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The Cognitive Science of Intelligence Analysis

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Over the years, the human factors community has identified many challenges and complexities associated with intelligence analysis, many directly related to cognition. The pressures that intelligence analysts must deal with on a day-to-day basis stretch one's cognitive bandwidth. Through a review of human factors related intelligence analysis research, this paper presents multiple cognitive challenges that impact intelligence analysts' work. In response to these challenges, the authors outline ways in which human factors can be beneficial to alleviating many of the challenges. Finally, the authors introduce the Living Lab approach as a valuable and unique means for understanding the cognitive science of intelligence analysis.

COGNITION AND INTELLIGENCE ANALYSIS

Intelligence analysis has long been of interest to the human factors community. Through research within the community and other related disciplines, we have learned a great deal about the nature of intelligence analysis work and its surrounding environment. Specifically, and simply, we have learned that intelligence analysis is complicated. The job of analyzing monumental amounts of information and making cohesive sense of it is challenging. Yet, there are many other factors adding to the complexities of analysis. Through years of research, we have learned that many of the challenges associated with intelligence analysis are directly related to cognition.

Cognition is critical to any job or environment. Yet, certain jobs and environments apply more pressure to one's cognition than others, often resulting in decreased performance and a myriad of other issues. For example, the profession of firefighting is considered a high stress job. Firefighters must deal with extreme environments laced with time pressures, ambiguous and ever changing goals, and a physically demanding work set. Although an intelligence analysts' job might not seem as extreme or stressful to one's cognition, there are certainly many aspects that make it cognitively demanding and that stretch cognitive bandwidth.

An intelligence analyst has *many* tasks in a time-pressured environment. As a result, many cognitive issues find themselves at the forefront of the analytical process. Analysts must shift through an onslaught of data (Hutchins et al., 2007) and deal with constant time pressures (Patterson, Roth & Woods, 2001). For example, it is not unusual for analysts to scan 1000s of incoming messages and read 100s of word documents in a short period of time, all to gain only a small piece of new insight (Pirolli, Lee & Card, 2004). Moreover, analysts are under relentless pressure not to miss anything (Connors et al., 2004), and if they do, they bear the burden and consequences of failed intelligence analysis (e.g. the attack on Pearl Harbor, Chinese sending combat troops into Korea, the Tet Offensive, the collapse of the Soviet Union, the Indian nuclear test, and 9/11; Johnston, 2005). These, and other cognitively related factors, make intelligence analysts' work inherently complex and cognitively demanding.

Also, in recent years, new data sources (remote sensing, big data, social media, etc.) and new contextualized problems (healthcare- ebola, climate change, ISIS developing, etc.) have made the job of an intelligence analyst even more complicated. Today's analysis relies on more information, problems, and methods than ever before. The implications of this fall directly on the intelligence analyst. Although there are advanced technologies aimed at scanning information and sorting it in a meaningful way, the real synthesis or analysis of that information still falls squarely on the shoulders of a *human* analyst. Due to the influx of new problems and more intelligence, analysts' cognition is stretched farther than it ever has been.

In this paper, we explore many of the cognitive aspects of intelligence analysis that make the context and profession so difficult and challenging. By reviewing the human factors related literature, we can readily see many of the cognitively related issues that intelligence analysts must deal with on a daily basis. The objective of this paper is not only to review what the literature says, rather to makes sense of it and think about how the intelligence analysis community should move forward in trying to curb many of these problems. We know from decades of research, that when one's cognition is put under extreme pressure, it often results in failures (both minuscule and tragic) (Davies et al., 2013). Therefore, knowing this, it is important that we (the human factors community) consider how we can help improve intelligence analysts' working context and their individual (and team) cognition.

In the remainder of this paper we first highlight how intelligence analysis has and is traditionally studied through the methodology known as a cognitive task analysis (CTA). Then, using the CTA literature as a foundation we systematically highlight the key cognitive challenges associated with intelligence analysis. In response to the key challenges, we discuss how the human factors community can make an impact in lessoning many of the cognitive issues. Specifically, we note the impact of utilizing a Living Lab Approach for studying the cognitive impacts of intelligence analysis. Finally, we conclude by indicating future cognitively oriented work areas within intelligence analysis.

