Reasoning in Criminal Intelligence Analysis through an Argumentation Theory-Based Framework

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ABSTRACT

This thesis provides an in-depth analysis of criminal intelligence analysts' analytical reasoning process and offers an argumentation theory-based framework as a means to support that reasoning process in software applications. Researchers have extensively researched specific areas of criminal intelligence analysts' sensemaking and reasoning processes over the decades. However, the research is fractured across different research studies and those research studies often have high-level descriptions of how criminal intelligence analysts formulate their rationale (argument). This thesis addresses this gap by offering low level descriptions on how the reasoning-formulation process takes place. It is presented as a single framework, with supporting templates, to inform the software implementation process.

Knowledge from nine experienced criminal intelligence analysts from West Midlands Police and Belgium's Local and Federal Police forces were elicited through a semi-structured interview for study 1 and the Critical Decision Method (CDM), as part of the Cognitive Task Analysis (CTA) approach, was used for study 2 and study 3. The data analysis for study 1 made use of the Qualitative Conventional Content Analysis approach. The data analysis for study 2 made use of a mixed method approach, consisting out of Qualitative Directed Content Analysis and the Emerging Theme Approach. The data analysis for study 3 made use of the Qualitative Directed Content Analysis approach.

The results from the three studies along with the concepts from the existing literature informed the construction of the argumentation theory-based framework. The evaluation study for the framework's components made use of Paper Prototype Testing as a participatory design method over an electronic medium. The low-fidelity prototype was constructed by turning the frameworks' components into software widgets that resembled widgets on a software application's toolbar. Eight experienced criminal intelligence analysts from West Midlands Police and Belgium's Local and Federal Police forces took part in the evaluation study. Participants had to construct their rationale using the available components as part of a simulated robbery crime scenario, which used real anonymised crime data from West Midlands Police force. The evaluation study made use of a Likert scale questionnaire to capture the participant's views on how the frameworks' components aided participants with; understanding what was going on in the analysis, lines-of-enquiry and; the changes in their level of confidence pertaining to their rationale. A non-parametric, one sample z-test was used for reporting the statistical results. The significance is at 5% (α=0.05) against a median of 3 for the z-test, where μ =3 represents neutral. The participants reported a positive experience with the framework's components and results show that the framework's components aided them with formulating their rationale and understanding how confident they were during different phases of constructing their rationale.

Keywords: Analytical Rationale, Argumentation, Criminal Intelligence Analysis, Cognitive Task Analysis (CTA), Critical Decision Method (CDM), Qualitative Content Analysis

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Table of Acronyms

Acronym	Description
5WH	Who, What, When, Where and How
ABC	Accuracy, Brevity and Clarity
ABC Rule	Assume nothing, Believe nothing and Challenge/Check everything
ACPO	Association of Chief Police Officers
ACH	Analysis of Competing Hypotheses
AI	Artificial Intelligence
ANPR	Automatic Number Plate Recognition
APCC	Association of Police and Crime Commissioners
APP	Authorised Professional Practice
ARG	Acceptability, Relevance and Grounds for adequacy
CBA	Criminal Business Analysis
CCA	Comparative Case Analysis
CCI	Contested Collective Intelligence
CCTV	Close Circuit Television
CDM	Critical Decision Method
CI	Collective Intelligence
CoP	College of Policing
COP	Community Oriented Policing
CORDIS	Community Research and Development Information Service
CPA	Crime Pattern Analysis
CRC	Community Rehabilitation Company
CTA	Cognitive Task Analysis
DFM	Data Frame Model
DSTA	Demographic and Social-Trend Analysis
GSC	Government Security Classification
HMIC	His Majesty Inspectorate of Constabulary
HOLMES 2	Home Office Large Major Enquiry System 2
IARPA	Intelligence Advanced Research Projects Activity
IMPEL	European Union Network for the Implementation and Enforcement of Environmental Law
INTERPOL	International Criminal Police Organisation
IO	Investigative Officer
KAC	Key Assumption Check
LoE	Lines of Enquiry
LPU	Local Policing Units
MAUA	Multi-Attribute Utility Analysis
MI5	Military Intelligence, Section 5

ML	Machine Learning
MO	Modus Operandi
MoRiLE	Management of Risk in Law Enforcement
MSFM	Mutual Support Function Model
NCA	National Crime Agency
NIM	National Intelligence Model
NPCC	National Police Chiefs Council
NPDS	National Policing Digital Strategy
NPS	National Probation Service
OIA	Operational Intelligence Assessment
PESTELO	Political, Economic, Social, Technological, Environmental, Legal and Organisational
PHIA	Professional Head of Intelligence Analysis
POP	Problem-Oriented Policing
PPP	Participatory Planning Processes
RFI	Request for Information
RQ	Research Question
SARA	Scanning, Analysis, Response, Assessment
SAT	Structured Analytical Techniques
SATNAV	Satellite Navigation
SFM	Support Function Model
SMART	Specific, Measurable, Achievable, Realistic or Relevant and Timely
SME	Subject Matter Experts
STEMPLE	Social, Technological, Economical, Military, Political, Legal and Environmental
SWOT	Strengths, Weaknesses, Opportunities and Threats
TOR	Terms of Reference
TT&CG	Tactical Tasking and Co-ordination Group
UNODC	United Nations Office on Drugs and Crime
UCD	User-Centric Design
VALCRI	Visual Analytics for sensemaking in Criminal Intelligence Analysis
VRM	Vehicle Registration Mark
XIP	Xerox Incremental Parser

Chapter One
Introduction

1. Introduction

The investigation of crime and criminals involve a wide variety of police activities that aim to provide support to various law enforcement agencies (Paulsen et al., 2009). This support is in the form of intelligence products that are created by people known as criminal intelligence analysts through an intricate reasoning and sensemaking process. The reasoning involved in the creation of the intelligence products are evaluated by decision-makers and then used to direct and manage police resources, with the aim to prevent or mitigate crime (ACPO/Centrex, 2005,2007). It is therefore important for the decision-makers to understand the reasoning process that criminal intelligence analysts employ during the sensemaking process and how that reasoning contributed to the creation of corresponding intelligence products.

In 1993, the Audit Commission produced a report which found that the recurring failure of law enforcements agencies to effectively address crime was due to the variation in practices used across these agencies (IMPEL, 2017). As a direct result, the National Intelligence Model (NIM) was designed in 1999 and serves as a business model to unify the working-practices across those law enforcement agencies that use or produce intelligence products (IMPEL, 2017). NIM was implemented in the United Kingdom in 2004 and is still in use (ACPO/Centrex, 2005,2007).

The renewed focus on improving the way law enforcement agencies work has paved the way for the creation of professional policing bodies. College of Policing (CoP) was announced by the Home Secretary in 2011 (Police Federation, 2022) and launched in 2012 (House of Commons, 2016) for developing knowledge and standards. CoP handles the Authorised Professional Practice (APP), an official online resource repository that outlines the professional practices that policing staff should regard when discharging their policing responsibilities (College of Policing, 2013c). APP combines many of the intelligence practices such as Structured Analytical Techniques (Heuer and Pherson, 2015) to mitigate cognitive biases during the intelligence cycle, as well as tried-and-tested police practices, such as the ABC (Accuracy, Brevity and Clarity) rule when writing intelligence reports.

Although policing practices have been standardised, the continual efforts to support and protect communities are affected by the rapid enhancements within technology and the way offenders use technology to commit crimes (APCC/NPCC, 2020). In response to this, the National Policing Digital Strategy:2020–2030 (NPDS) launched in 2020 and it estimates that the UK policing service will spend between £7bn-£9bn on technology to bring it in line with current digital innovation trends. Even with the consideration of including a wide variety of innovative technologies such Artificial Intelligence (AI) and Machine Learning (ML), the police workforce will remain at the heart of the digital transformation to adopt and adapt-to the digital transformation. NPDS

therefore includes the aim to embed user-centric design methods as part of the digitisation process (APCC/NPCC, 2020).

VALCRI launched in 2015 and was a €13m European funded user-centric research project with the aim to put humans in the decision-making seat, whilst letting computers do the heavy-lifting (CORDIS, 2018). VALCRI researchers aimed to understand how criminal intelligence analysts think and reason to facilitate the design of a visual analytics system (CORDIS, 2018). The VALCRI project made great strides in producing, amongst others, design guidelines for supporting sensemaking using visual analytics (Haider et al., 2015), but some gaps remain on understanding how criminal intelligence analysts, reason during the sensemaking process.

In other research areas, argumentation diagrams are gaining popularity as a visualisation tool to aid people with externalising their reasoning (Van Gelder and Rizzo, 2001; Reed and Row, 2004; De Liddo and Shum, 2007,2013; De Liddo et al., 2012; Tonilio et al., 2015; Wyner et al., 2015; Tecuci et al., 2018). Similarly, a steady flow of research within the AI and Evidential Reasoning space have made great strides in understanding how people, such as judges and juries, reason with evidence and how AI can aid with that process. These research areas have mainly focused on how judicial people reason with information as evidence (Pennington and Hastie, 1981, 1992, 1993, 2000; Wagenaar, 1995; Bex et al., 2006, 2010; Bex and Verheij, 2013). Some gaps remain on how transferrable the argumentation concepts from the evidential reasoning space are to other similar spaces, such as intelligence analysis.

Bridging this gap would inform initiatives such as NPDS on specifically, how criminal intelligence analysts' reason and to what extend argumentation concepts would be useful during the sensemaking process.

2. Background

Part of NPDS' £7bn-£9bn technology strategy is to cope with the rapid increase in data that is being produced globally. In 2013, 90% (APCC/NPCC, 2020) of the world's data was produced (9 zettabytes[1]) over a two-year period and it is estimated that by 2025 the figure will rise to 181 zettabytes globally (statistica.com, 2021). Criminal intelligence analysts will have to be able to make sense of the growing volume of public data as well as the newly proposed fluid inter-departmental information and insight sharing (APCC/NPCC, 2020). With this massive influx of information, it will become crucial to understand how criminal intelligence analysts' reason with information during the sensemaking process and how best to relay that reasoning process to themselves, their fellow colleagues and eventually the decision-makers.

The VALCRI research project has produced many research papers covering; privacy and ethical considerations; bias mitigation; various interactive visualisations (special, temporal, conceptual etc.); data manipulation with tactile interaction, ontologies and machine learning. Part of the research objective covered how criminal intelligence analysts think; Wong and Kodagoda (2015)

[1] One zettabyte is the equivalent of around one trillion gigabytes

explored the inferencing process (deductive, inductive and abductive) and how the inference process influences the creation of anchors when information is missing or ambiguous. Wong and Kodagoda (2015) further explained how criminal intelligence analysts construct stories from anchoring points and how associative questioning allows criminal intelligence analysts to connect information. Gerber et al. (2015) explored how criminal intelligence analysts use leaps-of-faith, intuition and insight to bridge gaps to create those first anchoring points. Selvaraj et al. (2016) explored how criminal intelligence analysts make use of think-steps as a method to approach a case. These researchers have built upon the established schematisation research concepts from Klein et al.'s (2007) Data Frame Theory and Kahneman's (2003) system-one and system-two thinking.

Prior to VALCRI, Pirolli and Card (2005) have produced a Notional Model of Analytical Sensemaking which outlines the complex interplay between the foraging, sensemaking and policy-reality loops, when intelligence analysts make sense of information. Patterson et al., (1999) and Elm et al. (2005) produced the Convergent, Broadening / Narrowing Intelligence Analysis Framework, which outlines the interplay between the broadening and narrowing activities that intelligence analysts' employ to cope with information overload.

Various design guidelines have been produced for analytical systems in intelligence analysis; Cook and Thomas (2005) produced a research and development agenda for visual analytical systems covering various design recommendations across the intelligence cycle. Wong (2016) extended the research of Cook and Thomas (2005) by introducing a visual analytical conceptual framework that includes three subspaces (data, analysis and hypothesis) and the need to support two different continuums (fluid and rigour) in each of these spaces. Passmore et al. (2015) recommends a hybrid approach towards the representation and externalisation of arguments within criminal intelligence analysis. Hybrid approaches are also found in the well-established evidential reasoning space, as seen with Bex et al.'s (2006) Anchored Narrative Theory (developed from Anchored Narrative (Waggenaar et al., 1993)). Bex et al. (2006) as well as Pennington and Hastie (1992, 1993, 2000) made extensive use of a user-centric research approach to further the understanding of how judges and juries' reason with evidence.

All these research agendas have contributed to the understanding on how criminal intelligence analysts' think and work, together with a set of design guidelines for using visual analytical tools within intelligence analysis.

3. Problem Description

Significant effort has been put into the establishment of a unified working practice (under NIM) across the police force and the activities (under APP) that involve the intelligence cycle (ACPO/Centrex, 2005,2007). Ideally, these efforts in the unification of working-practices should not be forgotten during initiatives such as NPDS when new innovative technologies are introduced. A user-centric approach should drive the innovations, so that the workforce remains

at the heart of crime fighting (APCC/NPCC, 2020). However, the NIM framework and APP techniques provide little insights on how the analytical reasoning process takes place within the framework, during the intelligence cycle and during the application of various analytical techniques. This raises several research questions; (1) If we were asked to transfer the existing working practices of criminal intelligence analysts' analytical rationale-formulation process into NPDS or similar initiatives – what would we implement? (2) How do criminal intelligence analysts develop confidence in their analytical rationale, so that they are confident that the intelligence products that they produce sufficiently address the Terms of Reference? (3) Which structures do criminal intelligence analysts employ to aid with developing their analytical rationale? (4) How relatable is the analytical reasoning process with formal argumentation? (5) Which areas of criminal intelligence analysts' analytical reasoning process can be supported in software and how? A user-centric study of criminal intelligence analysts in how they reason during the sensemaking process remains paramount in answering these questions.

The first research question is concerned with the current working practices of criminal intelligence analysts in relation to how they reason and how they are currently expressing their analytical reasoning process. NIM places the importance on providing criminal intelligence analysts with the tools and resources they need to produce intelligence products that are value-adding for downstream processes (ACPO/Centrex, 2005,2007). NIM however fails to go into the details on the requirements for supporting that analytical reasoning process. APP provides guidance to aid criminal intelligence analysts with techniques in conveying their analytical rational in reports at the end of the analysis process, but does not provide insights on how to capture that analytical reasoning process during the analysis process (College of Policing, 2013d). Pirolli and Card's (2005) top-down approach process suggests that criminal intelligence analysts can revisit and refine their 'already-developed' analytical rationale with additional analysis and related questioning. SAT is predominantly used to aid the analytical reasoning process with tools to find and mitigating cognitive biases (Heuer and Pherson, 2015). The cyclical intelligence process and NIM consists out of high-level boxes covering analysis and evaluation without giving further details on the analytical reasoning process involved in each of the boxes (Cope, 2004; Gibbs et al., 2015). So, how do criminal intelligence analysts currently externalise and keep track of their analytical rationale? This research question is addressed in chapter three.

The second research question is concerned with how the reasoning process develops alongside the sensemaking process and how confident criminal intelligence analysts are with the outcomes they produce as intelligence products. Despite there being much research on the high-level sensemaking activities within the intelligence cycle, limited attention has been given to how criminal intelligence analysts reason during those sensemaking activities (Ribarsky et al., 2009). Pirolli and Card (2005) admits that their Notional Model of Sensemaking is a broad-brush description of the information flow and the sensemaking activities that intelligence analysts perform and that their model should serve as a steppingstone for more detailed research. The researchers from the VALCRI project contributed to this understanding of sensemaking in criminal intelligence analysis, by introducing research concepts such as anchoring, laddering, associative questioning (Wong and Kodagoda, 2015), leaps-of-faith (Gerber et al., 2016) and think-steps (Selvaraj et al., 2016), but little detail has been given on how these concepts

contribute to the analytical reasoning process and in particular, criminal intelligence analysts' confidence in the analytical outputs they produce. So, how do criminal intelligence analysts develop confidence in their analytical rationale, so that they are confident that the intelligence products that they produce sufficiently address the Terms of Reference? This research question is addressed in chapter four.

The third research question is concerned with the structure that criminal intelligence analysts use as a container for their reasoning process. Selvaraj et al. (2016) introduced the concept of think-steps as a method to conceptualise the investigative problem and to divide it into manageable chucks. Is this the only structure that criminal intelligence analysts use? Klein et al.'s (2007) Data Frame Model (DFM) serves as a tacit schema for sensemaking, where a person's initial understanding (as frames) can be created, elaborated, questioned, combined and discarded. Klein et al.'s (2007) DFM is however generic and how it exactly applies to the analytical reasoning process of criminal intelligence analysts has yet to be researched. So, which structures do criminal intelligence analysts employ to aid with developing their analytical rationale? This research question is addressed in chapter four.

The fourth question is concerned with how relatable existing argumentation structures are from the evidential reasoning space with the criminal intelligence analysis space. Great strides have been made by researchers in the evidential reasoning and AI spaces towards the understanding of how judges and jurors' reason with evidence and how AI can aid with this process (Pennington and Hastie, 1992, 1993, 2000; Wagenaar, 1995; Bex et al., 2006; Bex and Verheij, 2013). An important contribution to argumentation is Walton et al.'s (2008) critical questions within argumentation schemes which is being utilised by the AI community to support evidence-based reasoning and collaborative agent-based reasoning in intelligence analysis (Toniolo et al., 2015). These researchers are however creating visual interfaces to test the enhancements of the formulas and logic used in AI research, with little input from users on how the visual interface should look like, which is appropriate, considering the rigour nature of AI. Wong (2016) formulated the Fluidity and Rigour model which explains the cognitive support needed to facilitate the appropriate type of reasoning within criminal intelligence analysis on each side of the fluidity and rigour scale. Wong et al. (2018) argued that the tools needed on the fluid side (playful-thinking, tentative, loose-story) would be different to that of the rigour side (validation, critical-thinking, formal argument). Structured, critical thinking is predominantly the main quality of intelligence analysis (Heuer and Pherson, 2014), although researchers have stressed that intelligence analysts often engage in abductive inferencing which is speculative (Josephson and Tanner, 1996; Walton, 2005). Wong et al. (2018) have thus provided design requirements for the support of fluidity and rigour, but have not covered what argumentation structures could look like to support those design requirements. So, how relatable is the analytical reasoning process with formal argumentation? This research question is addressed in chapter four.

