How Analysts Think: How do Criminal Intelligence Analysts recognise and manage significant information?

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***Abstract*— The Criminal Intelligence Analyst's role is to create exhibits which are relevant, accurate and unbiased. Exhibits can be used as input to assist decision-making in intelligence-led policing. It may also be used as evidence in a court of law. The aim of this study was to determine how Criminal Intelligence Analysts recognise and manage significant information as a method to determine what is relevant for their attention and for the creation of exhibits. This in turn may provide guidance on how to design and incorporate loose and flexible argumentation schemas into sense-making software. The objective is to be informed on how to design software, which affords Criminal Intelligence Analysts with the ability to effortlessly determine the relevance of information, which subsequently could assist with the process of assessing and defending the quality of exhibits.**

***Keywords*— Uncertainty; Sense-making; Defensible Assessments; Security; Government and Law**

I. INTRODUCTION

'How Analysts Think' is a series of papers with the aim to enhance our understanding on how Criminal Intelligence Analysts (from now on referred to as Analysts) think. The objective is to be better informed on how to design software that analysts use as part of their daily analytical and sense-making activities. A sub-branch from the above series is titled 'Navigating Uncertainty', which looks into how analysts navigate through uncertainty by using various techniques, approaches and strategies.

The first paper in this sub-branch [1] researched the methods analysts used to overcome uncertainty and as a result, allowed analysts to turn information into exhibits. Please note that exhibits could be object-based such as a knife used in a murder. Exhibits could also be report-based, such as the information put together by analysts. When we refer to exhibits, we are referring to report-based exhibits. Exhibits are collections of information, which when combined, form the basis of assertions analysts made through the application of rigorous analytical processes. Exhibits could be requested to serve as evidence in a court of law. The building blocks of evidence are based on how certain the underlying information of exhibits is and the relevance of that information in relation to the assertions the exhibits represent.

As analysts start their analysis with uncertain information, we researched the strategies analysts used to work their way through uncertainty (similar to how a captain would navigate his/her boat through rough seas using various instruments and techniques).

This paper is the follow-up from that work [1] and looks at how analysts recognise significant information, in order to determine which information is relevant for the creation of exhibits (similar to how a captain would use a map to assist with tracking where the boat is and where he/she wants to go and which areas to avoid).

This paper attempts to answer the following research questions:

- (RQ1) How do analysts recognise significant information?
- (RQ2) How do analysts manage significant information?

The results section shows that analysts recognise significant information (RQ1) when their prior knowledge and expertise indicate that something about the information is strange or interesting. When those cues are not present or apparent, analysts search for a point of certainty within the information, which they can use as a traction point to progress their understanding. The process by which analysts manage significant information (RQ2) consists of cataloguing, comparing and tracking activities.

The next section outlines why these two research questions are important and how it ties in with defensible assessments. Defensible assessments refer to analysts' abilities to assess their analyses and to demonstrate that the outcomes produced are relevant, accurate and unbiased.

II. LITERATURE REVIEW

Analysts produce exhibits as outcomes from the course of their analysis. Exhibits serve as a starting point for informed

action within intelligence-led policing [2][3] as well as for serving as evidence in a court of law [4]. Both paths carry a lot of weight in terms of responsibility, as exhibits are required to be relevant, accurate and unbiased. With such responsibility attached to each exhibit produced, the role of defensible assessments becomes apparent. This is backed up by our interview with an operational intelligence analyst from West Midlands Police (WMP) [4]. The analyst described the role of a physical Day Book as a method to record analytical tasks and subtasks for the purpose of creating exhibits.

The Day Book records why analysts conducted specific tasks, the outcomes of those tasks and the information that support each outcome. The interviewee admitted that the nature of performing analytical tasks is complex and disjointed. This indicates that the process of tracking information is difficult, due to the natural affordances that books present in reference to their linear nature and the physicality of the medium. The analytical tracking is complicated further as analysts work on more than one case at a time. Apart from the difficulties that the Day Book poses, it does help analysts to assess their analysis and to produce unbiased and relevant exhibits, which they can defend. The interview indicated that analysts (at least those who work for WMP) rely on methods such as the Day Book to assist with the support of defensible assessments, but 'law-like' argumentation schemas are not used. It also suggested that the creation of defensible assessments occur after the exploration phase of the analysis, when the facts are known and when recommendations can be made.