STUDYING INTELLIGENCE ANALYSIS FROM A HUMAN FACTORS PERSPECTIVE: COGNITIVE TASK ANALYSIS

One of the most effective and historical methods for studying intelligence analysis from a human factors perspective is through a cognitive task analysis (CTA). CTA is a widely respected research methodology, often used in many human factors contexts. CTAs are aimed at understanding cognition in the real world and the associated work and tasks of people (Crandall, Klein, & Hoffman, 2006). A baseline understanding of people's cognition and work is developed with the goal of aiding people in their cognition and decision-making (Crandall, Klein, & Hoffman, 2006). A CTA is often associated with knowledge elicitation methods, and over a 100 different types of CTA methods have been identified (Cooke, 1994). Therefore, in order to effectively conduct a proper CTA, the researcher must fully understand what a CTA is and what associated methods are best for the context and project. A sampling of the different methods that a CTA might utilize include cognitive interviewing, field observations, and concept mapping, just to name a few.

Due to the ability to gain significant insights about cognition in complex environments and gain knowledge about how people work, CTAs are the main methodology for conducting research oriented at cognition within intelligence analysis. Most of the CTAs that have focused on intelligence analysis are published within the Human Factors community. In the following section we summarize the cognitive challenges that have been identified through CTAs that have focused on intelligence analysis.

COGNITIVE CHALLENGES OF INTELLIGENCE ANALYSIS

Lack of Expertise

The Intelligence Community has experienced a steady decrease of experts due to declining budgets marked by the end of the Cold War (Treverton & Gabbard, 2008) and accelerated by the recession of the 1990s (Cooper, 2005). However, budgets cuts set aside, other reasons prevail for the drastic decline of intelligence experts. It has been difficult to retain genuinely skilled intelligence analysts because of an ever increasing push to broaden expertise through rotational work assignments and promotional policies that consist of attitudes such as, either move up or out (Cooper, 2005). Moreover, the shift from in-depth, long-term intelligence analysis to quick, short, daily briefs impacts developing and maintaining expertise "because they require different kinds of mental operations that reduce the scope and scale of an analyst's research and knowledge" (Swenson, p. 48, 2003).

An implication of dwindling numbers of intelligence experts is that the Intelligence Community increasingly lacks valuable mentors (Cooper, 2005). Hence, incoming analysts may have a difficult time to learn the "tricks of the trade" as a direct result of insufficient mentoring. Other consequences of reduced numbers of experts is an overall diminished quality of the analytical process. Examples include losing a deep understanding of the analytical domain, paying attention to information that does not matter, and less comprehension of complex data and pattern recognition (Johnston, 2005). Furthermore, with fewer experts around, there is an increased potential for biases during the analysis (Heuer, 1999; Trent, Patterson & Woods, 2007). This occurs because novices are trying to reduce their cognitive load through mental short cuts in order to work through complex issues and make sense out of the vast amount of data (Heuer, 1999). To counterbalance these negative consequences, the Intelligence Community needs to find ways to retain analysts beyond the average 2-5 years (Swenson, 2003).

Time

Perhaps one of the biggest stressors for intelligence analysts is the lack of time (Folker Jr., 2000; Johnston 2005; Patterson et al., 1999; Patterson et al., 2001). The growing absence of time has wide reaching consequences within the analytical process. First, rushing to get things done, analysts may not even take enough time to understand the problem statement or questions being asked (Miller et al., 2006). This impacts the rest of the intelligence process. Second, the constant time pressure limits data and hypotheses exploration as well as data interpretation (Folker Jr., 2000; Johnston, 2005) leading to overly narrow exploration. Third, analysts are spending little to no time on in-depth research and long term security issues (Johnston, 2005) because they are too caught up in the here and now. Fourth, the essence of intelligence analysis–anticipatory analysis–is cast aside due to the constant time crunch (Cooper 2005). Fifth, analysts no longer have the luxury to spend time on exploration and creative thought (Cooper 2005), yet this may be one of the most valuable activities of an analyst - how else will they discover how al Qaeda or ISIS is transforming? Sixth, other areas such as learning, training, and collaboration also suffer due to insufficient time (Johnston, 2005). After all, how can an analyst devote any time to learn about new tools, methods, or processes when they do not even have enough time for analysis? On the other hand, with the ever increasing proliferation of security issues for the United States, a bigger question begs to be answered: Can the analyst and the Intelligence Community as a whole afford not to have enough time?