The fifth question is concerned with understanding the design requirements for supporting the reasoning process within criminal intelligence analysis. Wong and Varga (2012) presented 20 design problems that hinder sensemaking within visual analytical systems. Their problems are

categorised to each of the three sub-spaces (data, analysis and hypothesis) within their visual analytical conceptual framework. Wong and Varga (2012) provided a detailed account of three of the data-space problems namely; the keyhole problem where criminal intelligence analysts see a large data set through a limited lens; the blackhole problem where criminal intelligence analysts are unaware of which data is missing; and the brown worm problem where criminal intelligence analysts need to build their understanding from deceptive information. These problems have been addressed in the context of cognitive biases and Bedek et al. (2017) produced methods to detect cognitive biases within visual analytical systems. Hillemann et al. (2015) outlined that a wealth of literature exists on the identification and classification of cognitive biases, of which Heuer's (1999), the SIRIUS program's (IARPA, 2011; MITRE, 2016) and the United States Government Centre for the Study of Intelligence's (US Government, 2009) taxonomies are some of the more well-known taxonomies within criminal intelligence analysis. The initial guidelines by Haider et al. (2015) addresses a sub-part of Wong and Varga (2012) design problems and concentrates on the capabilities that visualisations within visual analytical systems, should afford criminal intelligence analysts when they are making sense of information during Comparative Case Analysis (CCA) tasks. Even with all these guidelines, there is no single framework or toolkit available for practically showing how to support the reasoning process within criminal intelligence analysis. So, which areas of criminal intelligence analysts' analytical reasoning process can be supported in software and how? This research question is addressed in chapter five.

4. Research Scope

The user-centric scope of the research in this thesis is summarised below and the relevant terminology is covered within the literature review:

- The focus is on criminal intelligence analysis as an analytical activity within the operational intelligence community within the United Kingdom and Belgium police forces. The operational intelligence community covers both volume crime (such as a series of vehicle thefts) and serious crimes (such as murders).
- The criminal intelligence analysts within the operational intelligence community performs the duties of intelligence analysis, criminal investigative analysis and operational/tactical crime analysis.
- Criminal intelligence analysts work with various information resources. They may make use of intelligence as gathered from covert operations, informants and the community, but they do not perform these covert activities themselves.
- The inferences that criminal intelligence analysts make during the intelligence analysis cycle is considered to be 'intelligence' and covers criminal intelligence, crime intelligence, contextual intelligence and community intelligence.
- The criminal intelligence analysis activity is a pre-cursor for intelligence-led policing, evidence-based policing and criminal court proceedings. The focus of this research is on how criminal intelligence analysts' reason with information that is uncertain and ambiguous. This thesis is not concerned with where or how their intelligence is used in down-stream

processes, except that those down-stream processes are affected by the quality of the intelligence that criminal intelligence analysts produce.

5. Research Contributions

- Extension of NIM (ACPO/Centrex, 2005,2007) to include the externalisation of the reasoning-formulation process of criminal intelligence analysts. This is covered in chapter three.
- Extension of Pirolli and Card's (2005) Notional Model of Sensemaking to include the reasoning/argumentation cycle. This is covered in chapter four.
- Extension of the sensemaking triangle (Wong and Kodagoda, 2015, 2016; Gerber et al., 2016) to include the externalisation of the reasoning-formulation process. This is covered in chapter four.

6. Outline of Chapters

Chapter two is the literature review and provides information in section one on who criminal intelligence analysts are, what they do daily, which frameworks were put in place to aid them with their analytical work and the various analytical techniques that they have to their disposal. Even with all these frameworks and analytical techniques in place, criminal intelligence analysts still rely on their cognitive and reasoning skills, to aid them with creating intelligence products. The literature therefore explores these subjective processes in section two and the influence it has on the analytical process. Section 2.5 covers research methods commonly used in in the field of cognition and which this thesis employed in chapters three, four and five. Section three outlines various argumentation components and how a persons' argument or reasons in support of a conclusion can be externalised in a diagrammatical format.

Chapter three explores the existing pen and paper method that criminal intelligence analysts use to externalise their analytical rationale.

The results from chapter three are further explored in chapter four as part of two CDM studies. Study one explores how criminal intelligence analysts develop confidence in their rationale and study two explores how they make use of lines-of-enquiry to track and manage relevance of information and the rationale used to analyse the information. Both studies extend Pirolli and Card's (2005) Notional Model of Sensemaking to include an argumentation loop. Both studies also offer a means to express the analytical rationale in the format of formal argumentation's linked-notation and convergent notation.

Chapter five puts all the results together to create an argumentation theory-based framework. The frameworks' components are evaluated with a low-fidelity prototype using experienced criminal intelligence analysts for the study. The results of the study are presented.

Chapter six concludes by supplying an overview of the research results produced, offers future research endeavours and outlines lessons learned.

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Chapter Two
Literature Review

1. Criminal Intelligence Analysis

1.1. Overview

Crime and criminals can be investigated with an activity known as crime analysis. Crime analysis is defined as the "systematic study of crime and disorder problems as well as other police-related issues - including sociodemographic, spatial, and temporal factors - to assist the police in criminal apprehension, crime and disorder reduction, crime prevention, and evaluation" (Boba, 2005).

Crime analysis is a broad umbrella with subsets namely; intelligence analysis, criminal investigative analysis, tactical crime analysis, strategic crime analysis and administrative crime analysis (Boba, 2005). Boba (2005) differentiates between these subsets based on their purpose, scope, data, and analysis techniques: An intelligence analyst would be concerned with understanding the relationships between criminals and criminal activities. A criminal investigative analyst would be concerned with the profiling of criminals, profiling the way in which they commit a crime and profiling the location that they prefer to offend in. An operational/tactical crime analyst would be concerned with recent criminal incidents and strategic crime analysts would be concerned with longer-term crime problems. The administrative crime analyst would be concerned with going through previously conducted analysis, finding interesting facts within the analysis, and then collating it into different formats for different audiences, such as to inform the public of specific crimes.

Crime analysis can take place several policing contexts. Some of the wider known policing contexts that are of interest to academic research are; community-oriented policing, evidence-based policing, intelligence-led policing, and criminal intelligence analysis. Each of these policing contexts is concerned with addressing or improving a problematic area within the police force: Community Oriented Policing (COP) places the emphasis on building or rebuilding trust between the police force and the community. The community is an important source of information, so COP aims to increase the visibility of police officers in the community and to set up a working relationship between the two groups (Bullock, 2013). Research in this context is less concerned with the process of analysing information, as the focus is on setting up and running community projects.

Evidence-based policing places emphasis on "targeting, testing and tracking law enforcement activity" (College of Policing, 2013b). Criminal intelligence analysts within evidence-based policing play a vital role in contributing to the understanding of the effectiveness of the techniques they use to make inferences. This informs decision-makers on which techniques work best in each situation. To aid with finding the level of effectiveness, criminal intelligence analysts can make use of the five-level Maryland scale (College of Policing, 2013b). The scale starts with 'once-off' impact statements, where it is possible that external forces played a role in resolving the criminal activity. The scale then moves up to 'promising' and 'what works' statements. At latter levels, it is less likely that external forces played a role and that the intelligence supplied, played the leading role in resolving the criminal situation. With evidence-based policing, the

analysis phase has already ended, and the criminal intelligence analyst is evaluating the effectiveness of their work.

In intelligence-led policing, the research focus is based on how well police offers work with the intelligence that criminal intelligence analysts supply and how the organisational viewpoints differ between the two groups (Cope, 2004). Intelligence-led policing is about empowering the decision-makers with enough intelligence, so that they can effectively direct police resources according to priorities (Bullock, 2013). Ratcliffe (2003) defines intelligence-led policing as, "the application of criminal intelligence analysis as an objective decision-making tool in order to facilitate crime reduction and prevention through effective policing strategies and external partnership projects drawn from an evidential base".

From Ratcliffe's (2003) definition on intelligence-led policing, it can be said that intelligence-led policing is applied criminal intelligence analysis. So, what is criminal intelligence analysis? The United Nations Office on Drugs and Crime (UNODC) defines criminal intelligence analysis as, "a philosophy which sets out how we can approach the investigation of crime and criminals by using the intelligence and information that we have collected concerning them. It supplies techniques that structure our natural deductive powers and thought processes, the 'natural intuition' which proficient investigators use subconsciously all the time. It also supplies tools that help us to understand the information we collect, and to communicate that understanding to others" (UNODC, 2011). This definition suggests that criminal intelligence analysis is not just one activity, but a working style.

This thesis is concerned with:

- Criminal Intelligence analysis as a working style
- Criminal intelligence analysts who perform the duties of intelligence analysis, criminal investigative analysis, and operational/tactical crime analysis

The next section considers the role of criminal intelligence analysts within the police force and how they work through information to produce intelligence products.

1.2. Role of criminal intelligence analysts

The role of criminal intelligence analysts is to produce strategic or operational intelligence products which are used to satisfy various law enforcement goals. Strategic intelligence aims to inform proper changes and enhancements to law enforcement policies, programmes, and legislation, thus satisfying the longer-term goals of these agencies at a national or international level (Cope, 2004; Innes et al., 2005; UNODC, 2011). Operational intelligence enables law enforcement personnel to use the inferences that were produced during the intelligence analysis cycle, to act or react to present criminal activities at a local level (Cope, 2004; Innes et al., 2005; UNODC, 2011). Operational intelligence products that are produced through operational analysis is also referred to as tactical intelligence (Paulsen et al., 2009) which is the product of tactical analysis (INTERPOL, 2014).

Operational analysis can further be divided into volume crime analysis and serious crime analysis. Volume crime analysis is "any crime which, through its sheer volume, has a significant impact on

the community and the ability of the local police to tackle it. Volume crime often includes priority crimes such as street robbery, burglary, and vehicle-related criminality, but can also apply to criminal damage or assaults" (College of Policing, 2009). Serious crime analysis involves crimes that "(a) involves the use of violence, results in substantial financial gain or is conducted by a large number of persons in pursuit of a common purpose, or (b) the offence or one of the offences is an offence for which a person who has attained the age of twenty-one and has no previous convictions could reasonably be expected to be sentenced to imprisonment for a term of three years or more" (Legislation.gov.uk, 1997). Examples of serious crime are murder and drug trafficking (Selvaraj et al., 2016).

To understand the work of the operational intelligence community, it is useful to understand the difference between intelligence and information: Information can be considered as, "raw data of any type" (UNODC, 2011). Information can be acquired through routine collection and stored in databases such as the Home Office Large Major Enquiry System (HOLMES 2), firearms licensing databases, custody records and case files. Further information acquisition can be on a volunteer basis as offered from crime stoppers and neighbourhood watches. Information can also be acquired based on the analysis requirements, such as requesting data from Close Circuit Television (CCTV) systems and Automatic Number Plate Recognition (ANPR) systems (ACPO/Centrex, 2007).

Intelligence is the outcome (product) of the intelligence analysis process. It is when criminal intelligence analysts have worked with the information and because of their interpretations, given it added value and meaning (UNODC, 2011). The added value and meaning are then passed on to the relevant law enforcement agencies to act upon (Ratcliffe, 2003; Cope, 2004; UNODC, 2011; HMIC, 2015). Intelligence produced in this manner is referred to by Innes et al. (2005) as modes of intelligence and consists out of; (i) "criminal intelligence" which "details the activities of 'known' suspects"; (ii) "crime intelligence" which "enhances the police's understanding about specific crimes of series of crimes" and (iii) "contextual intelligence" which relates to the "wider social, economic and cultural factors [which] may impact upon levels of crime and patterns of offending".

A different type of intelligence is the intelligence that comes from human sources such as members of the public, criminals, and police officers (ACPO/Centrex, 2007). This type of intelligence needs to follow a specific process to record and evaluate the reliability of the intelligence that comes from these human sources, and this is achieved by using variations of the 5x5x5 process (Ratcliffe, 2003; ACPO/Centrex, 2007; UNODC, 2011). Each number is a score out of five that reflects the degree of reliability of the intelligence source, the reliability of the intelligence supplied and the level of dissemination that is allowed for the intelligence within the organisation (ACPO/Centrex, 2007). The intelligence offered by the wider public is referred to by Innes et al. (2005) as "community intelligence".

Criminal intelligence analysts need to supply their own intelligence products through their analysis of information and some of the information can be in the form of intelligence that was supplied by human sources. Therefore, not all information is intelligence, but all intelligence can be regarded as information. Since the differentiation between intelligence and information has been made, the definition from the United Nations Office on Drugs and Crime (UNODC) is

explanatory on what the process of intelligence analysis involves; “In its simplest form, intelligence analysis is about collecting and utilising information, evaluating it to process it into intelligence, and then analysing that intelligence to produce products to support informed decision-making” (UNODC, 2011).

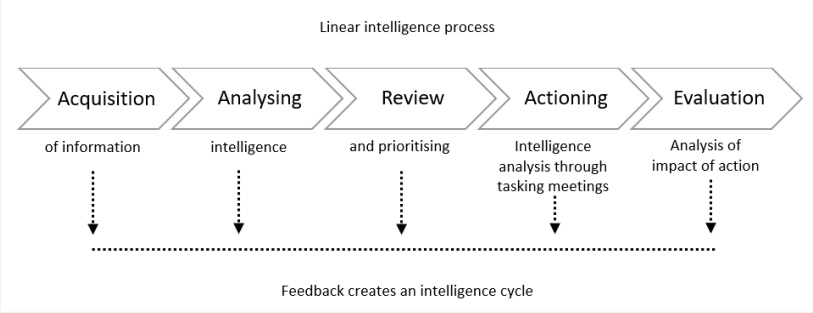
This thesis is concerned with:

- Criminal intelligence analysts who are part of the operational intelligence community, who conduct both volume crime analysis as well as serious crime analysis.

1.3. Frameworks, models, and processes within criminal intelligence analysis

Cope’s (2004) intelligence-led policing research, with sixteen criminal intelligence analysts, yielded the distinct phases of the intelligence analysis cyclical process (see Figure 1). Cope’s (2004) research can be considered in this thesis based on Ratcliffe’s (2003) earlier definition, which outlines that intelligence-led policing is applied criminal intelligence analysis.

Figure 1 – Chapter 2: Cyclical Intelligence Process. Adapted from Cope (2004)

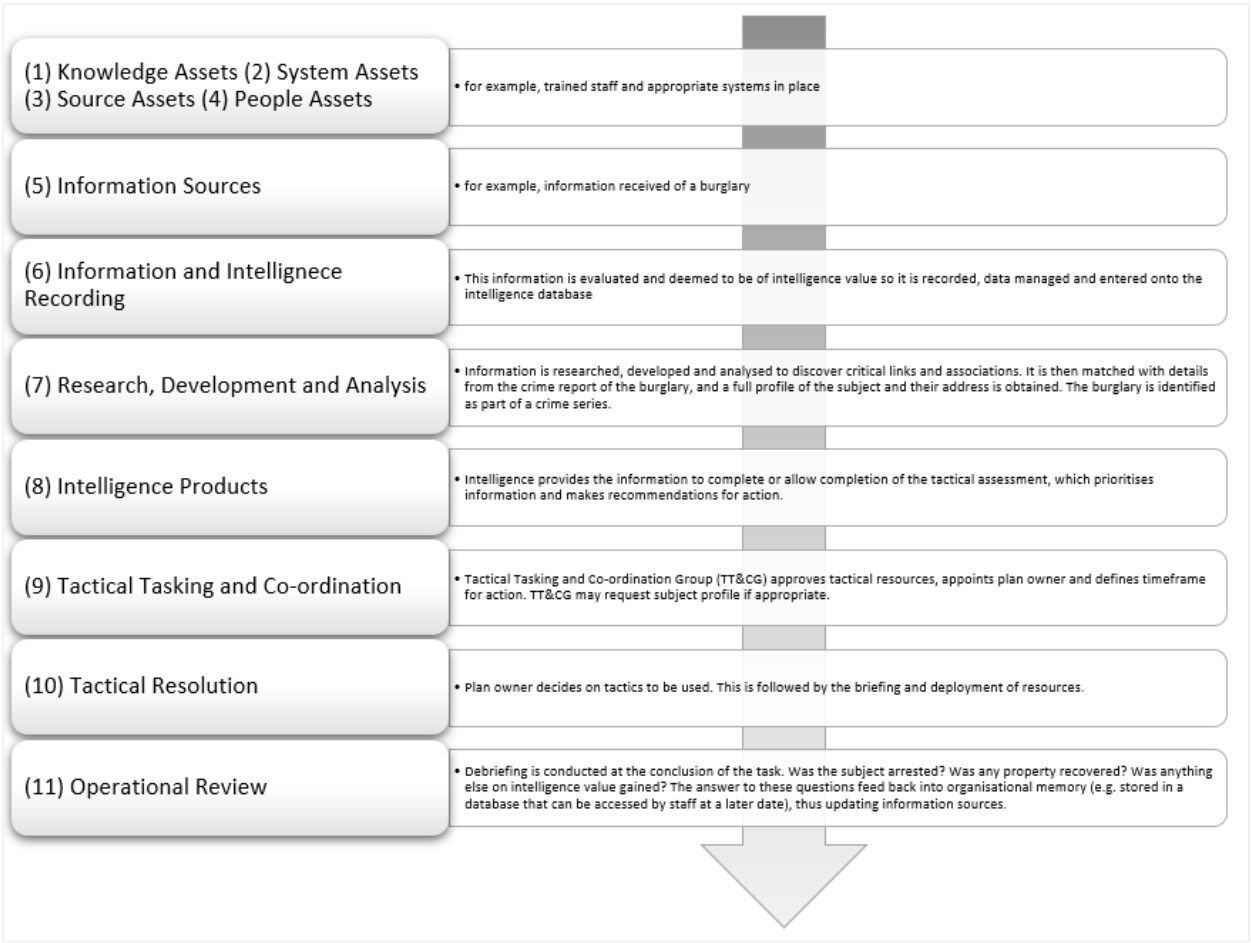


Cope (2004) outlines that the intelligence process starts with the acquisition of information, which is then analysed to infer meaning and thus produce intelligence products. The intelligence is reviewed and prioritised according to the aims of the law enforcement agency. The intelligence products are then used in a practical way, for example, police officers are tasked to patrol a specific area at a specific time. The outcomes of the tasks are then evaluated on their effectiveness and that can lead back to the criminal intelligence analyst getting further or the latest available information to work on. And so, the intelligence cycle continues, thus making it cyclical.