Verheij [5] outlined that methods for creating and evaluating defensible assessments should go beyond the traditional techniques of creating boxes and arrows, such as seen in the work of Wigmore [6] and then subsequently simplified by Toumin [7]. Verheij's [5] views may be taken even further by adding that defensible assessments should not be an afterthought, but be part of the exploration phase of any analytical or investigative query. The reason for this is that there may be benefits in knowing sooner, rather than later, where the weak areas in the assessments are [8].

Multiple areas in intelligence analysis have been researched, but none (that we could find) have proposed any ideas or solutions on how to incorporate defensible assessments as part of the analytical exploration phase, within criminal intelligence analysis operations or how to move away from boxes and arrows.

Researchers from the sense-making domain have outlined the process of what criminal intelligence analysis entails, as illustrated in the well-known Notional Model of analytical sense making [9]. Wong and Kodagoda [10] illustrated the natural propagation of uncertainty through a conclusion pathway. A conclusion pathway can be described as a series of connected conclusions of varied strengths and certainties. Klein et al. [11] proposed their Data Frame Theory, which illustrates how cognition could work during sense-making activities in terms of creating, evaluating, questioning and expanding frames.

Apart from these process and cognitive models, argumentation schemas and templates have been proposed by various scholars. Argumentation schemes are described as "forms of argument (structures of inference) that represent structures of common types of arguments used in everyday discourse, as well as special contexts like those of legal argumentation and scientific argumentation [12]. Walton et al. [12] further stated that it covers three forms of argumentation namely: deductive, inductive and defeasible (also known as presumptive or abductive). The work of Walton et al. [12] has primarily taken Hastings [13] and Walton's earlier work [14] further, by providing a comprehensive collection of defeasible argumentation schemes and critical questions (ScCQ) in one volume.

Selvaraj et al.'s [15] "think steps" are described as providing "a template that enables the analyst to approach the case and decompose it into separate elements". They then continue by stating that it "begins at an early stage based on an understanding of what crime it is that is being investigated or major phenomena around". They have described the "elements" as the building blocks that would make up a typical case for example recruiting, transport, housing, work, medical care and finance for a human trafficking case. They stated that the police are given such templates during their initial training for cases of type (but not limited to) murder, burglary, human trafficking, drug trafficking, and money laundering.

Schemes and Critical Questions (ScCQ) as well as templates, are both necessary and useful in the creation and validation of defeasible arguments. Both types may be more appropriate in the later stages of analysis, when analysts know what the problems are that they are trying to solve and which schema or template would allow them to complete the greater picture.

What is afforded to analysts through schemas, templates and critical questions, are a means for analysts to determine the missing 'slots' of a schema or a template. They can then use the structure of the schema or template as a suggestion to what the next steps are in order to fill in those missing 'slots'. The structure therefore serves as a method to indicate relevance of information needed to complete a particular schema or template. It does however not offer an explanation on how analysts regard and manage information during the analysis process, before they can apply a particular schema or template. Walton et al.'s [12] proposed questions for a schema are also more general in nature and is missing the granularity of overcoming specific instances of uncertainty during analysis. Our earlier work [1] is therefore more granular in its approach and provides questions to assist analysts with overcoming multiple variations of uncertainty, which may be more useful for the earlier stages of analysis, when analysts do not yet know what the problems are that they are trying to solve and are therefore unable to easily apply a specific schema or template.

The research outlined in this paper takes our previous research further and describes how analysts recognise and manage significant information at a granular level, which in turn

assists with determining the relevance of information during the exploration phases of analysis. This research therefore ties in with the functionality and purpose of the West Midlands Police's (WMP) Day Book, but extends it further by incorporating the views and methods of Belgium Operational Criminal Intelligence analysts. By looking at two different police forces across countries, the commonalities in approaches can be identified and addressed. The aim is to determine how analysts (regardless of country) recognise and manage significant information as a method to determine what is relevant for their attention and for the creation of exhibits. This in turn may provide guidance on what the requirements are for designing and incorporating loose and flexible schemas. The purpose for this is to aid analysts with the process of determining the relevance of information, which subsequently could assist with the process of assessing and defending exhibits.