Information Overflow Coupled with Inadequate Tools

With advances in information technology, the incoming flow of data never seems to end. High-tech advances have unfortunately contributed to an information saturation problem. Yet, even with advances in technology, analysts still must rely on many manual mechanisms. This is often due to the technologies not accurately aiding the work they were designed for. For instance, in many cases, the scanning of information is still done manually and therefore continues to be very time consuming (Pirolli et al., 2004). Many analysts also use rudimentary methods such as 'cut and paste' to sort their data sets (Pirolli et al., 2004) because they do not possess adequate tools to assist them with this task. Additionally, limited tools are available to keep track of information (or intelligence) in order to illustrate how events unfold over a long period of time (Miller, Patterson & Woods, 2006). Furthermore, there is often not a single database available to correlate inputs across multiple systems (Connors, et al., 2004; Hutchins et al., 2007).

This makes integrating data such as, text documents, newspapers, audio, video, photographic images, maps, graphs, diagrams, equations, and others difficult (Elm et al., 2004; Treverton & Gabbard, 2008).

Yet, in the scope of intelligence analysis, collecting the data is just the first step. The analyst must summarize, synthesize, and interpret all the gathered information with the final goal to produce an intelligence report (Cooper, 2005; Swenson, 2003; Elm et al., 2004; National Research Council, 2011). This never ending cycle of gathering, synthesizing, and interpreting information has to be done at an ever increasing speed due to the growing number of intelligence concerns for the United States (Patterson et al., 2001; National Research Council, 2011). Consequently, the intelligence analyst is cognitively overloaded, overworked, and highly stressed (Hutchins et al., 2007).

Training

Training of new hires in the Intelligence Community is sporadic, inconsistent, and in some cases completely missing (Johnston, 2005; National Research Council, 2011; Treverton & Gabbard, 2008). Unfortunately, training is also all too often viewed as a hindrance to "getting work done" and reserved solely for the "green" inexperienced analyst (National Research Council, 2011). With this negative view of training however, the Intelligence Community misses out on great opportunities for improving intelligence analysis through formal training. Without training, it is hard for analysts to keep up with new analytical methods and procedures, or transform from novices to experts. Another huge disadvantage is that without a comprehensive "communitywide basic training program, differentiation between the intelligence analysis discipline, as a whole, and other fields of study is unlikely" (Johnston, p. 29, 2005). As a result, the Intelligence Community and their analysts will lack professional identity, and this in turn will affect interaction and communication among each other and with other agencies (Johnston, 2005). Instead of seeing training as a burden, the community should view it as a necessity to one's career, and more importantly, expertise development (National Research Council, 2011).

Feedback

Much of an analyst's learning is through hands on experience, but in order for this type of learning to be effective, adequate feedback is essential (National Research Council, 2011). Sufficient ongoing feedback however is greatly lacking within the Intelligence Community (National Research Council, 2011; Trent et al., 2007). More often than not, analysts receive no feedback at all, or at best, receive it at the very end of the analysis (when their Senior Analytical Officer reviews their report before it is sent out to customers) (Swenson, 2003). Any comments this late in the process are usually negative and leave the analyst frustrated, rushed, and sometimes even humiliated (Swenson, 2003). In order to achieve better learning outcomes, feedback should start early on and continue through the analytical process starting with peer reviews (Cooper, 2005) and ideally ending with Senior Analytical Officer's inputs. Without specific feedback, analysts end up guessing what success and failure look like (National Research Council, 2011).