The results from Cope’s (2004) research corresponds with the framework that is outlined within the National Intelligence Model (NIM). NIM is a “business model for law enforcement agencies” which “takes an intelligence-led approach to policing” (ACPO/Centrex, 2005,2007). NIM was designed in 1999 (IMPEL, 2017) and implemented in the United Kingdom in 2004 (ACPO/Centrex, 2005, 2007). The need for NIM is a result of the Audit Commission, in 1993, showing that the recurring failure of law enforcement agencies to effectively address crime is due to the variation in intelligence practices across law enforcement agencies (IMPEL, 2017).

NIM is a top-down framework which consists out of eleven elements (see Figure 2) where each element feeds into the next element in top-down approach. The first four elements in NIM outline the organisational assets that should be in place (knowledge, systems, sources, and people). The fifth element reflects the different informational sources needed that should be evaluated (sixth element) on its intelligence value and stored accordingly. The seventh element outlines how the information is researched, developed, and analysed.

Figure 2 - Chapter 2: National Intelligence Model (NIM) with example text. Adapted from ACPO/Centrex (2005)



The intelligence products that are developed form the seventh element forms the basis of the eighth element, where the intelligence is assessed and prioritised for action. The nineth and tenth elements are where the Tactical Tasking and Co-ordination Group (TT&CG) actions the intelligence. The final element is a review of the execution of the earlier ten elements which results in the updating of the first five elements so that the intelligence cycle can continue.

NIM also stipulates that it works on three levels (local, cross-border and serious/organised crime across national or international levels) and the resources and communication should flow effectively between these three levels (ACPO/Centrex, 2007).

NIM outlines the intelligence-cycle phases (see Figure 3) to be; direction, collection, collation, evaluation, analysis, dissemination and then back to direction (ACPO/Centrex, 2007). Although not directly stipulated, there is a relationship between the intelligence cycle and the NIM framework (see Figure 4). Direction is the tasking stage and is linked to the ninth element (TT&CG) (ACPO/Centrex, 2007). Collection, collation, and evaluation links to elements five and six. Analysis covers elements seven and eight. Dissemination covers elements ten and eleven.

Figure 3 – Chapter 2: Intelligence Cycle. Adapted from Gibbs et al. (2015)

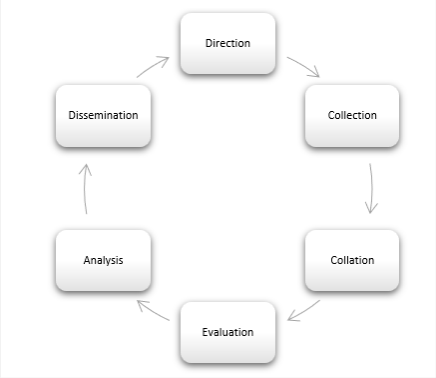
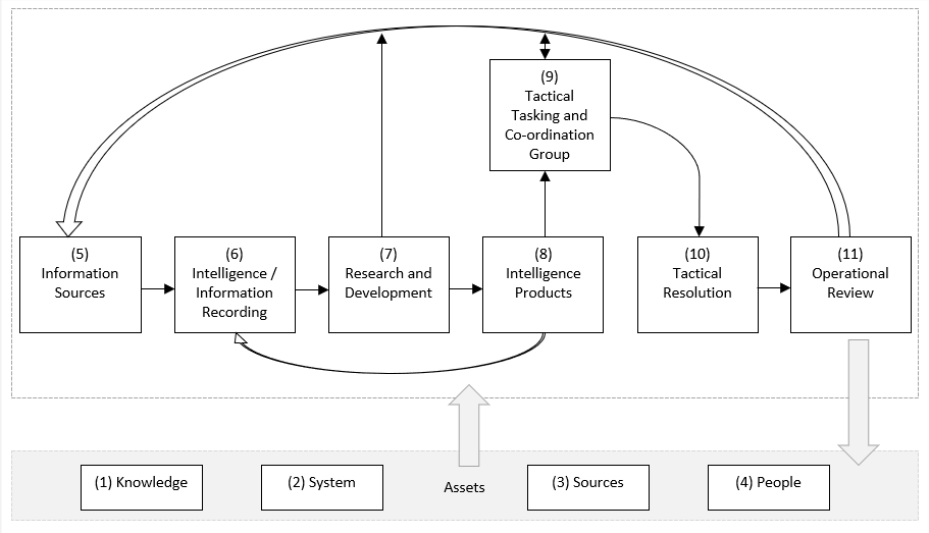


Figure 4 - Chapter 2: Relationship between NIM and the Intelligence Cycle. Adapted from ACPO/Centrex (2005)



There is criticism that the intelligence cycle is flawed, and an ill representation of what criminal intelligence analysts do. Ratcliffe (2016:p78) points out that analysts tend to jump between the phases and do not follow a linear process. Hulnick (2006) points out that the intelligence consumers (i.e., TT&CG) rarely kicks off the intelligence process, so direction should not be the starting point. An intelligence analyst from IntelligenceAnalysis.net (2008) argues that collation

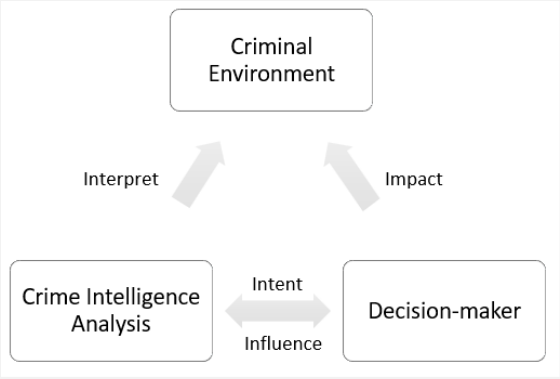
is a paper-based process of the 1970s and should therefore be omitted as technology only requires information to be stored once. IntelligenceAnalysis.net (2008) further reckons that evaluation refers to the 5x5x5 intelligence recording process and that criminal intelligence analysts will therefore have intelligence *before* their analysis process starts and hence could cause issues in believing that the information is 'intelligence' and thus not question its reliability.

There are other methodologies such as SARA (Ratcliffe, 2016:p55) which is used in Problem-oriented policing (POP) (also known as problem-solving policing). POP is defined as "an approach to tackling crime and disorder that involves the identification of a specific problem, thorough analysis to understand the problem, the development of a tailored response and an assessment of the effects of the response" (College of Policing, 2020). SARA involves scanning, analysis, response, and assessment activities (POPcenter, 2015; Ratcliffe, 2016). The scanning process involves the identification of crime problems, their consequences and assigning priorities accordingly.

The analysis process involves understanding the identified problems and developing a working hypothesis on why the problem is reoccurring. The response process involves deciding on how to intervene and to carry out the intervention. The assessment process involves the evaluation of the effectiveness of the actioned response and lessons learned.

Ratcliffe (2016:p83) prefers his 4i model over the intelligence cycle as it places importance on the impact of the intelligence products on the reduction of crime. Although intelligence is the interpretation and evaluation of information to supply intelligence as a product (as per definitions previously provided), Ratcliffe (2016:p83) urges that intelligence is only useful *if* it influences the crime scenario. The 4i model places the criminal intelligence analyst into a broader framework, where he needs to interpret the criminal environment based on the intent (direction) of the decision-maker, influence the decision maker with the intelligence produced and finally, have an impact on the criminal environment.

Figure 5 - Chapter 2: 4i Model. Adapted from Ratcliffe (2016:p83)



Chapter 3 contributes to the above-mentioned research, by expanding NIM's element 7 (Research and Development) to supply greater detail on how criminal intelligence analysts currently externalise their analytical rationale using a physical medium (pen and paper) that they

refer to as a daybook (see Figure 34). Chapter 4 contributes by supplying specific examples of analytical task groupings that exists within element 7 and how it is used to build confidence in criminal intelligence analysts' analytical rationale, which in turn influences the creation of NIM's element 8 (Intelligence Products) (see Figure 100).

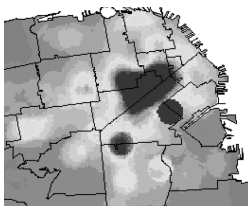
1.4. Techniques used by criminal intelligence analysts

NIM, SARA, 4i and the cyclical intelligence process are examples of high-level descriptions that informs where intelligence analysis should be situated within law enforcement agencies and that intelligence analysis should be conducted in a uniformed manner across these law enforcement agencies. Criminal intelligence analysts have a variety of analytical techniques available to them to analyse information and hence, produce intelligence. The most common techniques are briefly described below:

Crime Pattern Analysis (CPA) is used to show the "nature and scale of emerging and current crime and disorder trends, linked crimes or incidents, hot spots of activity and common characteristics of offenders and offending behaviour" (College of Policing, 2016b). Criminal intelligence analysts must therefore have a general understanding of the typical nature of the crime that is taking place, in and around their Local Policing Units (LPUs).

CPA includes techniques for hot spot identification, crime and incident trend identification, crime and incident series identification and general profile analysis. Hot spots are geographical areas where "the concentration of crime is relatively greater than the crime distribution in other parts" (Hajela et al., 2020). Hot spots make use of variations of colour to show the various concentrations of crimes (see Figure 6).

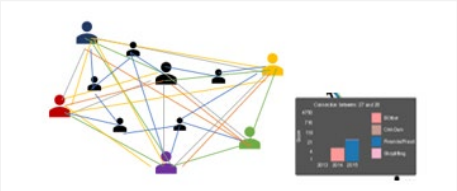
Figure 6 - Chapter 2: Hot spot map. Adapted from Hajela et al., (2020)



Case analysis examines an "incident or series of events in order to support the investigation" (College of Policing, 2016b). It aids with finding new lines of enquiry and the sequence of events (before, during and after) an incident. It also aids with the corroboration of case information and the links or involvement of individuals.

Network analysis supplies an "understanding of the nature and significance of the links between entities [and] assesses the strengths and weaknesses of criminal groups or organisations" (College of Policing, 2016b). This is useful for intelligence gathering and to find disruption opportunities. Disruption refers to the disruption of the criminal activity.

Figure 7 - Chapter 2: Network analysis chart (Haider et al., 2017)



Criminal Business Analysis (CBA) is used to "develop an understanding of how criminal activity, businesses and techniques work" (College of Policing, 2016b). It finds the logical order of activities and events of a particular crime and is used to formulate an understanding of what the crime is and to decide on the best opportunities to halt or disrupt the criminal activity. It is used in conjunction with market and subject analysis.

Market analysis is to show the "criminal market around a commodity or service and can be used to describe a criminal market at any level" (College of Policing, 2016b). It allows for the identification of latest trends and potential new sources of information.

Subject analysis supplies a "detailed analysis of an individual identified as a victim or witness, suspect or offender" (College of Policing, 2016b). It is used to create a subject profile and is not constructed by the criminal intelligence analyst but given to them to enhance their understanding of the subject's lifestyle, or to understand the scale and seriousness of the threat (or harm) posed by (or to) the subject.

Demographic and Social-Trend Analysis (DSTA) examines how "demographic and social changes within an area or within a demographic group can affect levels and types of crime and disorder" (College of Policing, 2016b). It is divided into single incidents, which may be social events such as music festivals or long-term changes, such as an influx of an ethnic group into a specific area. DSTA usually happens because of changes in normal offending patterns as discovered during CPA. It aids with predictive policing as well as decision-making at strategic levels.

Risk Analysis supports the "assessment of the scale of the risk posed by individual offenders, organisations or crime types to potential victims, the public generally, law enforcement agencies or the criminal justice system" (College of Policing, 2016b). It aids with predictive policing and assessing the impact of action or inaction of police enforcement in an area. It is coupled with SWOT Analysis, which finds the **S**trengths, **W**eaknesses, **O**pportunities and **T**hreats that a person or group faces.

Results Analysis evaluates the "effectiveness of an activity" (College of Policing, 2016b) and can occur at the operational or strategic level. It aids in the evaluation of the effectiveness of decision-making and the effectiveness of projects and tasks.

Operational Intelligence Assessment (OIA) is a method of "ensuring that medium to long-term investigations remain focused on their original objectives" (College of Policing, 2016b). It also ensures that new legislation and compliance rules are being adhered to, such as found in the Human Rights Act 1998 and the Regulation of Investigatory Powers Act 2000. Criminal intelligence analysts are involved but are not solely responsible for this activity.

The above analytical techniques are supported by an array of tools such as association and network charts; timelines and sequence of events charts; comparative case charts; maps, flow charts; frequency charts; story boards and mind maps. Maps, graphs, and tables aid with CPA while flow charts tend to aid with CBA (College of Policing, 2016b). Although these tools can be applied using traditional mediums, such as pen and paper, commercial software applications are also available. One such an example is IBM i2 Analyst's Notebook (IBM, 2009)[2] that can be used for CPA and CBA. IBM i2 Analyst's Notebook supports the criminal intelligence analyst by providing; visualisation and analysis of complex networks; target discovery with social network analysis; integrated mapping for geographical analysis and visual filters, histograms, and heat maps for general analytical activities. VALCRI[3] (Casey et al., 2019; Revell, 2017), is a visual analytical tool to support decision-making in crime analysis. VALCRI "attempts to make connections in crime reports that may be missed by analysts and to present them in visual form." (Casey et.al., 2019). Other applications such as Jigsaw support the investigative analysis process by "representing documents and their entities visually in order to help analysts examine them more efficiently and develop theories about potential actions more quickly" (Stasko et al., 2008).

Even with the available tools and analytical techniques outlined above, Cope (2004) argued that although the intelligence cycle is viewed as an objective analytical process, it is a very subjective process. This is because criminal intelligence analysts use these analytical techniques to produce intelligence that are based on their inferences and understanding of the available information, within the available time that they have for the analysis process. Objectivity is therefore understood as something that can be achieved in degrees, for example by applying certain methods and ways of thinking, thereby creating distance to the object of analysis when interpreting the collected pieces of information.

Structured Analytical Techniques (SAT) were introduced by Heuer and Pherson (2015) to allow criminal intelligence analysts to "question [their] intuitive judgements by identifying a wider range of options for analysts to consider" (Heuer and Pherson, 2015:p6). SAT is defined as involving a "step-by-step process that externalises the analyst's thinking in a manner that makes it readily apparent to others, thereby enabling it to be viewed, discussed and critiqued piece by piece, or step by step" (Heuer and Pherson, 2015:p23). SAT therefore aids with the subjective nature of criminal intelligence analysis and aims to increase the robustness of intelligence products produced. Heuer and Pherson (2015) divided the fifty-four structured techniques into eight groups namely; decomposition and visualisation, idea generation, scenarios and indicators, hypothesis generation and testing, assessment of cause and effect, challenge analysis, conflict management and decision support.

SAT's influence on the Authorised Professional Practice (APP) can be seen through APP's categorisation of their analytical techniques. APP is an online repository serving as an "official source for professional practice on policing" (College of Policing, 2013) and policing staff should have a "regard to APP in discharging their responsibilities" (College of Policing, 2013). APP's categorisation of their analytical techniques is categorised into five broad groups that are similar

[2] https://www.ibm.com/uk-en/marketplace/analysts-notebook
[3] http://valcri.org/

to SAT, namely; creative thinking and hypothesis generation, making sense of complex data, hypothesis testing, generation and evaluation of scenarios and other techniques.

SAT techniques such as Key Assumption Checks (Heuer and Pherson, 2015:p209) and Analysis of Competing Hypothesis (Heuer and Pherson, 2015:p181) are listed and outlined on the APP online repository (College of Policing, 2013).

Table 1 supplies an outline of the structured analytical techniques as outlined by Heuer and Pherson (2015) and the corresponding analytical techniques as outlined by APP. Similarities across multiple groups are highlighted in colour.

Table 1 - Chapter 2: Outline of SAT and APP analytical techniques

SAT Categories	**SAT Examples**	**APP Categories**	**APP Analytical Technique Examples**
Decomposition and visualisation	• Checklists Chronologies and timelines • Sorting, Ranking, Matrices • Venn & Network analysis • Maps: Mind, Concept & Process • Gantt Charts	Making sense of complex data	• Crime pattern analysis *(identify emerging and current trends, linked crimes or incidents, hotspots of activity and common characteristics of offending behaviour. Uses maps, graphs, charts and tables.)* • Comparative Case Analysis *(identifies similarities between incidents)* • Network Analysis *(uses association charts to link relationships between people, locations, objects etc.)*
Scenarios and indicators	• Scenario Analysis *(identify multiple ways a situation might develop. Can use Clone of Plausibility)* • Indicators *(early warnings of future events or validating what is being observed)* • Indicator Validation *(assess the power of the indicator)*	Generation and Evaluation of scenarios	• Quadrant Crunching • Force-Field Analysis • Cone of Plausibility • Red teaming • Backcasting *(provide precursor events which will lead to something to occur)*
Idea generation	• Structured & Virtual Brainstorming • Starbursting *(generating questions)* • Cross-Impact Matrix *(identify a list of variables relevant to a particular project)* • Morphological Analysis *(identify and consider all possible relationships when little data available)* • Quadrant Crunching (*rethink a situation from a broad spectrum of alternatives)*	Creative thinking and Hypothesis generation	• Key Assumption Checks • Hypothesis Generation • Structured Brainstorming

<table>
<tr><td>Hypothesis generation and testing</td><td>• Hypothesis Generation
• Diagnostic Reasoning (evaluate a single item of evidence in multiple hypotheses)
• Analysis of Competing Hypotheses (ACH) (evaluate multiple items of evidence within multiple hypotheses)
• Argument Mapping (rigorous logical test of a particular hypothesis)
• Deception Detection</td><td>Hypothesis testing</td><td>• Analysis of Competing Hypotheses (ACH) (Generate alternative explanations using same evidence)</td></tr>
<tr><td>Assessment of cause and effect</td><td>• Key Assumption Checks (make assumptions explicit)
• Structured Analogies (compare issues against different analogies)
• Role Playing (see problem from another person's perspective)
• Red Hat Analysis (perceive threats and opportunities as others see them)
• Outside-In Thinking (reach beyond specialist's area)</td><td rowspan="3">Other</td><td rowspan="3">• SWOT Analysis
• Crime Script Analysis (breaks down information into logical steps in an organised sequence. There are four stages to a crime: preparation, pre-activity, activity and post-activity)
• Team A / Team B (used when there is no clear answer to the problem. Two teams come up with alternative research for decision maker to review)</td></tr>
<tr><td>Challenge analysis</td><td>• Premortem Analysis (identify possible failure before it occurs)
• Structured Self-Critique (identify weaknesses in own analysis)
• What If? Analysis (alert decision makers of alternatives)
• High Impact/Low Probability Analysis (assumes an event has occurred and analyse how it occurred and consequences)
• Devil's Advocate (make a possible case against current analysis)
• Red Team Analysis (challenge conventional thinking)
• Delphi Method (different analysts use different techniques to arrive at same conclusion)</td></tr>
<tr><td>Conflict management and decision support</td><td>• Adversarial Collaboration (agreement between opposing parties on how they'll work together)
• Structured Debate (planned debate on opposing views)
• Decision Trees (chart ranges of available options)
• Decision Matrix (stipulate trade-offs between conflicting goals)
• Pros-Cons-Faults-and-Fixes (strategy for critiquing new policy ideas)
• Force Field Analysis (identifies and assigns weights to the relative importance of factors or forces that influence a situation)</td></tr>
</table>

	• SWOT Analysis *(identifies strength, weaknesses, opportunities and threats to achieve a goal)* • Impact Matrix *(assess the impact of a decision)* • Complexity Manager *(assess the changes in a policy and the consequences)*		

Table 1 shows that SAT covers the entire range of analytical techniques from the planning phase all the way to the evaluation phase of the intelligence cycle. Corresponding phases of NIM would be elements five (information sources) through to seven (operation review). By referring to Table 1, it may seem that APP outlines less analytical techniques than what are available within SAT, but it should be noted that APP categorised their techniques according to their various analysis phases which are: Getting started, Analytical techniques, Delivering effective analysis, Evaluation and review and Intelligence Products. The analytical techniques for APP as outlined in Table 1 only covers the techniques that fall within APP's category of 'Analytical Techniques'. The sections that follow outline further APP techniques.