The next section describes the methodology used for the study.

III. Methodology

The research questions of interest are:

- (RQ1) How do analysts recognise significant information?
- (RQ2) How do analysts manage significant information?

Transcripts from eleven Critical Task Analysis (CTA) interviews of UK and Belgium Operational Criminal Intelligence Analysts were analysed. The transcripts covered cases on serious crime and volume crime analysis. Volume crime analysis involves crimes that have a significant impact on the community through sheer volume in the number of offences [16]. Serious crime involves crimes where, for example, the use of violence results in substantial financial gain, individuals are over 18 years of age, or the crime is punishable by a minimum of three years in prison [17].

Crandall et al. [18] outline the typical phases of data analysis of CTA interviews to be, preparation, data structuring, discovering meanings and representing findings. They recommend making multiple passes through the data in order to gain the most out of the richness and complexity of the data set.

The Open Coding technique as part of Grounded Theory [19] was used to make the first pass through our data set in order to answer RQ1. Instances where analysts recognised significant information were coded. We then categorised the instances into three emergent groups namely, *certain*, *interesting* and *strange* phenomena. We then went back to the data to determine the process by which analyst manage instances of significance to answer RQ2.

The next section outlines the findings for each of the research questions.

IV. Results

A. (RQ1) How do analysts recognise significant information?

Significance refers to the quality of being worthy of attention or importance. Analysts have to decide which information is worthy of their attention and consideration. This may be due to the time sensitivity of the case as often found in a missing persons case. It may also be that the sheer volume of data may make it difficult to consider all information.

In this study, we have found three instances that prompt analysts' attention for consideration of significance and it may be where (1) the most (certain) information about an entity is known at that point in time in the analysis phase, or the available information about an entity is deemed to be (2) *interesting* or (3) *strange*. The term entity refers to an object, a person or an idea. Analysts' judgement on what is considered to be interesting or strange may come from years of experience with working in the domain of criminal intelligence analysis. Interesting or strange may also develop from surrounding information within the context in which the entity is considered or evaluated as demonstrated in the examples below. A 'nominal' is a term used by the UK police to refer to a victim, offender or witness and are used in the examples below.

(Please note: The following examples have been anonymised and generalised to protect the identities of the people involved.) In the first example, the analyst was tasked to determine if an offender had something to do with the death of a victim who belonged to a group, where certain behaviours were not allowed as part of the groups' normal behaviour. The offender was known to intervene when it was believed that members of this group overstepped their boundaries. Close associates of the victim were suspected of giving concent for this intervention and are thus accessories to murder / manslaughter. When the analyst got involved in the case, only the victim's body was known and the possibility that the offender might have contributed to the death, due to the types of injuries sustained. The assistance of the analyst was required as the investigative officer did not have any evidence to support his/her hunch.

During the analysis, the analyst found the group's living conditions to be 'strange' as it was different to what the analyst would regard as normal group behaviour. Normally, close associates would protect each other, unless there were influences which contradicted this norm. The analyst found that the victim's close associates did not get involved with the victim's external associates. This suggested an isolated and group-bound existence, which may dictate the steps the victim's close associates were willing to take, if the victim's frowned-upon behaviour was discovered. This information became significant in determining the involvement of the victim's close associates. *(P1:189-191) "...but [victim's close associates] doesn't get in touch with the [victim's external associates] so [victim's close associates] is in a little [group]. **Strange** because... that way, so there's [group] where [victim's close associates] doesn't get out of..."*

In the second example, the analyst was tasked to determine the identities of the possible group of offenders who robbed a jewelry sales agent in a large city town centre. The investigating officers had too much telephone data and were unable to determine the identities of the group of offenders without assistance. The analyst devised a strategy to narrow down the volume of numbers and through clustering, found a group of pre-paid numbers. This was considered interesting as the analyst reckoned that offenders would have tried to hide their identities with pre-paid numbers. This cluster therefore became significant in finding their identities. *(P7:88-90) "...all of the numbers were pre-paid numbers, so anonymous. Okay, so that cluster I thought of as most* ***interesting****..."*

