite could prove invaluable to the human decision-maker, particularly for aiding generation of multiple hypotheses.

I think simulation tools, which have recently become more of a focus for training and system design, are equally important as tools in the battlespace, helping to make sense of the unfolding situation, and actually testing coherence. In planning a simulation and particularly scenario design, generating stories helps one consider all the possible interactions between agents and actions. This has been realized for some time in user interface design with a movement sometimes referred to as *Scenario-Based Design* (Carroll, 1999). For example, if I am trying to design a new information interface, I might consider the role the human is going to play, what information I, or some subject matter expert (SME) think is relevant, and what they are going to use it for. Unfortunately, I have left a lot out of this. What kinds of things might actually happen when the user tries to use this interface? What other things is the user trying to do or think about at the same time? Is trying to do certain things at certain times going to frustrate the user because of the different ways tasks are set up – that is, how does the user feel and what is the user's point of view?

The same thing applies to a complex simulation. Simulations of human systems in dynamic environments are not always captured well by parameter lists and algorithmic weightings. They need stories as well, not unlike the writers' conference that might be done before creating a television series and its progress over the next season. In this case, a mixture of computer programmers, soldier SMEs and even storytellers collaborate to evaluate and elaborate the nature of the thematic organization of this simulation. Simulations, like stories, need to be imbedded in a domain and a context (Snowden, 2000). General simulations are not likely to capture the kinds of interactions that we see as the context of each operation changes. When things change, the simulation has to adapt, just as the decision-maker's thinking has to adapt. The simulation will never be able to provide the decisions, but it must be able to portray the changes those decisions are based on.

What sorts of engineering solutions might become valuable in creating these simulation tools? We do not really know just yet because no one has really approached this problem in this way. However, there are promising pieces awaiting an architecture that assembles them. One is the use of flexible, dynamic networks that can represent complex relationships and the relative certainty of relationships or connections in the network. For example, there is a good deal of work being done with Belief Nets and Social Networks that look promising. Currently, these tend to be rule-based solutions, but adaptive social networks that could adapt to new knowledge (e.g., a person who changes roles depending on their context, requiring "on-the-fly" reconfiguration of relationships) given that a sufficiently coherent knowledge base seems possible. Another possibility is using intelligent agents (AI knowledge bots that can search for and act upon knowledge in a network), probably in conjunction with adaptive networks, to search for and organize in a narrative fashion relationship in the network and in new information.

Immersive simulation is a technique that has been explored for training situations for some time. However, it might also be a technique that could be used by the decision-maker to explore possible outcomes and relative risk. Because of the inherent "storytelling" involved in setting up an immersive simulation that integrates many aspects of an experience, gaps in knowledge might be quickly identified.

Note that the way we are thinking about the use of engineering to support knowledge building might provide an interesting perspective on use of automation and automation trust. This involves a set of assumptions, which are straw men at the moment, but which seems to fall out of the framework as discussed in this report.

Real world decision-making requires that we are able to make the situation make sense (the situation must be coherent). If the situation makes sense, you can infer and make predictions. People value people who tell coherent and useful stories. "Useful" here refers to the consequences of operating off the coherent knowledge. If it is reliable and leads to good decisions and outcomes, then it is "useful." The greater the amount of uncertainty the more important it is to aid a decision-maker in building a coherent story that will be useful in the unfolding situation. People will value automation that helps build a coherent and useful story. Here is where it might be useful to return to that distinction I made once before between storytelling and story building. Storytelling, as has been suggested before, is a human cognitive activity for conveying coherent knowledge. Story building is a cognitive process that can be done by a human but which can also be aided by technology.

CONCLUSIONS

The military, joint and coalition forces, find themselves involved more and more in smaller force, rapid deployment missions in far flung areas of the world where culture, languages, and expectations are more novel, where unexpected events can happen rapidly and where one may not even be sure who is or is not the enemy. These operations require rapid knowledge building and adaptiveness for which the decision-maker and his or her staff rely on rapid, meaningful intelligence. The best tool the human has for understanding these situations in order to make pragmatic decisions is their own narrative cognitive abilities. As automation is used to make more and more data available to the decision-maker, we need to find better ways to support and exploit the human decision-maker's storytelling abilities. The best common operational picture (COP) may in fact be a common operational story. The RAVENS framework provides an approach for exploring (research) and developing such tools and for further investigating how human narrative cognition is used in sense making.

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