Under APP's category of 'Getting Started' they outline the necessity of deciding the Terms of Reference (TOR) which is an agreement on what is to be analysed. Part of TOR is to find which questions need to be answered and agreeing to parameters, such as the purpose of the analysis and the time needed for completing the analysis work. It further outlines a collection plan for collecting information and resources needed for the analysis. This may involve Key Assumption Checks (KAC), structured brainstorming, using their expert judgement on how to perform the analysis, the process of generating multiple hypotheses, figuring out the 5WH questions (Who, What, When, Where and How) and Environmental Scanning such as PESTELO (political, economic, social, technological, environmental, legal and organisational) or STEMPLE (social, technological, economic, military, political, legal and environmental). After the relevant information is collected, the criminal intelligence analyst can collate the information so that it is stored and easily retrievable. This forms an audit trail and proves adherence to various laws such as the Data Protection Act of 2018. Collation also aids with the evaluation process. Evaluation is used to decide if the collected information is reliable, relevant to TOR and if it relates to other information. APP also makes the criminal intelligence analyst aware of cognitive biases. Heuer's main purpose for SAT is to aid with the mitigation of these cognitive biases (Heuer and Pherson, 2015).

Under APP's category of 'Effective Analysis', they make references to Ratcliffe's 3i model (which has since been enhanced by Ratcliffe's (2016:p83) with his 4i model). This links APP to the need for intelligence analysts to develop actionable intelligence products. Intelligence products are usually conveyed as written intelligence reports although they can also be in the form of meetings or briefings. APP therefore emphasised the importance to write clearly and provides techniques such as using the ABC (Accuracy, Brevity and Clarity) technique, Bottom Line Up-Front (lead with the conclusion), the 4-3-3 principle (no sentence should be more than 4 lines, no paragraph should be more than 3 sentences and no section should be more than 3 paragraphs). APP further

states to only use visualisations within reports when necessary and to use the Professional Head of Intelligence Analysis (PHIA) Probability Yardstick when conveying probabilities. When writing for actionable intelligence the criminal intelligence analyst's recommendations should be SMART (Specific, Measurable, Achievable, Realistic or Relevant and Timely). The criminal intelligence analyst is responsible for creating an intelligence report of quality and it should go beyond the TOR's description, which means that the intelligence supplied should add value. The last part of authoring the report is dissemination and the criminal intelligence analyst should ensure that the proper Government Security Classification (GSC) is assigned before distributing it to the relevant audiences.

Under APP's category of 'Evaluation and Review', they place emphasis on self-evaluation and organisational evaluation. With self-evaluation, the criminal intelligence analyst must assess if the analysis satisfies the TOR, find any deviations from the TOR and decide if a different analytical method could yield equivalent results. As the intelligence products are created for action, criminal intelligence analysts must decide if the problem was resolved based on their inferences during the analysis they have conducted and the recommendations they have made. If the problem is not resolved, then the criminal intelligence analyst needs to decide what other information they need for further analysis.

On an organisational level, the decision makers will conduct results analysis to decide if the intelligence products provided by the criminal intelligence analyst were effective. This would include activities such as outlining good practices, cost-benefit analysis and cause-and-effect analysis. Operational Intelligence Assessment (OIS) is used by the organisation to ensure that the applicable laws are adhered to and to focus the analysis and to approve any deviations from the TOR. The Management of Risk in Law Enforcement (MoRiLE) is used to set and evaluate tactical and strategic policing priorities and to assess the impact of the policing activities on the immediate and wider community as well as the environment.

The SAT and APP descriptions outlined in the above sections, show that criminal intelligence analysts are guided towards using a uniform set of analytical processes and techniques. The models, frameworks and processes inform researchers on what is expected of criminal intelligence analysts, where and how their intelligence products will be used in down-stream processes and which tools and techniques criminal intelligence analysts can use to make their intelligence products more robust for evaluation and scrutiny.

Chapter 4 contributes to the above-mentioned analytical technique classifications, by matching possible analytical techniques against different analytical tasks. The analytical tasks form part of criminal intelligence analysts' analytical rationale formulation process. It supplies a template for understanding which techniques are typically used at specific points during the analytical reasoning process of criminal intelligence analysis.

Even with all this help from above mentioned models and frameworks, criminal intelligence analysts still face various subjective problems during the intelligence process and these problems are described in the sections that follow.

2. Cognition and Reasoning

2.1. Overview

The concept of cognitive science is "cross-disciplinary [and] devoted to exploring and understanding the nature of the mind" (Frankish and Ramsey, 2012:p1). Cognition is defined as "the states and processes involved in knowing, which in their completeness include perception and judgment. Cognition includes all conscious and unconscious processes by which knowledge is accumulated, such as perceiving, recognising, conceiving, and reasoning. Put differently, cognition is a state or experience of knowing that can be distinguished from an experience of feeling or willing" (Britannica, 2021).

It is said that "cognition does not happen in a vacuum" and that researchers need to "appreciate the context in which cognitive functions are carried out" (Crandall et al., 2006). This context is referred to as the "cognitive landscape" by Crandall et al. (2006) and they describe the components as; (a) purpose of the task by means of forming goals; (b) the way people use prior experience to work through the problem; (c) the features of the situation such as uncertainty, ambiguity, time pressures, bounded systems (nuclear plant) or unbounded systems (peace keeping missions); (d) the nature of the challenge such as how well defined the task/problem is; (e) the availability of the tools needed to complete the task; (f) the availability and skills of the team members and; (g) the organisational constraints such as having to follow specific procedures.

One of the tools available to criminal intelligence analysts is visual analytical systems. The purpose of visual analytics is to help the analytical reasoning process of "perceiving, understanding and reasoning about complex and dynamic data and situations" (Thomas and Cook, 2005). Analytical reasoning is said to be a central part of "analysts' task of applying human judgements to reach conclusions from a combination of evidence and assumptions" (Thomas and Cook, 2005).

The analytical reasoning process gives rise to tangible outcomes that aid with the formulation of defensible judgements. These outcomes are referred to as reasoning artefacts and can be classified as; elemental artifacts (source intelligence, relevant information, assumptions, and evidence); pattern artefacts (patterns and structures as well as temporal and special patterns); higher-order knowledge constructs (arguments, causality, and models of estimation) and; complex reasoning constructs (hypothesis and scenarios) (Thomas and Cook, 2005). It is said that the analytical process forms the "basis for the ongoing dialogue between analyst and their information" (Thomas and Cook, 2005) and that this dialogical iterative process to produce judgements about an issue is known as analytical discourse. This is in line with the notion that the intelligence process is a cyclical process (Cope, 2004; Gibbs et al., 2015) and that it is subjective process (Cope, 2004) as the dialogue between the analyst and his/her information is a personal interaction. This means that even with the introduction of structured analytical techniques to make the intelligence process objective, the nature of analytical discourse makes

it subjective. Supporting analytical discourse requires an understanding of the reasoning process as well as the underlying cognitive and perceptual principles (Thomas and Cook, 2005).

Reasoning, as part of the cognitive process, can be described in the context of how people make inferences based on the given information and then what they then later decide to do because of their reasoning process (Oaksford et al., 2012:p131). People can make use of deductive and inductive reasoning and the terminology is used interchangeably with deductive and inductive arguments (Oaksford et al., 2012:p131). An argument is said to be deductive when "the premises are true, then the conclusion must also be true" (Oaksford et al., 2012:p131). With an inductive argument, the "premises merely make the conclusion plausible or probable" (Oaksford et al., 2012:p131). Arguments are described in detail within section 3 of this chapter.

The reasoning process is influenced by cognitive biases. An example of a cognitive bias that is related to deductive reasoning, is when people prefer to pursue with the task of finding evidence that confirms a hypothesis over finding evidence that falsifies a hypothesis. This has been illustrated by Wason (1968) in his experiment where people were given the facts that there are four birds where; one is a crow, the second is a swan, the third is white and the fourth is black. Participants were asked how they would figure out if all the swans were white and the participants suggested to look if the white bird was a swan. It would be more proper to disprove the hypothesis by checking if the black bird was a swan. A detailed description of different cognitive biases typically found within intelligence analysis can be found in section 2.3. Biases occur due to the nature of heuristics which is described in the section 2.2 which follows.

2.2. Heuristics

Section 1 of this chapter outlines that criminal intelligence analysts follow a specific set of analytical techniques and organisational processes. The 'investigative mindset' is a term used by crime investigators and is based on the ABC rule, which stands for: **A**ssume nothing, **B**elieve nothing and **C**hallenge/Check everything (Cook et al., 2013). This rule serves as a reminder to investigators and even criminal intelligence analysts to consider a wider range of possibilities when analysing information and to be aware of any assumptions that they might be making, based on their experience and knowledge. Cook et al. (2013:p60) outlines the investigative mind-set as follow: "This is a pragmatic mantra used to keep an open mind and remaining receptive to alternative suggestions; looking for other explanations and not becoming too focused on one or two hypotheses." (Cook et al., 2013:p41). A hypothesis is defined as, "a supposition or proposed explanation made on the basis of limited evidence as a starting point for further investigation." (Cook et al., 2013:p60).

The need for an investigative mindset is due to the nature of work and that it is performed by criminal intelligence analysts. They must often work on a limited number of information, they need to rely on the 5 WH's questions, and they need to decide what information is correct, reliable and relevant. This decision-making process is outlined by (Cook et al., 2013:p62): "Decision making relies upon good information which must be carefully scrutinised, reviewed

and assessed. It involves remaining sceptical and testing the accuracy, reliability and relevance of material relied upon" (Cook et al., 2013).

Hammond et al. (1987) outlined that "cognitive processes and task conditions can be arranged on a continuum that ranges from intuition to analysis". This points to the link between mental processes and the tasks people perform. Criminal intelligence analysts rely on their reasoning and thought processes to make inferences and those are governed by their expert intuition and unique experience-based knowledge (Gerber et al., 2016). This is in line with Cope's (2004) argument that the intelligence products that criminal intelligence analysts produce is a result of a subjective process rather than an objective process, even though researchers try to make it objective through analytical techniques such as SAT.

The process of making use of experience-based knowledge is known as heuristics. The theory of heuristics refers to, "the use of experience-based knowledge (or 'working rules') for problem solving" (Cook et al., 2013:p61). It allows for the "association of current circumstances with past examples in order to help in selecting appropriate and effective decision-making options and draw inferences that can, in some circumstances, prove very useful." (Cook et al., 2013:p61). Heuristics are important in situations where information is limited, missing, or ambiguous, as it allows criminal intelligence analysts to draw upon prior experience and knowledge to progress the analysis (Gerber et al., 2016).

Heuer and Pherson (2015) argued for the importance of criminal intelligence analysts to be aware of instances when they are relying on heuristics, as it may limit them from exploring other hypotheses in favour of one hypothesis that confirms their current theory. Tversky and Kahneman (1974) outlines three types of heuristics (representativeness, availability and anchoring) used in statistical probabilities and estimation. These types of heuristics are used by people when making judgments under uncertainty.

Representativeness is described by Tversky and Kahneman (1974) as the possibility of something being more like to one group than another group, based on the characteristics it displays. Availability has to do with people's natural ability to recall some information much easier than other information and thus, rely on the first impression that comes to mind. Anchoring has to do with people's starting point based on what they have in front of them.

One such example that reflects this, is from Bruner and Minturn's (1955) experiment which illustrates the effect that context has on accessibility. Their experiment proved that an imperfect letter B would be interpreted as such, when surrounded by other letters and interpreted as the number 13, when surrounded by other numbers (see Figure 8). They further argued that people would likely not even consider the numerical context if they were only given the alphabetical context and vice versa.

Figure 8 - Chapter 2: Bruner and Minturn's experiment on the effect of context on accessibility. Adapted from Kahneman (2003).

Heuer and Pherson's (2015) Structured Analytical Techniques (SAT) was developed to aid criminal intelligence analysts with their heuristics and the biases that go with system-one thinking. This is done by using SAT to make the analytical process more deliberate and visible and in doing so, allowing criminal intelligence analysts to become more aware of when system-one thinking is at play. Kahneman (2003) argues that the characteristics of system-one thinking is "fast, automatic, effortless, associative and often emotionally charged". He further argues that system-one thinking is being "governed by habit and are therefore difficult to control or modify" (Kahneman, 2003). Kahneman (2003) argues that intuitive thought is spontaneous and that skill acquisition "gradually increases the accessibility of useful responses and of productive ways to organise information, until skilled performance becomes almost effortless". This means that the more experienced a criminal intelligence analyst becomes, the more they will make use of system-one thinking or leaps-of-faith and intuition as Gerber et al., (2016) describes it.

Kahneman (2003) argues that system-two thinking is "slower, serial, effortful, deliberately controlled and relatively flexible and potentially rule-governed". System-two thinking can have a "monitoring and corrective function" (Kahneman, 2003) on what is produced by system-one thinking. From Bruner and Minturn's (1955) experiment (Figure 8), the need for Heuer and Pherson's (2015) SAT becomes clear on why criminal intelligence analysts should be encouraged to question their interpretations and to seek alternative explanations through the more deliberate system-two thinking.

2.3. Cognitive Biases

When heuristics are present (which falls within the quick and automatic system-one thinking), then cognitive biases are due to present itself (Kahneman, 2003). Heuer (1999) describes cognitive biases as serving as rules of thumb (Bedek et al., 2017) to "ease the burden of mentally processing information to make judgements and decisions. [And] rules of thumb are often useful in helping us deal with complexity and ambiguity". Heuer (1999) continues by describing cognitive biases as "mental errors caused by our simplified information processing strategies. Cognitive biases do not result from any emotional or intellectual predisposition toward a certain judgment, but rather from subconscious mental procedures for processing information". Heuer (1999) outlines that other forms of biases exist such as "cultural bias, organisational bias and biases that results from one's own self-interest".

Hillemann et al. (2015) outlined that a wealth of literature exists on the identification and classification of cognitive biases, of which Heuer's (1999), the SIRIUS program's (IARPA, 2011; MITRE, 2016) and the United States Government Centre for the Study of Intelligence's (US Government, 2009) taxonomies are some of the more well-known taxonomies within criminal intelligence analysis. Table 2 through to Table 5 summarises the cognitive biases taxonomies as typically found within criminal intelligence analysis.

Heuer's (1999) bias taxonomy includes four main categories with multiple types of cognitive biases grouped together within each category. The main categories are:

1) Biases in the evaluation of evidence
2) Biases in perception of cause and effect

3) Biases in estimating probabilities and
4) Hindsight biases in evaluation of intelligence reporting.

Heuer's (1999) work has been adapted by the United States Government Centre for the Study of Intelligence (US Government, 2009, Hillemann et al., 2015) and consists out of a few similarly named categories:

1) Biases in evaluating evidence
2) Perceptual biases
3) Biases in perceiving causality and
4) Biases in estimating probabilities

The SIRIUS program under the Intelligence Advanced Research Project Activity (IARPA) found six types of cognitive biases (IARPA, 2011; Hillemann et al., 2015, MITRE, 2016) that can occur within criminal intelligence analysis namely:

1) Confirmation bias
2) Fundamental attribution error
3) Bias blind spot
4) Anchoring bias
5) Representativeness bias and
6) Projection bias

Criminal intelligence analysts need to go through information to produce intelligence. For this reason, the biases in the evaluation of evidence (or information) comes to the forefront. Heuer (1999:p115) outlines the importance for criminal intelligence analysts to notice the impact that cognitive biases have during the process of evaluating evidence with the following words: "Evaluation of evidence is a crucial step in analysis, but what evidence people rely on and how they interpret it are influenced by a variety of extraneous factors. Information presented in vivid and concrete detail often has unwarranted impact, and people tend to disregard abstract or statistical information that may have greater evidential value. We seldom take the absence of evidence into account. The human mind is also oversensitive to the consistency of the evidence, and insufficiently sensitive to the reliability of the evidence. Finally, impressions often remain even after the evidence on which they are based has been totally discredited".