In the third example, the analyst was tasked to determine if a group of vehicle crimes were related or if they were committed by different offenders. After determining that they were related, the analyst attempted to determine how the group of offenders moved within and between the Local Police Units (LPUs). This proved a difficult task as the vehicle crimes were reported by the victims usually the morning after, so offending periods were stretched over the duration of an evening. After discovering information which allowed the analyst to narrow down the offending time periods, the analyst used all the known data points to create a fictional compass, which illuminated the possible travelling routes of the offenders. The known data points therefore became significant in solving the case. The concept of a compass was used to orient the analyst in the analysis process. *(P10:178-179) "...[Found] information that could narrow down the offending time so that I could plot as many as possible from start to end at the actual times the offences actually happened." (P10:182-184) "...I colour coded them so that I could see and work out an arrow from the arterial routes where they, what direction they would have worked in, so the way I was thinking about it was like a compass..."*

B. (RQ2) How do analysts manage significant information?

Terminology. Analysts' cognition may be better understood by using the 'frame' terminology as found in Klein et al.'s [11] Data Frame Theory as well as Attfield and Barber's [20] notion of general and situation-specific frames. When the analyst takes information and infers something from that, then one could say that the analyst cognitively created a situation-specific frame that ties in with the analyst's general frame (knowledge). This frame is in the analyst's mind, unless externalised in some physical format to represent the meaning of that frame. The process of creating such a frame can be based on an inferencing process, which can be in the form of an induction, abduction or dedcution, depending on the relationship between the general and situation-specific frame. Once a frame is created, the analyst can elaborate, question and reframe the original frame. Klein et al.'s [11] model only specifies one frame, which suggest that their frame refers to the holistic understanding of the situation, rather than a specific understanding of specific details at specific moments in time. Klein et al. [11] also does not explain how their frame is managed or externalised by a person. We would like to explain the finer details of 'frames' and have therefore added terminology for the purpose of 'naming' concepts which Klein et al. [11] have not yet defined.

Abstraction. Abstraction refers to the process of creating 'something' from one or more information sources, that can be added to a 'frame' (understanding). We use the term 'abstraction', because that 'something' which added to our frame (understanding) may not represent an exact match to the underlying information, which would be true if we used the term 'extraction'. When the 'something' does not represent an exact match to the underlying information, then it has been modified or transformed. This 'transformation' can be explained through the example of reading an article about the company Apple, which is one frame in relation to your understanding of the company. Whilst reading the Apple company article, one might think of fruit, which makes one think of the groceries one need to buy. This is a different frame, where the understanding of buying groceries is not found or related to the Apple company article, but inspired by it. All types of extraction, modification and transformation is therefore referred to as abstraction and may or may not appear in the source information.

Abstraction of information to entities. Once information is abstracted to 'something' and added to a frame (understanding) then the overall understanding is enhanced, but how do we differentiate between all the different 'somethings'? If the frame is the understanding about the abstraction to 'something', then we need to find a term describing that 'something' and which should also allow us to externalise that 'something'. For this purpose, we use the term 'entities' which can represent a person, object or an idea. So a frame can consist out of multiple entities which togehter enhances a particular understanding about a topic, but entities affords us with the ability of externalising that understanding and provides a method to physically interact with them.

Entity management process. If Klein et al.'s [11] frames are the mental representation of our understanding, then entities can be seen as the external representation of a frame. Klein et al.'s [11] frames undergo a process of elaboration, questioning and reframing, so frames are not static but dynamic in nature. Similarily, entities are also not static creations and can undergo similar processess as to those found in frames. To avoid confusion between the mental processes in relation to frames, we shall refer to our entity processess as lifecycles.

Lifecycles of entities. Entities are not static creations, but are 'organic' in nature. This means that they evolve and change over the course of the analysis phase. Entities 'live' to explain their part in the analysis and subsequently the investigation. They can grow, stagnate, die off, be resurrected or transformed.