Knowledge is Power

As mentioned earlier, the focus on short-term fast turnaround reports is due to the need for immediate intelligence analysis stemming from fast moving developments in the world. This short-term report cycle is fuelling a production cycle in which quantity is becoming more important than the quality of intelligence (Johnston, 2005). What is more, cranking out daily briefs is closely viewed, and often tied to promotions (Treverton & Gabbard, 2008). As a result, analysts compete over who gets to publish the newest intelligence first (Swenson, 2003). Knowledge becomes a means to power instead of discovery.

Collaboration & Teamwork

Collaboration within the Intelligence Community reads like a story with two endings. In one scenario, collaboration is an essential part of the intelligence process (Trent et al., 2007). Here, analysts are working together to reduce uncertainty, double-check validity of information and their sources, and cross-check analytical inferences (Connors et al., 2004). In the other scenario, analysts are described as competitive school children, lacking collaboration within and across intelligence agencies (Swenson, 2003). Wherever the pendulum of collaboration may fall, it is important to consider the numerous benefits of it.

Today's world problems are complex and rapidly changing requiring an increase in collaboration and communication (National Research Council, 2011). Improving collaboration among the Intelligence Community would distribute knowledge and skill sets between analysts and intelligence agencies (National Research Council, 2011). Moreover, collaboration has the power to reduce analysts' biases because analysts can re-adjust assumptions, clarify information, and re-examine and expand on exiting hypotheses (National Research Council, 2011). Analysts working in teams may gain additional benefits by drawing on their unique set of expertise and knowledge, which is especially important when looking at unusual non-intuitive scenarios (Rajivan et al., 2013). Overall, "collaboration during the analytical process should be routine, not exceptional, and workloads should be balanced accordingly" (Cooper, p.43, 2005).

RESPONDING TO INTELLIGENCE ANALYSIS CHALLENGES

There are certainly a myriad of issues pertaining to intelligence analysis, with many of them being directly linked to cognition (time, stress, expertise, training, and technology). In response to this, the human factors community has the potential to help alleviate many of the aforementioned issues. Specifically, our community can help address issues relating to workflow (stress & time), issues related to training, and developing better *human*-centered technologies. Below, we discuss each of these areas. We conclude by introducing a valuable approach for studying intelligence analysis in the future, the Living Lab Approach.

Developing Recommendations for Improving Intelligence Analysts' Workflow

Conducting a CTA provides valuable insights into how individuals and teams work together. Through this insight, the workflows of individuals and teams become apparent. Knowledge specific to what, when, and how, is gathered in regards to work. As previously noted, analysts' work is hard due to a number of reasons (stress, time pressured, too much work, etc.). All of these challenges impact analysts' workflows. Often, in many contexts, people are not conducting their work in the most efficient manner. Conducting a CTA of intelligence analysts' work and their environment has the potential to lead to multiple recommendations being developed that will help the analysts complete their work. The goal is for the analyst to conduct work differently, in a more time effective manner while still maintaining quality.

Effective Individual & Team Intelligence Analysis Training

Human factors has long been focused on understanding effective individual and team training mechanisms (Salas et al., 2012). Over the years, researchers have noted a direct relationship between effective training and performance (Salas et al., 2008). Knowing this, it is critical that the training of intelligence analysts at the individual and team level is meaningful. Thorough training on how to conduct specific intelligence analysis work must be implemented, as well as training specific to the utilization of technologies and collaboration. In order to accomplish this type of training, it is important to understand that the training must be motivated by real world work and contexts. This is where human factors is valuable. Upfront evaluations of real analysts' work must be conducted to understand the competencies that need to be trained. Furthermore, the training that is developed needs to be tested to ensure that it is effective and makes sense to the human. Provisions for effective delivery of feedback can also be made to facilitate learning.

Developing Effective Human-Centered Technology

There has been a proliferation of different technologies and tools developed with the goal to aid intelligence analysts complete their work (Kang & Stasko, 2011; Eachus & Short, 2012). In fact, many of the tools developed today were in response to the aforementioned cognitive challenges. Yet, though many of the tools are effective, there are also many that fail to address the analysts' work in an effective manner, and are thus, never utilized. These failed tools are often designed with minimal consideration to what the *human* user needs the tool to accomplish. The human user (in this case an intelligence analyst) should motivate what the tools aim is and how the tool is designed. A complete understanding of the user's work is needed in order to understand when, where, and how a tool can help aid the work of an analyst. Without this understanding, there is no evidence that a tool is even needed. Human-centered design of technology, and the insights found in this community can help drive the development and implementation of effective tools that are specifically motivated and guided by the analysts' work and needs. Technology in general has the potential to mitigate many of the challenges mentioned in this paper, but it must be focused on and motivated by the human.