When criminal intelligence analysts form an initial impression about the information, that impression is likely to persist even when other information or evidence disproves their initial impression. This type of bias is known as "Persistence of Impression Based on Discredited Evidence bias" (Heuer, 1999), "Discredited information bias" (US Government, 2009) or simply as "Confirmation Bias" (MITRE, 2016). Confirmation bias is introduced in instances where criminal intelligence analysts rely on their heuristics in a manner that causes them to only explore one hypothesis. Confirmation bias is outlined by (Cook et al., 2013:p62) as follow: "If a theory is thought to be correct, then investigators are more likely to believe unsound arguments that support it. This is known as verification or confirmation bias".

Due to similarities (see Table 2), Perceptual Biases (US Government, 2009) can be considered as related to the evaluation of evidence bias, even though it is listed as a separate category by the US Government (2009). Perceptual biases (US Government, 2009) occur when criminal

intelligence analysts perceive what they expect to see from the information (expectations), when they resist change even after they were proven wrong (resistance) and when their initial blurred understanding persists, due to initial ambiguous information, even when that ambiguity is resolved with subsequent clear information (ambiguities).

Part of criminal intelligence analysts' function is to go through the information (evidence) to make connections and to find patterns. At times, the information may be limited. The risk in this scenario is that criminal intelligence analysts could place too much emphasis on a perceived pattern within a small sample of data without reflecting on the reason on why the pattern is appearing (Heuer, 1999). Similarly, criminal intelligence analysts could have a higher confidence level when patterns consistently appear within a small sample of information, as opposed to the same consistent pattern within a large sample of information (US Government, 2009).

Criminal intelligence analysts often do not have all the information they need at the start of the investigation to resolve the case. The risk is that criminal intelligence analysts could forget to factor in the missing information when producing intelligence (Heuer, 1999) or have difficulties to judge the impact of the missing information on what they currently believe to be happening in the given crime scenario (US Government, 2009).

Heuer (1999) further outlines that criminal intelligence analysts could regard all the information as valid even though only some of the information is valid (Coping with Evidence of Uncertain Accuracy bias). Heuer (1999) also outlines that criminal intelligence analysts are more prone to remember facts from information that they have worked with first-hand and may be prone to disregard information as received from other sources, especially when that additional information is cumbersome to assimilate i.e., statistical reports (Vividness Criterion bias).

Table 2 summarises the biases that are related to the evaluation of evidence, as typically found within criminal intelligence analysis.

Table 2 - Chapter 2: Summary of the cognitive biases related to the evaluation of evidence as typically found within criminal intelligence analysis

<table>
<tr><th>Heuer (1999)</th><th colspan="2">United States Government Centre for the Study of Intelligence (2009)</th><th>SIRIUS program (MITRE, 2016)</th></tr>
<tr><td>Evaluation of Evidence Bias</td><td colspan="2">Biases in evaluating evidence</td><td>Biases</td></tr>
<tr><td rowspan="4">Persistence of Impressions Based on Discredited Evidence bias
When an impression is formed, it will likely persist even if other information or evidence disproves the initial impression</td><td colspan="2">Discredited information
The initial perception may not easily change when information subsequently discredited</td><td rowspan="4">Confirmation Bias
If a theory is thought to be correct, then investigators are more likely to believe unsound arguments that support it</td></tr>
<tr><td rowspan="3"></td><td>Perceptual biases</td></tr>
<tr><td>Expectations
Perceiving what one expects to see
Resistance
Resisting change when proven wrong
Ambiguities
Initial exposure to ambiguous information causes the initial blurred understanding to persist,</td></tr>
</table>

	even with subsequent clear information	
Oversensitivity to consistency bias Placing too much emphasis on patterns within small sample information without reflecting on the reason for the patterns	**Consistency** Higher confidence when working with consistencies found in smaller data groups than same consistencies in larger data groups	
Absence of information bias Forget to factor in missing information	**Missing information** Difficulties in judging the impact of missing information	
Coping with Evidence of Uncertain Accuracy bias Place too much validity on all the information, based on some valid information.		
Vividness criterion bias Remember and use information experienced first-hand more easily than cumbersome statistical reports.		

Heuer (1999) compares criminal intelligence analysts to storytellers as they construct a story-plot from "dominant concepts or leading ideas". This can lead to biases in perception of cause and effect (see Table 3). Heuer (1999:p127) provided an overview of how judgements relate to causality with the following words: "Judgments about cause and effect are necessary to explain the past, understand the present, and estimate the future. These judgments are often biased by factors over which people exercise little conscious control, and this can influence many types of judgments made by [criminal] intelligence analysts." (Heuer, 1999:p127)

Criminal intelligence analysts could judge situations from their own perspective, without considering the perspective of the offenders they are analysing. This is known as "overestimating our own importance bias" (Heuer, 1999), attribution (US Government, 2009) or projection bias (MITRE, 2016). Criminal intelligence analysts may perceive random events as having meaning and order, when they are in fact just random, which could lead to wrong beliefs about what is actually happening within the crime scenario (Heuer, 1999; US Government, 2009). Related to this, is the internal vs. external cause of behaviour bias (Heuer, 1999), where criminal intelligence analysts omit to account for external factors (environment or situation) as a contributor to the behaviour that they are observing with the offender. MITRE (2016) lists a similar bias as fundamental attribution error.

The bias favouring perception of centralised direction (Heuer, 1999) is when an offender's actions are seen as planned actions when they were in fact random consequences of the situation. Similarity of cause-and-effect (Heuer, 1999) bias is when the inferred cause is proportionately regarded to the effect, for example; big events must have important consequences, which may not always be true. Illusory Correlation (Heuer, 1999) bias is when the criminal intelligence analyst assumes that one event caused a second event, when there is in fact no factual evidence to support that. These types of biases can cause criminal intelligence analysts to construct an incorrect storyline to explain the offender behaviour that they see in the information and thus produce incorrect intelligence products.

Table 3 summarises the biases that are related to causality, as typically found within criminal intelligence analysis.

Table 3 - Chapter 2: Summary of the biases related to perceived causality as typically found within criminal intelligence analysis

Heuer (1999)	**United States Government Centre for the Study of Intelligence (2009)**	**SIRIUS program (MITRE, 2016)**
Biases in perception of cause and effect	**Biases in perceiving causality**	
Overestimating Our Own Importance bias See threats in the behaviour or policies of foreign countries towards their own country, when none actually exist	**Attribution** Judge situations based on one's own experiences and understanding rather from the other person's perspective	**Projection bias** "Tendency to unconsciously assume that others share one's current emotional states, thoughts, and values"
Bias in favour of causal explanations Random events are regarded as having meaning and order, when they are in fact just random	**Rationality** Randomness, accidents or errors are disregarded as such	
Internal vs. External Causes of Behaviour bias Placing less importance on the external factors that influenced a person's behaviour at that time and predict similar behaviour in a different environment		**Fundamental Attribution Error** "Tendency to over-emphasize personality-based explanations for behaviours observed in others while underestimating the role of situational influences on the same behaviour"
Bias Favouring Perception of Centralized Direction Actions are seen as planned actions when they are in fact unintended consequences or coincidences		
Similarity of cause-and-effect bias When the inferred cause is proportionately regarded to the effect i.e., big events have important consequences		
Illusory Correlation bias Assumes that one event caused a second event, when there is in fact no real evidence to support that		

Criminal intelligence analyst must often express their understanding in terms of probability due to the uncertain and ambiguous nature of the information that they work with. Heuer (1999:p147) outlines that probability judgements ease the burden on decision making with the following words: "In making rough probability judgments, people commonly depend upon one of several simplified rules of thumb that greatly ease the burden of decision."

Heuer (1999) argues that criminal intelligence analysts fall victim to the anchoring bias when they rely too heavily on one piece of information which is used as an anchoring point on which to base all other judgements. He explains it as follow: "with the 'anchoring' strategy, people pick some natural starting point for a first approximation and then adjust this figure based on the results of additional information or analysis. Typically, they do not adjust the initial judgment enough."

(Heuer, 1999:p147). It is suggested that criminal intelligence analysts very rarely deviate far from the original starting point when added information is considered (Heuer, 1999; US Government, 2009). This starting point is usually something that they are familiar with, such as similar information from an earlier case that previously proved useful.

As seen with Tversky and Kahneman (1974) in earlier sections, criminal intelligence analysts can be biased based on what is currently available. Availability bias is when criminal intelligence analysts base a probability on how easily they can remember or imagine it occurring. Heuer (1999:p147) outlines it as follow, "Using the 'availability' rule, people judge the probability of an event by the ease with which they can imagine relevant instances of similar events or the number of such events that they can easily remember". The US Government (2009) suggests that criminal intelligence analysts can be overconfident with their estimates in probability, thus falling victim to the overconfident bias. MITRE (2016) outlines that the representativeness bias occurs when criminal intelligence analysts "judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data".

Heuer (1999) argues that criminal intelligence analysts should use numbers to express probability rather than words. Heuer (1999) refers to it as follow, "Expressions of probability, such as possible and probable, are a common source of ambiguity that make it easier for a reader to interpret a report as consistent with the reader's own preconceptions". This is due to the expression of uncertainty bias where the criminal intelligence analyst may not know or remember how sure they were when re-reading their reports and the probabilities were expressed in words rather than numbers. Treverton (2022) offers three questions as a test for criminal intelligence analysts' concerning their confidence about their analysis: "(1) How reliable is the available evidence? (2) What is the range of opinion on the issue? (3) What would it take for me to change my view?"

Heuer (1999) argued that people are naturally poor at probabilistic reasoning and can therefore fall victim to the 'assessing probability of a scenario' bias. As seen previously, criminal intelligence analysts are storytellers where multiple pieces of information are strung together to convey a plausible crime scenario. The probability will be lower for the entire crime scenario when there are more information-pieces and will be higher when there are fewer information-pieces. When criminal intelligence analysts consider statistical information, they will have the tendency to ignore base rates when the base rate is not apparently applicable to their analysis. This could lead to suggesting a probability that is far from the base rate.

Table 4 summarises the biases that are related to the estimation of probabilities, as typically found within criminal intelligence analysis.

Table 4 - Chapter 2: Summary of the biases related to estimating probabilities as typically found within criminal intelligence analysis

Heuer (1999)	**United States Government Centre for the Study of Intelligence (2009)**	**SIRIUS program (MITRE, 2016)**
Biases in estimating probabilities	**Biases in estimating probabilities**	
Anchoring Bias	**Anchoring Bias**	**Anchoring Bias**

Using a known starting point from which make judgements	"Probability estimates are adjusted only incrementally in response to new information or further analysis."	"Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments."
	Over Confidence Bias "In translating feelings of certainty into a probability estimate, people are often overconfident, especially if they have considerable expertise."	
		Representativeness bias "Tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data."
Availability Bias "Imaginability or retrievability from memory"		
Expression of Uncertainty Bias The degree of uncertainty is ambiguous as words are used rather than numbers.		
Assessing Probability of a Scenario bias The struggle to correctly apply probabilistic reasoning		
Base rate fallacy Ignoring statistical base rates because the relationship of the base rate to the current analysis is not apparent		

It is also possible for criminal intelligence analysts to succumb to biases in the review stage of the intelligence process. Heuer (1999:p161) describes this bias category and emphasises that they occur due to the nature of human mental processes: "analysts overestimate the quality of their analytical performance, and others underestimate the value and quality of their efforts. These biases are not simply the product of self-interest and lack of objectivity. They stem from the nature of human mental processes and are difficult and perhaps impossible to overcome" (Heuer, 1999:p161). MITRE (2016) outlined that blind spot bias occurs when criminal intelligence analysts notice errors in their colleague's work, but not their own.

Heuer (1999) warns that criminal intelligence analysts can be overconfident when reviewing their analysis, as they might have a good record of accomplishment in earlier cases. The intelligence consumer, such as seen in Cope (2004), could undervalue the intelligence that criminal intelligence analysts produce. People who handle the review of criminal intelligence analysts' work after-the-fact, could be biased to think that information and events are clearer than what they were at the time the criminal intelligence analyst performed the analysis (Heuer, 1999).

Table 5 summarises the biases that are related to the evaluation of intelligence reporting, as typically found within criminal intelligence analysis.

Table 5 - Chapter 2: Summary of the biases related to the evaluation of intelligence reports, as typically found within criminal intelligence analysis

Heuer (1999)	United States Government Centre for the Study of Intelligence (2009)	SIRIUS program (MITRE, 2016)
Hindsight biases in evaluation of intelligence reporting		
Criminal Intelligence Analyst Over confident in past performances **Intelligence Consumer** Under-value the intelligence that criminal intelligence analysts produce **Reviewer** View information and events as more apparent than what it actually was at the time		**Blind Spot Bias** "Tendency to see the errors in another analyst's collection and interpretation work while not seeing mistakes in their own research work"

Notably, all human beings are prone to these types of cognitive biases, not just criminal intelligence analysts. The take-away from this section is that human beings are prone to cognitive biases, which is a consequence of the subconscious mental procedures for processing information, and this could lead to producing incorrect intelligence products.

Criminal intelligence analysts make use of visual analytical systems to aid with their analytical tasks. Visual analytics is the "science of analytical reasoning facilitated by interactive visual interfaces" (Cook and Thomas, 2005).

Various research about the detection and mitigation of cognitive biases within visual analytical systems have been conducted. Some examples are as follow: Cook and Thomas (2005) have defined the research and development agenda for visual analytical systems which includes cognitive and perceptual principles. Mersch et al., (2013) and Mullinix et al. (2013) used a Game-Based Trainer (Heuristica under IARPA project) to test for occurrences of confirmation bias and to remind participants when they are under the influence of confirmation bias. Wall et al., (2017) created an initial matrix to quantify the detection of confirmation bias within visual analytical systems, thus serving as quantitative evaluation tool. Bedek et al., (2017) proposed evaluation techniques to evaluate the degree of effectiveness of visual analytical system's ability to mitigate cognitive biases. Haider et al., (2015) supplied design guidelines for visual analytical systems in the areas of cognitive bias mitigation, evidential structuring and reasoning, sense-making and insight, and legal, ethical and privacy aspects. Wall, Stasko and Endert (2019) offers design guidelines for the design-space in visual analytics systems to mitigate cognitive biases.

Chapter 4 contributes to the above-mentioned research, by matching possible cognitive biases against different analytical tasks. The analytical tasks form part of criminal intelligence analysts' analytical rationale formulation process. It supplies a method for becoming aware on how cognitive biases can propagate through each step of the analytical reasoning process.

2.3. Thinking, Reasoning and Sensemaking

Wong et al., (2017) describe crime analysis and criminal intelligence as concepts that form part of a thinking and reasoning continuum (see Figure 9). On the intelligence side of the continuum, criminal intelligence analysts are concerned with analysing large volumes of criminal activity that affect society negatively. The purpose is to form connections between those criminal activities to stop or reduce them (College of Policing, 2009). On the investigative side of the continuum, criminal intelligence analysts are concerned with serious crimes (Legislation.gov.uk, 1997), where they need to stitch together the before-during-and-after events of a crime scenario, such as found with a murder or a drug trafficking scenario (Selvaraj et al., 2016).

Figure 9 - Chapter 2: The Criminal Intelligence Analysis Continuum. Adapted from Wong et al. (2017)

Their reasoning process is influenced by the ambiguous and uncertain nature of the information that they are working with (Wong and Varga, 2012). Information is ambiguous when the information is; fragmented (the sequence of events is not in chronological order), missing (only bits and pieces about the alleged crime is available), misleading (the information may convey an incorrect understanding or interpretation) and deceptive (false leads as offenders try to cover their criminal activities) (Wong and Varga, 2012). On both sides of the continuum, criminal intelligence analysts must use their thinking and reasoning skills to reach a conclusion on what they believe to be happening within the crime scenario.

The next few sections outline the applicable research that has been done to understand criminal intelligence analysts thinking and reasoning landscape, as part of the criminal intelligence analysis continuum (Wong et al., 2017):

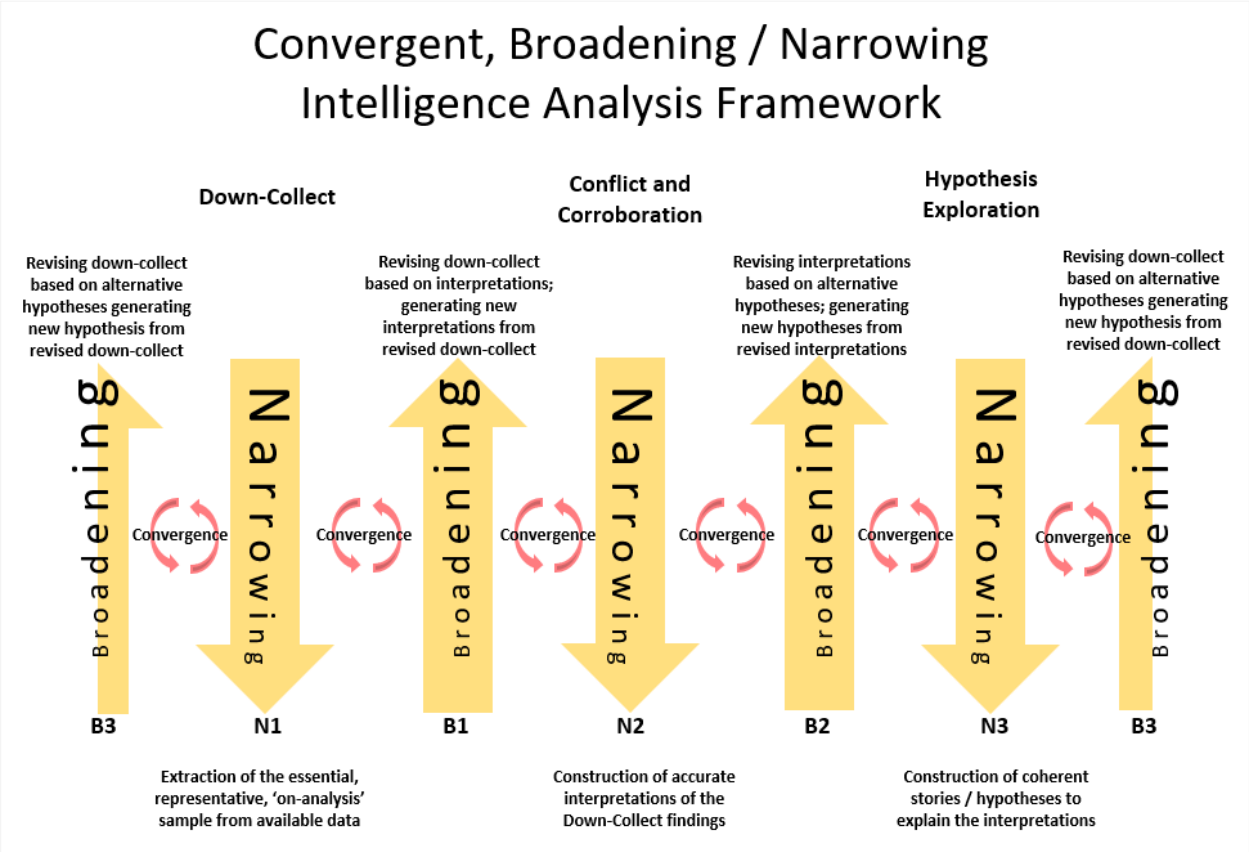
Elm et al., (2005) designed a Support Function Model (SFM) for [criminal] intelligence analysis which extends the work of Patterson et al., (1999) who researched how to aid [criminal] intelligence analysts in data overloading scenarios. Elm et al., (2005) concentrated on the need to support the "cognitive activities involved in the abductive inferential analysis which is at the heart of intelligence analysis" (Elm et al., 2005).