An entity grows when more information becomes available and when that information contributes to the analyst's understanding of that particular entity. During the entity's growth, the entity can become more significant or less significant, as a contributing factor to the resolution of the investigation. Significance refers to the implication the entity

has on the current thinking regime of the analyst. If the significance of an entity increases, then the analyst considers it as explaining or revealing more than what is currently known or understood and brings the analyst closer to an answer. Significance decreases when the analyst finds contradictory information, hit a dead end or the current explanation seems less likely than initially thought. So both types of significance enhances the analyst's understanding, but in different ways. If the significance continually decreases, then it will subsequently become stagnant. When an entity stagnates, the analyst has not found any new information about that entity, that can assist in increasing the analyst's understanding about it. At the point of death, the entity's usefulness has either surpassed as the analyst found it irrelevant or less significant as a contributing factor to the resolution of the investigation. However, it may be brought back to life (resurrected) when new information is found that is also significant. An entity can transform, which means that the analyst's new understanding about the entity caused him/her to merge two or more entities together to form a different entity altogether.

The purpose of the 'Lifecycles of Entities', may be to assist the analyst as a method to compartmentalise the available information in order to make sense of it and to track changes. It may also be a mechanism to build parts of the story and then to evaluate which sections fit together in order to make a coherent story [21]. Although the description above suggest a chronological order of case-specific events, the construction thereof may not be chronological as the analyst would work outward from the point of certainty or a point deemed strange or interesting. As the investigation progresses, the analyst could create more entities and fill in the gaps as they become available. The 'Lifecycles of Entities' therefore serve as a strategy by which an analyst navigates through the 'foggy' uncertainty, by creating and tracking a 'map' of entities, as they manoeuvre through the analysis.

Table 1 is an example of the lifecycle of the entity 'Anonymous Cluster', from creation to stagnation. Klein et al.'s [11] frames have been included to show how the mental representations (as frames) change as the understanding about the holistic situation changes. The physical processes of cataloguing, tracking and comparing have also been included.

In the example (see Table 1), an entity is created when the analyst finds a cluster with anonymous phone numbers in the source information. This can be externalised through a cataloguing process for example a list or a diagram. The significance of that entity is then tracked and updated over the course of the analysis.

Once enough understanding has been cultivated, the analyst can compare the entity with results in a database. The analyst can then decide to put the entity aside or to use it in further analysis.

Table 2 illustrates how significance played a role in the Lifecycle of the entity 'Offender's Transport'.

TABLE I. EXAMPLE DEPICTING THE LIFECYCLE OF AN ENTITY (LOE) AS 'ANONYMOUS CLUSTER'

Frames (mental)	*LoE Phase (external)*	*Description*	*Interview Excerpt*
Recognise the frame	Creation (catalogue)	Discover interesting information	(P7:88-90) "...all of the numbers were pre-paid numbers, so anonymous. Okay, so that cluster I thought of as most interesting…"
Question the frame (judge plausibility)	Life (track)	Discover a pattern	(P7:90-91) "…so I checked whether that group of numbers appeared over the entire period the [victim] was there..."
Elaborate the frame	Life (track)	Established communi-cation	(P7:243-244) "you make a timeline you can really see them going about and calling each other, er, seeing the [phone] towers..."
Preserve the frame	Life (track)	Explore a hunch	(P7:92-93) "I was convinced that this could be the group of perpetrators..."
Elaborate the frame	Transfor-mation (compare)	Confirm identities	(P7:106-107) "...I checked the [offenders] also in the police database and then I could relate them to other [offenders], which to me resembled very much the persons in the CCTV footage..."