MOVING FORWARD: UTILIZING A LIVING LAB APPROACH TO STUDY THE COGNITIVE SCIENCE OF INTELLIGENCE ANALYSIS

Addressing issues related to workflow, training, and human centered technology are impactful ways in which human factors can help alleviate some of the cognitively oriented issues associated with intelligence analysis. Yet, the question still remains as to how to effectively study and address these issues. Is conducting a CTA enough? As highlighted in this paper, CTAs are the main methodology in which researchers have chosen to study the intelligence analysis domain. This methodology is clearly effective in producing an understanding of analysts' work and their environment. In fact, we encourage researchers to pursue the endeavor of conducting a CTA in this context. Comparatively speaking, more work needs to be completed in intelligence analysis and CTAs are a great way to complete that work.

That said, we would like to introduce an integrated research approach (complimenting CTAs) that we feel would be highly beneficial to conducting human factors oriented intelligence analysis research. The Living Lab (LL) approach takes a holistic perspective to studying humans, their work, their context, their technology, and the many associated processes. The LL is a context and problem based approach aimed at considering both practice and theory to aid in the development of recommendations and technological development. It is holistic in that it begins with human oriented practice, continues through multiple aspects of the approach, and eventually feeds back into practice, eventually cycling back to the starting point. There are multiple variations of the LL, yet in this paper, we follow the LL approach postulated by McNeese (1996). This approach can simply be broken down into four different aspects: Ethnography, Knowledge Elicitation, Scaled Simulations (Empirical Testbeds), and Technology Development. As noted, the LL begins with *practice*. Understanding practice is dependent on ethnographic fieldwork to truly understand how users are working and the context that they are working in. In addition, knowledge elicitation is conducted during fieldwork. Ethnography and knowledge elicitation can be conducted during a CTA, meaning that a CTA may be utilized as a critical method within the overall LL approach. Once an understanding of practice is maintained, aspects are developed to test within the lab. Testing aspects of the real world within the lab allows researchers to further understand validity and integrate theory in a controlled manner. Once laboratory studies conclude, researchers then have the ability to develop new technologies based on field and lab data, both motivated by the human. Finally, researchers have the ability to apply what they learned from both the field and lab data to apply to actual practice (McNeese et al, 2013).

This type of approach is extremely valuable for intelligence analysis. First, it encompasses the ability to understand real world work and articulate what the real issues and problems are relevant to intelligence analysts. This upfront analysis is fundamental to understanding any type of context, and is at the

heart of the LL approach. Yet, due to the lack of controls in this type of an environment, it is *very* difficult to empirically test anything. Furthermore, within the context of intelligence analysis, it is quite difficult to gain access for long periods of time. A researcher might be able to gain enough access to conduct a brief CTA, but it is likely that further investigation will be needed. For these reasons, utilizing the lab is critical. Not only can a researcher study in more depth the issues that they learned about in the field, they can do so in a controlled empirically driven environment. This environment provides a testbed for a multitude of different focuses. Then, after being validated in the lab, researchers can apply their new knowledge or technologies to intelligence analysts in the real world. This approach is not only holistic and driven by the human, it is also appropriate for the context of intelligence analysis.

CONCLUSION

Intelligence analysis work is riddled by many complexities, many directly associated with cognition. In this paper, we have reviewed how many researchers currently study intelligence analysis within the human factors community- CTAs. Using the CTAs conducted within the community, we then reviewed the many cognitively oriented challenges of intelligence analysis. In response to the many challenges, we outline three high level areas to which human factors can contribute. Furthermore, we introduced the Living Lab approach, which we view as being fundamental to studying the cognitive science of intelligence analysis. It is our hope that this paper brings to light the many issues involved in intelligence analysis that the human factors community is well-positioned to positively impact.

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