Patterson et al., (1999) found that intelligence analysts use a broadening strategy to consider a large amount of information and to revisit initial interpretations or to consider alternative hypotheses. A narrowing strategy aids criminal intelligence analysts with obtaining high target information for example adding an extra search keyword to narrow down the search results returned or to construct correct interpretations from the broadening activities. Patterson et al., (1999) also found that searches would be ended pre-maturely if the software system did not

sufficiently allow for the incorporation of the broadening strategy (for example, highlighting that relevant information has been updated and re-evaluating hypotheses accordingly).

Elm et al., (2005) argues that decision support tools (with automation) must sufficiently supply support during the convergence of the broadening and narrowing process. Elm et al., (2005) integrated five requirements into their SFM described as observability, directability, teamwork with agents, directed attention and resilience. Observability allows the practitioner to "see sequences and evolution over time, future activities and contingencies, and the patterns and relationships in a process" (Elm et al., 2005). Directability allows the practitioner to "effectively control the processes in response to (or in anticipation of) changes in the environment" (Elm et al., 2005). Teamwork with agents allows the practitioner to "effectively re-direct agent resources as situations change" (Elm et al., 2005). Directed attention allows the "human-system team to work in a coordinated manner, resulting in increased effectiveness" (Elm et al., 2005). Resilience allows for "the ability to anticipate and adapt to surprise and error. This includes issues such as failure-sensitive strategies, exploring outside the current boundaries or priorities, overcoming the brittleness of automation, and maintaining peripheral awareness to maintain flexibility" (Elm et al., 2005). Their work was extended by Farry et al., (2011) through the Mutual Support Function Model (MSFM) and focused on intelligence analysis within irregular warfare. Farry et al., (2011) added Information Needs Management and Decision Selection to the original model.

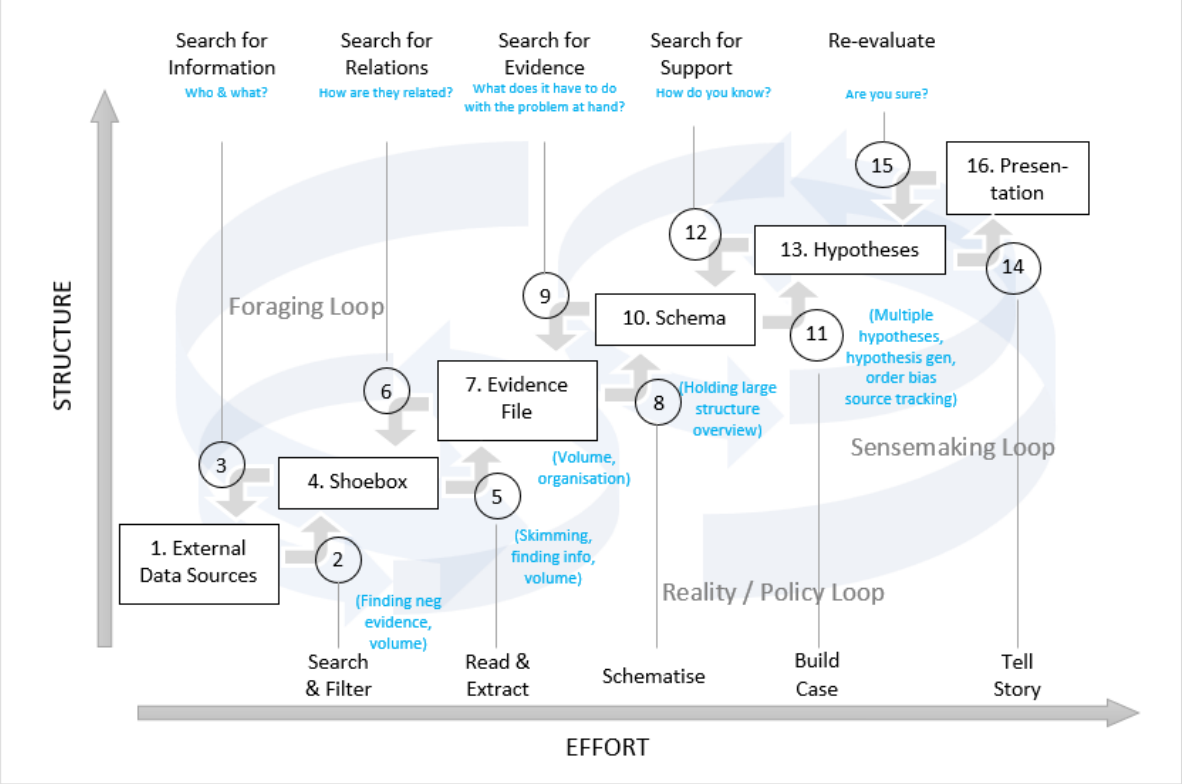
Figure 10 - Chapter 2: Convergent, Broadening / Narrowing Intelligence Analysis Framework. Adapted from Elm et al. (2005)



Elm et al.'s (2005) and Patterson et al.'s (1999) research did not fully explain how criminal intelligence analysts perform their activities and the complexities they face. Pirolli and Card's (2005) Notional Model of Analytical Sensemaking, is a "broad brush characterisation" (Pirolli and Card, 2005) of the intelligence cycle (see Figure 11). The purpose of their model is to outline the typical processes involved when criminal intelligence analysts forage for information (foraging loop) and when they then try to make sense of that information (sensemaking loop). Pirolli and Card's (2005) model offers various leverage points for researchers to improve areas of the process, typically with technology, in terms of the structure that is needed in relation to the effort that is needed to move from raw data to a report that can be presented to the decision-makers. Chapter four contributes to Pirolli and Card's (2005) research, by taking advantage of the offered leverage points of their top-down approach to include an argumentation loop, to aid with the analytical reasoning process of criminal intelligence analysts.

Figure 11 is a depiction of Pirolli and Card's (2005) model. The rectangular boxes indicate the flow of information from; external sources such as information stored in databases to; shoeboxes which represent a sub-set of information to; an evidence file which represents the most pertinent information to; a schema which represents a mental model of the crime or an externalised representation of the evidence file such as a timeline or a network diagram to; hypotheses which represent the tentative conclusions with supporting arguments to; presentations which represent the reports that criminal intelligence analysts create. The circles represent the process flow and can take the form of a bottom-up or a top-down approach.

Figure 11 - Chapter 2: Notional Model of Analytical Sensemaking. Adapted from Pirolli and Card (2005)



With a bottom-up approach; criminal intelligence analysts search and filter through the information from external data sources; they read and extract relevant information in the shoeboxes to extrapolate pertinent information such as names and telephone numbers; they could then structure the pertinent information in a schema such as a timeline; they then use the information to theorise about what is happening thus building a case; which are then presented to the decision-makers.

With a top-down approach; criminal intelligence analysts receive feedback from the decision-makers, and they use the feedback to re-evaluate their hypotheses; they then re-examine their lower-level schemas; and their lower-level evidence in their evidence file; they then may find new relations or insights; which then leads to the further search for information.

Regardless of the top-down or bottom-up approach, the various processes are governed reality-policy loop that governs the policies and procedures under which the foraging and sensemaking loops operates under.

Within NIM, External Data Sources would equate to elements one to five; Shoeboxing and Evidence File would equate to element six and; Schema, Hypotheses and Presentation would equate to elements seven and eight.

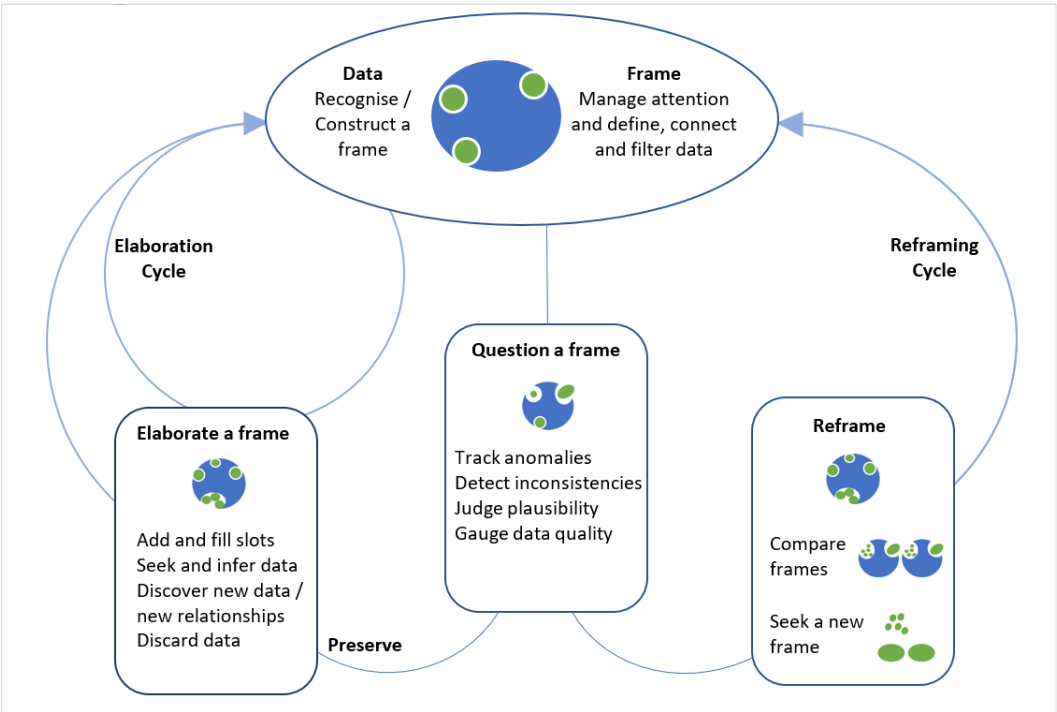
Although their model explains what is happening at a high-level, Pirolli and Card (2005) admits that it omits the finer details of each process and on what is going on in the minds of criminal intelligence analysts during the various sensemaking phases. Sensemaking is defined by Russel et al. (1993) as, “the process of searching for a representation and encoding data in that representation to answer task-specific questions”. Mental models can serve as such a representation (Johnson-Laird, 2010). The function of mental models is described by Johnson-Laird (2010) as “when [people] understand a description of the world, they can construct a similar, albeit less rich, representation - a mental model of the world based on the meaning of the description and on their knowledge”.

There are three characteristics of mental models; (a) they represent what is common to a distinct set of possibilities; (b) they are iconic and (c) they represent what is true at the expense of what is false. The inferences that people make from when viewing information, results in the construction of a particular mental model (Johnson-Laird, 2010). Based on the characteristics of system-one and system-two thinking (Kahneman, 2011), where system-one thinking makes use of ‘working memory’, a person is unable to hold many simultaneous mental models in place. Therefore, people form representations of what is true, as ‘storing’ the alternatives would cause an overload. Alternative representations of the information can be added to the mental model and explored during system-two thinking, which is a more deliberate thinking process (Johnson-Laird, 2010).

Klein et al. (2007) wanted to understand how mental models work and how they are constructed. They have therefore researched how people make sense in everyday settings with respect to mental representations. From this, they created their Data Frame Theory. The Data Frame Theory (Klein et al., 2007) is made up of frames, where a frame represents a person’s initial understanding of a situation, given the data. It is suggested that a frame can be subject to several types of modes, and they are; questioning, elaboration and reframing (see Figure 12). The type

of mode that is active or at the forefront of the sensemaking activity is dependent on the person's understanding at the time, given the information.

Figure 12 - Chapter 2: Data Frame Model of Sensemaking. Adapted from Klein et al. (2007)

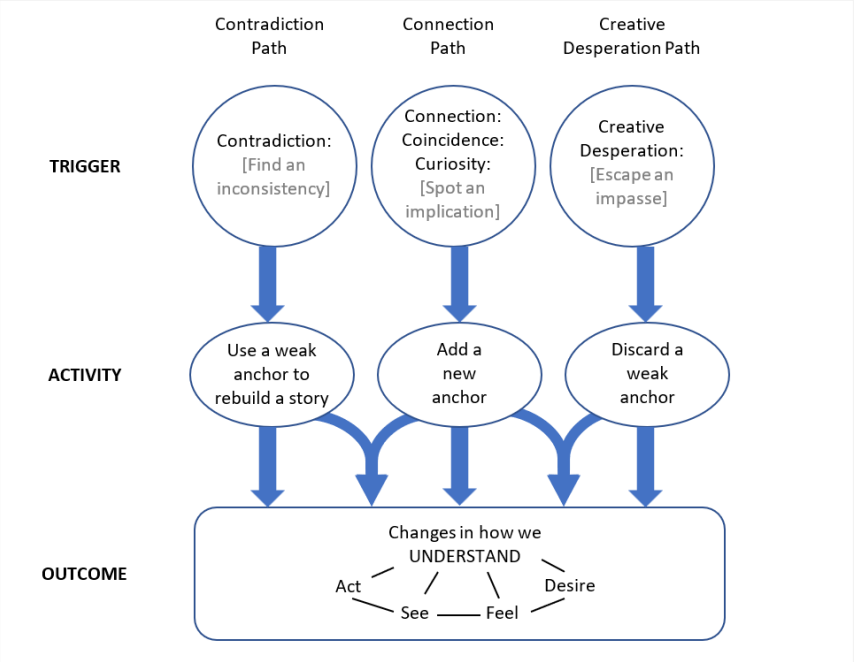


During the questioning mode, individuals question their initial understanding by tracking anomalies, detecting inconsistencies, judging plausibility or gauging data quality. During the elaboration mode, individuals seek new information to fill in empty slots (gaps in understanding) with new data, form new relationships or discard data that no longer fits in with their understanding. During the reframing mode, individuals compare frames with each other or seek new frames that would support their understanding. During each mode, individuals can preserve new understandings which in effect updates and expands their initial frame.

The Data Frame Theory did not explain how people derive insight during sensemaking activities, so Klein (2013) performed additional studies using fire fighters. From this, he created the triple-pathway model (Klein, 2013) which depicts how fire fighters (and possibly other individuals) derive insights. He proposed that individuals use cues (or triggers) from the information (or environment) and then follow one of three insight pathways; contradiction, connection or creative desperation: With the contradiction pathway, individuals identify a trigger which is some information or data that is inconsistent with their initial understanding. This in turn leads them to use a weak anchor to rebuild their initial understanding or the initial story that they had. With the connection pathway individuals identify triggers which are in the form of coincidences that occurred or from implications. This in turn allows them to combine their new findings with existing information and subsequently create a new anchor to progress their understanding. With

the creative desperation pathway individuals find themselves in a position where they have to escape an impasse (in other words - they are stuck). In these cases, they have to discard weak anchors and try something new. All three pathways change the way individuals understand the information or their understanding of the environment.

Figure 13 - Chapter 2: Triple-pathway model of insight. Adapted from Klein (2014)



There is criticism against the Data Frame Theory from Attfield and Barber (2017). They suggest that the Data Frame Theory only represents one type of schematisation and that it offers little new understanding in how sensemaking between frames occur. Attfield and Barber (2017) suggest that a person approaches a situation with a set of generic and situation-specific belief-structures and proposed an associative model of sensemaking. Generic belief structures are defined by Attfield and Barber (2017) as a "set of pre-formed and general 'understandings' that a sense maker can bring to situations to help them make sense of them." The 'understandings' might have developed over time such as work-place experience. Situation-specific belief structures "occur through information or 'cues' from a situation combined with the application of generic belief structures to form an interpretation of a prevailing situation" (Attfield and Barber, 2017).

They outline that the construction of situation-specific belief structures is a complex process as it could consist out of multiple belief-structures and that people would favour an opportunistic outlook when applying a belief structure to a situation. Their proposed associative model which suggests that people would have multiple tacit concept-map-like structures. Each concept map might encompass a specific belief-structure and that the nodes (concepts related to the belief, which may be other belief-structures) serve as specific entry points into the structure. The links

from the entry point to other nodes serve as relevant associations. Belief-structures are therefore 'inactive' until a situation activates one or more belief-structures, depending on the complexity of the 'concept-map'. Attfield and Barber (2017) thus offers researchers an alternative view on how sensemaking occurs.

Selvaraj et al. (2016) conducted research in understanding crime schematisation within criminal intelligence analysis and proposed the concept of "Think Steps". Think Steps have been defined by Selvaraj et al. (2016) as "providing a template that allows the analyst to approach the case, decompose it into separate elements and classify associated data accordingly". Although Klein et al. (2007) defined the use of frames (as schematisation) in their Data Frame Model, Selvaraj et al. (2016) have tailored their work specifically for the criminal intelligence analysis domain, thus allowing for greater understanding on how criminal intelligence analysts work.

Mental models alone did not fully explain the cognitive process during sensemaking tasks, so Hastie and Pennington (2000) explored this more through their research. Hastie and Pennington's (2000) Explanation-Based Decision-Making theory suggests that people make decisions based on a mental representation of the underlying information and background knowledge. This mental representation is referred to as an "intermediate mental model" (Hastie and Pennington's, 2000). The intermediate mental model is specific to decision-making domains and the causal rules and structures may differ between domains. For example, the legal judgement domain will use causal story structures based on human actions and social event rules, while a physician's causal structure will be that of biological structures and rules (Hastie and Pennington's, 2000).