TABLE II. EXAMPLE DEPICTING THE LIFECYCLE OF AN ENTITY (LOE) AS 'OFFENDER'S TRANSPORT' WITH CHANGES IN SIGNIFICANCE

Frames (mental)	*LoE Phase (external)*	*Description*	*Interview Excerpt*
Recognise the frame	Creation (catalogue)	Use known locations of victim and offender to establish a relationship	(P1:145) "…What I try to establish is was s/he in the Northern part of town…"
Question the frame	Life (significance increases) (track)	Determine the likelihood of the offender travelling to the crime scene	(P1:124-127) "…I will take a map of [city]…the highway. It goes around [city] and it goes to the North… I think it is approximately 5km [apart]…"
Reframe	Stagnation (significance decreases) (track)	Discovered that the offender was unable to drive, so less likely to be at the crime scene	(P1:120-121) "…S/He had no driver's license. S/He had no car...."
Elaborate the frame	Transfor-mation (compare)	Discovered that the offender was driven to the crime scene	(P1:374-382) "...I saw s/he sometimes came by… public transport… but at one time I saw him/her call this one and apparently his/her [Associate]… Is the driver, because I see him/her calling. I see him/her coming and then going up."

The analyst used this entity to determine if and how the offender was in the northern part of the town, which is where the victim lived. The significance increased by finding out that the two locations are relatively easily linked by a highway (or expressway / freeway / motorway).

The significance then decreased as the analyst discovered that the offender was unable to drive, so it was unlikely that the analyst could have used the offender's transport to progress the case. This changed when the analyst found, by using maps and telephone communication data, that an associate of the offender was driving him/her to the victim's location.

The next section concludes with how the 'Lifecycles of Entities' fit in with previous research, as outlined in the Literature section.

V. Conclusion

The analyst's role is to create exhibits. Exhibits can be used as input which affects decicion-making for intelligence-led policing. It may also be used as evidence in a court of law. A subset of analysts use the concept of a Day Book to log their tasks and subtasks performed during their analysis. This is to ensure that exhibits are relevant, accurate and unbiased. This can be referred to as a task-driven analytical approach. As not all analysts use the concept of a Day Book the authors have investigated how analysts across borders recognise, manage and track relevant information for the purpose of creating exhibits.

Whilst Klein et al. [11] provided researchers with a mental model on how the process of understanding is managed through the use of frames, they have not provided details on how those frames could be externalised. In this paper, we have looked at the concept of entities as an externalisation of abstracted information. The management of entities have been described through the process of lifecycles, which could be used to orient the analyst in the analysis process. It may even assist with the management of information with regards to significance and relevance.

Analysts should be able to defend the assessments they have made on the available information, which they subesquently used to create various exhibits. As a collection of information sources may be used to enhance understanding, *that* understanding resides in the analyst's mind and can be explained through the concept of frames [11]. Internal representations such as frames does make it difficult to produce a defense, if those representations are not externalised in some way. Externalisations such as argumentation maps [6][7] could be used, but the rigourness of those approaches does not afford analysts to use them from the onset, as analysts are still in the exploration phase of analysis and not in the verification phase of argumentation. These argumentation maps may also force analysts to prematurely commit to outcomes, which does not neccessrily serve the analysis process, but is required as it has been 'slotted' into the argumentation map.

It may be possible to use the concept of entities as a form of externalisation of frames. They can be used from the onset of the analysis process and analysts are not conditioned to commit to any particular entity. When entities are managed through the process of a lifecycle, analysts can log and track the changes in significance the entities offer to the solution and discard or abandon those entities as and when needed.

Once the analysis have been completed, only the most significant and relevant entities will be left, which can be used as input for an argumentation map. Rules of argumentation logic can then be used to test the strength of the assessment. By having entities prior to the use of argumentation maps, may afford analysts with a view on what has been considered during the analysis and what they have discarded. The simplicity and flexibility of entities should allow analysts to use them as part of a formal task-driven approach, but it may also be used in a less formal question-driven approach.

Application designers may wish to make use of the concept of entities as a method to externalise the thinking and understanding of users, in complex and uncertain sense-making environments. It may serve as a primer to argumentation maps, in situations where designers do not want to burden their users with complex argumentation notations, rigourous structures and the premature commitment of outcomes. Entities could also serve designers with a method to allow users to orient themselves in complex analysis processes and to allow users to judge what the most significant information is for the problem they are trying to solve (similar to how a captain would use a map to assist with tracking where the boat is and where he/she wants to go and which areas to avoid).

Although the examples in this paper where singular (only one entity), analysts usually work on very complex cases which could increase the number of entities needed to aid understanding. The need to manage the relevance of information and orientation within the analysis process increases with the level of complexity and uncertainty.

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