Hastie and Pennington's (2000) found that story-construction was the central cognitive process that took place within the juror's decision-making. This is a follow-on from their earlier research (Pennington and Hastie, 1981, 1992, 1993). This story-construction served as the intermediate mental model of the underlying facts and evidence for jurors. From this, Hastie and Pennington (2000) created a Story Model. The Story Model consists of three component processes; "evidence evaluation through story construction, representation of the decision alternatives (verdicts) by learning their attributes or elements and reaching a decision through the classification of the story in the best fitting verdict category" (Hastie and Pennington, 2000). Hastie and Pennington's (2000) central claim of their model, is that the "story that the juror constructs determine the juror's decision" (Hastie and Pennington, 2000). This emphasised the importance of the juror's intermediate mental model in relation to the verdict (decision) they made.

The story model explained how people make decisions when time was not a major factor. Klein and Klinger (1991) researched how people make decisions in natural settings where time constraints inhibited them from using deliberate analytical methods such as Multi-Attribute Utility Analysis (MAUA) and Decision Analysis. Decisions in these time-limited situations were based on prior experiences to "meet the needs of the situation" and to "recognise and classify a situation" (Klein and Klinger, 1991).

Klein and Klinger (1991) produced a macro-cognition model which explained that there is a multitude of factors that influence decision-making within a natural setting, as appose to a controlled laboratory setting. Later developments of their work added supporting macro-cognitive processes to the model as: developing mental models; mental stimulation and

storyboarding; maintaining common ground; turning leverage points into courses of management; attention management and uncertainty management (Klein et al., 2003). Klein et al. (2005) explained common ground refers to, "the pertinent mutual knowledge, mutual beliefs and mutual assumptions that support interdependent actions in some joint activity." Moore and Dunham (1995) refer to attention management within coordinated activities as, "when team members help each other direct their attention to signals, activities and changes that are important" (in Klein et al., 2005).

Bex and Verheij (2013) have taken Pennington and Hastie (1992) story model within legal settings a step further and created a hybrid theory that consists out of causal theory and evidential theory. Causal theory aids with the building of stories. Evidential theory aids with building arguments from the facts. The function of the 'story part', serves to organise multiple 'sub stories' into coherent accounts of what might have happened. Argumentation is then used to support each of the elements within the story (Bex and Verheij, 2013). Bex and Verheij (2013) pointed out the difference between legal and factual stories. Factual stories explain the evidence and legal stories serve as a perspective on what can be proven within the law, given the evidence.

Passmore et al. (2015) casted a wider lens over the different evidential structuring and reasoning approaches that exist within the literature. Passmore et al.'s (2015) review covered argumentation schemes, narrative and thematic sorting, and the role that each served during sensemaking and analytical activities. Passmore et al. (2015) concluded that any software application's design that is aimed at supporting the thinking and reasoning process throughout analytical and problem-solving tasks, should incorporate a hybrid of structuring and reasoning approaches.

Chapter 4 contributes to the above-mentioned schematisation research, by proposing lines of enquiry as an intermediary mental model where the 'causal structure' is based on the relevance of information in support of the Terms of Reference (case objective). Lines of Enquiry is outlined to support macro-cognitive processes (Klein et al., 2003).

2.4. Fluidity and Rigour

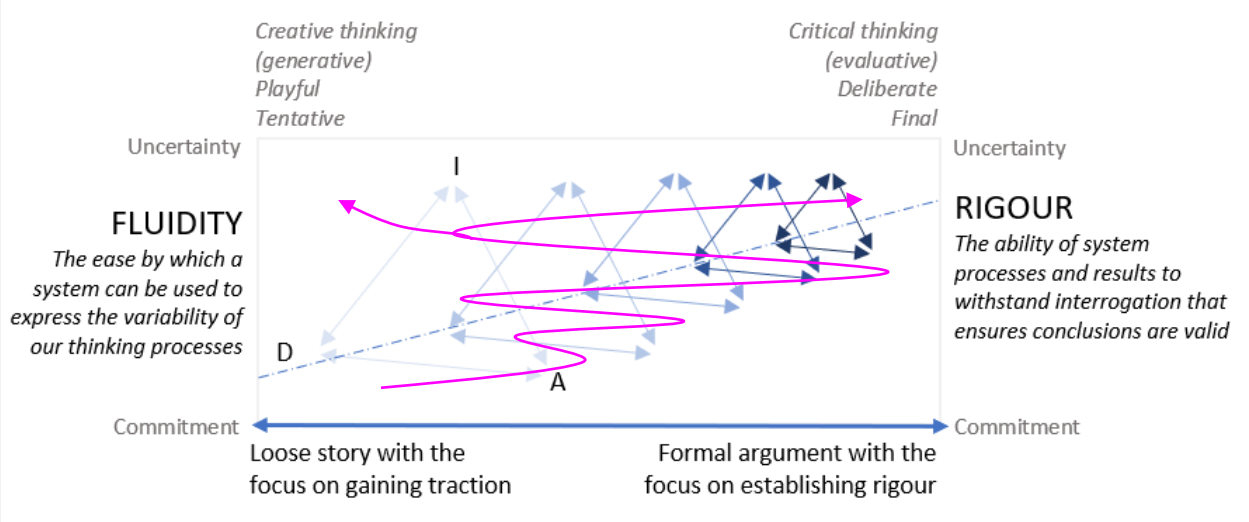
Earlier sections outlined that criminal intelligence analysts depend on mental models or schematisations during sensemaking tasks, but it did not fully explain the relationship between mental models and other cognitive functions, such how the inference process aids the development of understanding.

Wong and Kodagoda (2015) investigated how criminal intelligence analysts' analytical inferencing processes propagated from one conclusion to another. Their work builds upon Klein et al.'s (2007) concept of using data elements, such as anchors, to "create understanding and guide subsequent inquiry". Wong and Kodagoda (2015) suggested that criminal intelligence analysts use both data and non-data anchors during uncertain times (such as the absence of data) to afford the process of gaining traction and thus to progress their understanding. In Wong and Kodagoda's (2015) research, anchors serve as stepping-stones, thus serve to gain traction. In Bex

and Verheij's (2013) research, anchors serve to 'bind' the elements of the story to the evidence, thus serving as a justification. This difference in terminology hinted towards a difference in the utility of cognitive functions during the sensemaking process. Wong (2018) thus proposed the concepts of "fluidity and rigour" (Wong, 2018).

Wong (2018) argued that criminal intelligence analysts gradually move from a fluid phase of the analysis process to a more rigour phase of the analysis process (see Figure 14). The speed at which this shift between the fluid and rigour phase takes place, depends on the crime scenario, the quantity and quality of the information and the degree of uncertainty and ambiguity that surrounds the crime scenario.

Figure 14 - Chapter 2: The fluidity and rigour model. Adapted from Wong (2018)



The fluid phase consists of a loose story that criminal intelligence analysts use to gain traction. Their thinking is creative, playful and tentative, which means that they have low commitment to outcomes reached. During the rigour phase, criminal intelligence analysts have reached a conclusion that can undergo interrogation, so their thinking has shifted from playful, to being critical and deliberate. During the rigour phase they are committed to the outcomes that they have reached through their analysis process. A person may move between the fluidity and rigour phases (illustrated by the pink line in Figure 14) depending on the complexity and the requirements of the sensemaking task.

Wong (2014) built upon these concepts and adapted it to analytical software systems. Wong (2014) stated that fluidity refers to how easily a software system allows a person to express their various types of thinking processes and rigour refers to the ability to test the validity of outcomes of processes. To accommodate the notion of fluid sensemaking, Wong and Varga (2012) have considered representation design problems (keyhole effect, black holes and brown worms) that can occur within visual analytical systems and hinder fluid sensemaking. They have found three main representation design problems in relation to missing or ambiguous information: The keyhole effect Wong and Varga (2012) refers to criminal intelligence analysts having a limited

view or understanding of the information and having to rely on system-one thinking (or working memory) to construct a coherent picture of the crime scenario. Wong and Varga (2012) argued that visual analytical systems should allow criminal intelligence analysts to view their decision on the entire crime scenario for example, if a piece of evidence were to be removed, what would the effect be on the larger crime scenario? The black hole problem (Wong and Varga, 2012) deals with incomplete data sets and the absence-of-information-bias (Heuer, 1999) could rise because of it. Wong and Varga (2012) argued that a visual analytical system should show to the criminal intelligence analyst when information is missing, as it will prompt question as to the likely reason for why the information is missing. Criminal intelligence analysts cannot ask these types of questions, if they are not aware that information is missing or if missing information has been substituted with calculated averages. The brown worm problem refers to "dealing with and representing misleading or deceptive data" (Wong and Varga, 2012). The strength of a chain of evidence can be misleading when criminal intelligence analysts are not reminded to verify premises that are based on weak information.

In Kang, Gorg and Stasko's (2009) evaluation of visual analytical systems, they emphasised how varied and different the participants were in their approach with making sense of information and recommends that a system should be fluid in supporting these differences.

Wong and Kodagoda (2015) argued that when criminal intelligence analysts employ analytical strategies to make sense of information, then they do so through a cognitive process that involves abductive, inductive and deductive inferences. Wong and Kodagoda (2015) based their understanding of these inference types, based on Josephson and Josephson's (1994) definitions as follow: "deduction is considered to have occurred when an inference is based on the application of a general rule or knowledge. An induction is said to occur when new data is sought or collected to create an explanation or generalisation. An abduction occurs when inferences are made to generate the best plausible explanation for a given a set of data" (Wong and Kodagoda, 2015).

Wong and Kodagoda (2015) found that criminal intelligence analysts use abductive inferences to "create tentative and plausible explanations of the data they have" and that it depends on criminal intelligence analysts' prior experience and working goals. Deductive inferences are used to "narrow the scope of possibilities, to test the validity of the data they have or discover later, and the relationships of those data to the stories they have created to explain their understanding of the situation" (Wong and Kodagoda, 2015). Criminal intelligence analysts use induction to "postulate and evolve their tentative stories into more robust arguments" (Wong and Kodagoda, 2015). The inference making process of criminal intelligence analysts is "not a straightforward process, but instead, appears chaotic, haphazard, and sometimes cyclic, depending on when useful information becomes available" (Wong and Kodagoda, 2015).

Wong and Kodagoda (2016) built upon their understanding of the inferencing process that criminal intelligence analysts employ by researching additional cognitive techniques known as anchoring, laddering and associative questioning: Wong and Kodagoda (2016) describe the purpose of anchoring as a way to "create a specific understanding of a situation, given data, prior knowledge, general understanding of the world and the type of problem or crime, and the goals at the time. It provides the cognitive traction to enable reasoning to start. If one does not

understand what the data means nor how the data might be created, one is not able to start. The analysts know that, and use assumptions to create plausible explanations to "pin" down, or anchor, no-data, ambiguous data or data that is unclear about how they fit in. The correctness and accuracy of these frames can be corrected or modified later when more is known about the situation." Anchors are also used in Klein et al.'s (2007) Data Frame Theory, where it refers to "key data elements that serve to create understandings that guide subsequent inquiry". Wong and Kodagoda (2016) elaborated on this by outlining that an anchor could also be used on non-data elements such as hunches.

Laddering is described by Wong and Kodagoda (2016) as: "the process in which [criminal intelligence] analysts construct stories or explanations that leverages off the initial story in an anchor. It enables them to elaborate their understanding and make further sense of the situation by connecting with other data. The story structures are governed by rules of logic and creative storytelling. The laddering process assembles disparate pieces of data and assumptions in sequences to create possible explanations. These ladders become bridges that connect anchors with other data. The laddering process can be linear or can occur in parallel where several anchored frames are considered simultaneously to generate several ladders. Expert analysts appear to be able to hold several ladders in their minds while considering and developing other ideas and options." Wong and Kodagoda (2016) laddering concept touches on storytelling (narrative) which is in line with Hastie and Pennington's (2000) 'story model' explaining how story-construction serves as the intermediate mental model for understanding the evidence. It also ties in with Klein et al.'s (2007) concept of frame elaboration.

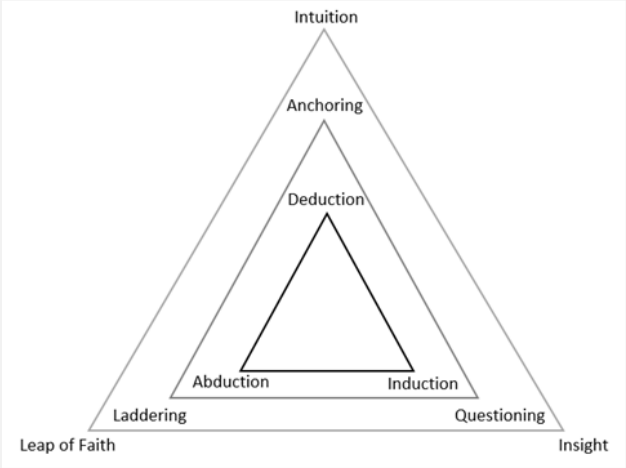
The function of associative questioning is to "expand one's [criminal intelligence analysts'] understanding of a problem and an appreciation of the wider context of the crime situation. The [criminal intelligence] analysts in these instances are not searching for alternative descriptions or semantically similar meanings, synonyms or similar concepts, or trying to disambiguate terms that have different meaning, but are asking questions that would help them make associations with concepts that may be totally un-related or not usually known to be related. Such associations can present new understandings that can lead to insight." This ties into Klein et al.'s (2007) concept of frame elaboration but explains the cognitive techniques that criminal intelligence analysts use.

The inferencing process along with the cognitive framing processes (anchoring, laddering and associative questioning) did not fully explain how criminal intelligence analysts progress the case when uncertainty about anchors were high or when there was little or no information to go on. Gerber et al. (2016) therefore built upon Wong and Kodagoda (2016) work and explored how criminal intelligence analysts make use of leaps-of-faith, intuition and insights during the fluid sensemaking phase when information is uncertain and ambiguous. Gerber et al., (2016) found that intuition aids criminal intelligence analysts with considering some aspect of information, even when they do not know why they are concentrating on it. It ties in with past experiences of criminal intelligence analysts and their level of expertise. Following on from intuition is a concept known as leap-of-faith. Gerber et al., (2016) defines leap-of-faith as, "interpretation of intuitive judgments that arise from experience consistent with perceptions of a current situation". Leap-of-faith serves to "assert an interpretation what the feeling provided by intuition could be about"

(Gerber et al., 2016). Insight "appears in the form of a new pattern as a result of modification or contradiction of a leap of faith" and appears unexpectedly.

Wong and Kodagoda's (2015, 2016) along with Gerber et al.'s (2016) research can be summarised in the sensemaking triangle (Wong and Kodagoda, 2016) which consists out of three interlinked triangles (see Figure 15).

Figure 15 - Chapter 2: The sensemaking triangle. Adapted from Wong and Kodagoda (2015, 2016) and Gerber et al., (2016)



The inner triangle is the inference-triangle and describes the process of inference making as a combination of deductive, inductive and abductive processes. Each inferential process type is interlinked, and a combination of factors will determine which inferential process will be at the forefront of criminal intelligence analysts' thinking and reasoning process. Some of these factors can be influenced by criminal intelligence analysts' experience, their domain and situation knowledge as well as the certainty, ambiguity and availability of information (Wong and Kodagoda, 2015). The second triangle is the anchoring-triangle and describes the sensemaking process in terms of anchoring, laddering and associative questioning (Wong and Kodagoda, 2016). The third triangle describes Gerber et al.'s (2016) added processes of insight, intuition and leap-of-faith. All three triangles work together in a complex combination of processes and sequences and forms an integral part of criminal intelligence analysts' cognitive processes, whilst moving from the fluid sensemaking phase to the rigour sensemaking phase.

Both the fluid and rigour phases require a person to be 'rigour' in the form of due diligence, as it is part of criminal intelligence analysts' obligations. Ideally, a system's design should match fluidity and rigour through interaction and processes, as well as the fluidity and rigour of sensemaking in the form of exploration and verification. These concepts tie in with the Association of Chief Police Officers (ACPO) Core Investigative Doctrine that states that criminal intelligence analyst's conclusions should adhere to the highest degree of certainty to minimise personal bias and stereotyping (ACPO/CENTREX, 2005).

Chapter 4 contributes to the above-mentioned fluidity and rigour research, by proposing task-justification-outcome combinations to allow for fluid constructions of criminal intelligence

analyst' rationale formulation process. By combining these fluid constructs into formal argumentation maps, can aid with the identification of Wong and Varga's (2012) representation design problems (keyhole effect, black holes and brown worms) in relation to criminal intelligence analysts' analytical rationale (see Figure 96).

The sections that follow consider appropriate research methods that can be applied to studies that involve cognition.

2.5. Research Methods

Cognitive Task Analysis (CTA) is defined as "a family of methods used for studying and describing reasoning and knowledge." (Crandall et al., 2006).

The three distinct parts of CTA is defined as follow:

- Cognitive: For the researcher to understand how Subject Matter Experts (SMEs) "think and what [SMEs] know, how [SMEs] organize and structure information, and what [SMEs] seek to understand better" (Crandall et al., 2006).
- Task: For the researcher to understand the "outcomes" that SME's "are trying to achieve" (Crandall et al., 2006).
- Analysis: The process of the researcher to analyse something, to "break it into parts in order to understand both the component parts and their relationship in making up the whole" (Crandall et al., 2006).

To affectively conduct CTAs (Cognitive Task Analysis), the researcher must elicit knowledge from SMEs, analyse the elicited data and then present it to the proper audiences. Crandall et al. (2006) outlines an extensive range of valid methods that can be used for the elicitation of knowledge from SMEs and how to analyse the collected data after the elicitation process. Crandall et al. (2006) lists interviews and the Critical Decision Method (CDM) as possible methods to elicit knowledge from SMEs and content analysis and Grounded Theory as possible methods to analyse the collected data.

Interviews are a suitable CTA data collection method that can be a rich source of information "about issues that are easily missed by the other methods [and to be] treated as exploratory data and as a source of hypotheses." (Crandall et al., 2006). It is said that the CTA's confidence in the findings from the interviews can be corroborated by other methods (Crandall et al., 2006).

Critical Decision Method (CDM) is described as a "retrospective cognitive task analysis (CTA) method (Klein et al., 1989) for investigating the decision processes invoked by people during major or significant incidents" (Wong, 2003). It is an approach where "the researcher tries to elicit information about cognitive functions such as decision making and planning, and sensemaking within a specific challenging incident. The overall data collection strategy is to gradually deepen on critical cognitive points, by making multiple passes through the incident"

(Crandall et al., 2006). CDM thus moves away from asking generic questions to participants and opts for a detailed recollection of a memorable incident.

Crandall et al (2006) outlines the four-step-sweeping process of conducting a CDM to be:

- Selection of the indecent: This is the first sweep through the incident. The interviewee should be the person who is the 'doer' during the incident, for example, the criminal intelligence who did the actual analysis. The account of the incident is a story, so the unfolding of the incident will supply guidance and direction. The content of the story supplies the 'bones' of the basic structure of the interview.
- Construction of a timeline: This is the second sweep through the incident. This is to supply sequence to the events within the basic story structure. It can be timestamps or specific sequence of events. Clarifying inconsistencies and filling in gaps forms part of this sweep.
- Deepening: This is the third sweep through the incident. This is to understand why the SME did what they did. It is a way to understand their "perceptions, expectations, goals, judgments, confusions, and uncertainties" (Crandall et al., 2006).
- What-if queries. This is the fourth sweep through the incident. It is an opportunity to understand the SMEs skills and the possible cognitive difference between skilled and novice SMEs. It is an opportunity to discover where a novice might struggle or miss.

Although the above-mentioned steps are considered the typical steps of CDM, researchers are urged to adapt the CDM process to the needs of the interview situation (Crandall et al., 2006).

Wong (2003) offers a structured approach and an emerging theme approach to analyse CDM interview data. The steps in a structured approach are:

- "Stage 1: Decision chart showing the decision process on a timeline with progressive deepening to illustrate how the decisions were made" (Wong, 2003). This stage is where the CTA researcher use the timeline sketch as created during the CDM interview and the CDM interview transcript to construct a decision tree. The decision tree is used to determine the order of decisions and possible parallel decision-making steps.
- "Stage 2: Incident summary" (Wong, 2003). This stage is where the CTA researcher summarises the events in the incident along with the respective decisions that were made. It is an overview/summary that the CTA researcher can refer back to without having to go back to the volume of data contained in the CDM interview transcript.
- "Stage 3: Decision analysis tables based on the a-priori decision-making framework" (Wong, 2003). This stage is where the CTA researcher uses the decision chart along with the incident summary to identify the key decision points and collate it into a framework describing the "Cues and situational factors" that led to the "Situation assessment" that led to "Courses of action" which led to the "rationale" for performing the action and how the rationale served the higher goals, objective or "purpose" (Wong, 2003).

- "Stage 4: Identification of items of interest in each incident" (Wong, 2003). In this stage the decision analysis table is used to infer interesting results such as what the higher order goals are.
- "Stage 5: Collation and comparing of common items of interest across incidents studied" (Wong, 2003). This final stage is used to compare the occurrence of interesting results across the study of multiple CDM interviews.

The emerging theme approach "does not impose such a framework but instead explores the data to identify ideas and their relationships. Based on an analysis of the transcripts, broad patterns—concepts and relationship between concepts—are identified. The broad patterns form the initial structure that direct the next round of indexing the transcripts. The indexed data are then collated and further organised within each grouping to reveal the themes" (Wong, 2003).

The steps for the emerging theme approach are as follow:

- Step 1: Index and Structure to Find Broad Patterns: In this stage the broad patterns across the CDM transcripts are shown and grouped together.
- Step 2: Theorise New Structures and Themes: In this stage the grouped patterns are re-analysed to form new themes. The patterns are re-classified under the newly identified themes.
- Step 3: Explore Each Theme: Index and Structure Again: In this stage each theme is analysed, and the relevant actions are classified in a structured format such as SME's actions, cues, knowledge, difficulties etc.
- Step 4: Synthesis: In this stage the structured classifications are brought together in a meaningful manner that could lead to new interface designs or learning materials or anything else that has meaning.

Crandall et al. (2006:chapter 5) outlines various CTA researchers who have made use of CDM to elicit information from SMEs. CDM has since become more widely applied in various study areas (see Appendix for a subset of paper listings).

Qualitative Content Analysis is defined as a "research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns" (Hsieh and Shannon, 2005). There are three approaches to qualitative content analysis, and each is outlined below:

- Conventional Content Analysis: Hsieh and Shannon (2005) outline that this approach strives to extend an existing theory of which still little is known or where literature lacks. The researcher emerges themselves in the data set to systematically derive reflective codes, which becomes the initial coding scheme. Codes are then categorised based on the relationships and linkages to form emergent categories that can be organised into a tree-diagram. This is followed with the formulation of definitions for each leaf on the tree-

diagram along with describing the relationships between the branches of the tree-diagram.

- Directed Content Analysis: Hsieh and Shannon (2005) outlines that this approach strives to extend existing theory that could "benefit from further description". Researchers make use of existing theory or research as initial coding categories. This approach offers supporting or non-supporting evidence for a theory. "Newly identified categories either offer a contradictory view of the phenomenon or might further refine, extend, and enrich the theory" (Hsieh and Shannon, 2005).
- Summative Content Analysis: Hsieh and Shannon (2005) outline that this approach "identify and quantify certain words or content in the text with the purpose of understanding the contextual use of the words of context [and that with this approach the] focus is on discovering underlying meanings of the words or the content" (Hsieh and Shannon, 2005).

Grounded theory, as a research method, has been around since 1967 (Glaser and Strauss, 1967) and developed by the sociologist researchers Barney Glaser and Anslem Strauss (Khan, 2014). Punch (1998:p163 in Khan, 2014) claims that grounded theory is a research strategy rather than a theory and the purpose to generate a theory from the underlying research data. "'Grounded' means that the theory will be generated on the basis of data; the theory will therefore be grounded in data. 'Theory' means that the objective of collecting and analysing the research data is to generate theory." Punch (1998:p163 in Khan, 2014).

Coding is defined as "The analytic processes through which data are fractured, conceptualised, and integrated to form theory" (Corbin and Strauss, 2014). The process of coding can be an inductive process or a deductive process (Corbin and Strauss, 2014; Khandkar, 2009).

Open Coding is defined as "The analytical process through which concepts are identified and their properties and dimensions are discovered in the data" (Strauss and Corbin, 1998). Texts are "opened-up [and] data are broken down into discrete parts, closely examined, and compared for similarities and differences. Events, happenings, objects, and actions/interactions that are found to be conceptually similar in nature or related in meaning are grouped under more abstract concepts termed 'categories'" (Strauss and Corbin, 1998). The open coding approach can be done on a line-by-line basis within the data set or on a per-section basis. The steps of open coding are the same regardless of the approach. A summary of the typical open coding steps within grounded theory is outlined below (Strauss and Corbin, 1998; Khandkar, 2009; Corbin and Strauss, 2014; Blair,2015):

- Data collection
- Open coding: This is where data is broken into excerpts and then excerpts are grouped into codes. In most cases it is an inductive process.

- Axial coding: This is where codes are grouped into categories. It is followed with the investigation on how categories relate to their subcategories and if further categories can be developed. In most cases it is a deductive process.
- Repeat open coding and axial coding until theoretical saturation is reached
- Selective coding (define the central idea)
- Document/Communicate the theory

The focus of human or user-centric design (UCD) is to involve end-users with the development and design of products, such as software products. Norman (2002; p188) defines UCD as "a philosophy based on the needs and interests of the user, with an emphasis on making products usable and understandable". This is to ensure that the needs of the people who are going to use the product is met (Abras et al., 2004). There are three broad phases to UCD; "understanding the users; designing the product and; to evaluate the user's interaction with the product" (Dwivedi et al., 2012). In Dwivedi et al.'s (2012) survey of UCD methods they outline interviews as a low-cost method to gather design requirements and paper prototype testing as a participatory design method. Participatory design methods lead to "rapid verifications of design iterations, which greatly reduces time and costs for fixing design flaws" (Dwivedi et al., 2012). Paper prototype testing can be done electronically using software (Dwivedi et al., 2012).

The next sections consider argumentation as part of the rigorous, verification and interrogation activities as part of Wong's (2018) fluidity-and-rigour model.

3. Argumentation

3.1. Overview

Earlier sections outline that criminal intelligence analysts use their thinking and reasoning skills to work through information to produce intelligence that could aid with solving a crime scenario. Criminal intelligence analysts' thinking and reasoning forms part of a thinking and reasoning continuum (Wong et al., 2017) that has a "fluid" and a "rigour" phase (Wong, 2018). Criminal intelligence analysts are in the fluid phase, whilst they are exploring the information to gain traction at figuring out what is happening in the crime scenario. Criminal intelligence analysts are in the rigour phase when they have completed their analysis and whilst they are producing a document that outlines their inferences (as intelligence). These documents are then presented to the decision makers for review and thereafter for actioning in the field (UNODC, 2011).

Researchers, as outlined in this chapter, have explored the use of argumentation to question the strength of a person's reasoning in relation to the inferences they make about a claim. But what exactly is argumentation and how can an argument represent a person's reasoning?

Argumentation is defined in several ways, depending on the context in which it is used:

1. "1. The reasons (proof, evidence) offered in support or denial of something. 2. In logic, a series of statements called premises logically related to a further statement called the conclusion." Angeles (1931)

2. “A sequence of statements such that some of them (the premises) purports to give reason to accept another of them, the conclusion.” (Audi, 1999)
3. “A verbal, social and rational activity aimed at convincing a reasonable critic of the acceptability of a standpoint by putting forward a constellation of propositions justifying or refuting the proposition expressed in the standpoint.” (Van Eemeren and Grootendorst, 2004).

The definitions above have similarities and differences: Angeles’ (1931) definition states that the first set of statements are referred to as premises and that the second set of statements (that have a logical relationship to the first) is referred to as the conclusion. Van Eemeren and Grootendorst (2004) omits this terminology completely and elects for the use of proposition and standpoint. Although different terminologies are used between the definitions, all three definitions suggest that argumentation have a starting point (premise or proposition) and an endpoint (conclusion or standpoint).

Audi (1999) places a different emphasis on the use of premises as appose to Angeles (1931). Angeles (1931) states that there is a logical way in which the premises relate to the conclusion, while with Audi (1999), the premise is merely used as a reason to accept the conclusion. Van Eemeren and Grootendorst (2004), similarly to Audi (1999), places emphasis on the purpose of the propositions, which is to convince someone of the acceptability of a standpoint. All three definitions point to various relationships that could exist between the start and the endpoint.

The use of accept or acceptability, may indicate that some sort of criteria is involved that will allow for judgement to arise on whether the conclusion is to be accepted or rejected. Angeles’ (1931) uses the terminology of support or denial and Van Eemeren and Grootendorst (2004) uses justify and refute, which is similar to accept and reject of Angeles’ (1931). Angeles’ (1931) does go further by supplying more information on the nature of the premise, by suggesting that it could take on the form of proof or evidence.

Audi (1999) states that arguments consist of a sequence of statements, which may show that there is a specific order to the statements. Angeles’ (1931) uses a series of statements which might convey that argumentation involves a specific group or set of statements, without necessarily any specific order to them. Van Eemeren and Grootendorst (2004) makes use of the terminology constellation, which could both indicate to pertaining a recognisable pattern and to the possible size of the set.

The above definitions are not an exhaustive list, but they do suggest that argumentation have at least the following argumentation concepts:

- A starting and end point
- That there is a relationship between the starting and end point
- There is some structure and grouping involved
- There is some form of judgement or rationality involved in the relationship between the start and end point.

The next section considers how the starting and end points can be structured to form a judgement on the relationships that exist between the start and end points.

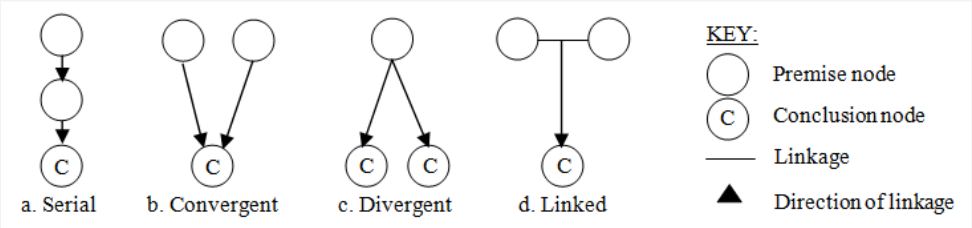
3.2. Argumentation Notation

One way to represent argumentation concepts is through linked diagrams (Walton, 1990) that outlines the logic of an argument (Walton, 1990). Such structures consist out of nodes representing various premises and conclusions, and arrows link one or more premises to a conclusion. Linked diagrams are also referred to as box-and-arrow diagrams or standard diagrams (Row and Reed, 2006). Passmore et al., (2015) refers to the diagramming constructs as argumentation maps. The use of linked diagrams to represent argumentation concepts is consistent with the four points that the definitions (Angeles, 1931; Audi, 1999; Van Eemeren and Grootendorst, 2004) highlighted, such as that argumentation have a structure.

Linkages from premise to conclusion can be combined in several ways to form various argumentation structures; serially, convergent, divergent or linked (Thomas, 1986; Van Eemeren and Grootendorst, 1984).

Linkages from premise to conclusion can be combined in various ways to form various argumentation structures; serially, convergent, divergent or linked (Thomas, 1986; Van Eemeren and Grootendorst, 1984).

Figure 16 - Chapter 2: Depiction of the nodes found in linked diagrams (adapted from Thomas, 1986)



In a diagram with a serial structure, each premise is linked in a serial line. Each premise offers support to the next premise in line, until a conclusion is reached (see figure 16a). A convergent structure represents two different premise nodes linked to one conclusion node (see figure 16b). In a divergent structure, one premise node is linked to two or more conclusion nodes (see figure 16c). In a linked structure, two premise nodes are joined together and then linked to a conclusion node (see figure 16d). The simplicity of having minimal diagrammatical components (the premise, conclusion and a linkage) and the way they can be linked (serial, convergent, divergent and linked), affords the creation of complex argumentation structures. These types of argumentation constructs are referred to as “standard argumentation notation” (Row and Reed, 2006).

Wigmore (1931) offered an alternative argumentation notation for the evidential reasoning domain, using the argumentation components of evidence and forces. Evidence is the statements or assertions made and the forces are the degree to which evidence supports (affirmatory) or opposes (negatory) other pieces of evidence. Both the affirmatory and negatory forces play a role in deciding the relevance of evidence, as the affirmatory supports the argument and the

negatory supports the counterargument (rebuttal). Wigmore's (1931) argumentation concept notation deviates from the standard argument notation, as he classified it according to the various statements and inferences that are specific to those which lawyers use within a court case (Row and Reed, 2006). Therefore, Wigmore's (1931) notation appropriately accounts for the proceedings of a court case as per the criteria outlined below by Row and Reed (2006):

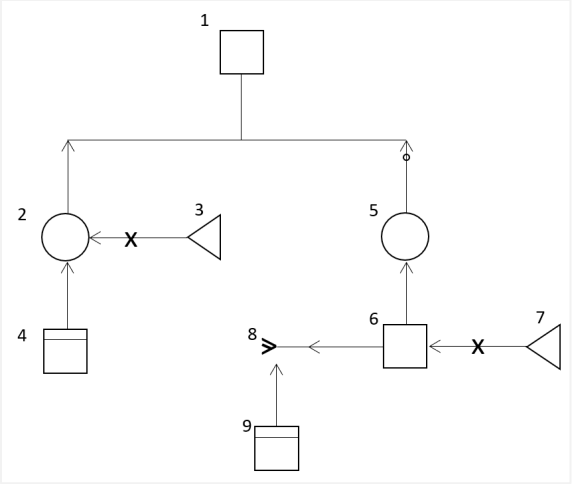
- "The notation supports two sides of the argument – one for the prosecution and one for the defence. Nodes with a double line near the top are the defendant's evidence and all other nodes are the prosecution's evidence.
- The topmost node is the conclusion.
- Each evidence node in the diagram can have up to three groups of other evidence nodes influencing it. Each group of nodes may be given a net probative value, which is the combined effect of the group of nodes on the conclusion (either affirmatory or negatory).
- Evidence can be testimonial, circumstantial, explanatory or corroborative:
    - Square nodes represent testimonial evidence, which refers to evidence stated by witnesses as fact.
    - Circular nodes represent circumstantial evidence, which refers to evidence that require some form of inference making.
    - The testimonial and circumstantial evidence can be affirmatory or negatory and are grouped below the supported node.
    - Nodes with greater than symbols represent explanatory evidence, which refers to evidence that is put forward to counter or lessen the impact of testimonial or circumstantial evidence. Explanatory nodes are grouped to the left of the nodes they explain.
    - Closed triangular nodes are corroborative evidence, which refers to evidence that supports testimonial or circumstantial evidence. The corroborative nodes are grouped to the right of the nodes they support.
- The arrows can have symbolic modifiers attached to them:
    - A single arrow indicates the direction of support.
    - A double arrow indicates strong support.
    - An arrow on the edge between two nodes indicates that one node detracts from the other node.
    - An X on the edge between two nodes indicates that the corroborative node supports the circumstantial evidence.
    - A small circle on the edge of a link indicates a negatory force.
    - A double arrow just below a circumstantial node indicates the net probative value of the supporting circumstantial nodes." (Row and Reed, 2006)

Wigmore's (1931) diagrammatic argumentation notation can be illustrated with the following example (see Figure 17):

1. The conclusion to prove is that the person is a British citizen.
2. The person in question stating that the birth certificate is a legal document
3. The relevant law to corroborate the relevance of the birth certificate (strong support)

4. The birth certificate provided by the person in question.
5. A witness testifying that the birth certificate is a counterfeit (negative influence on the conclusion)
6. A financial statement outlining an exchange of money, possibly for counterfeiting
7. The relevant law that states that a counterfeited birth certificate does not count (strong support)
8. Explanatory evidence that the witness has malicious intent against the person in question, thus lessening the force of number 5 and 6.
9. Police statement explaining previous malicious intent against the person in question

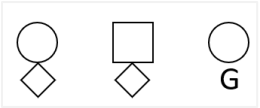
Figure 17 - Chapter 2: Illustration of a Wigmore diagram. Adapted from (Row and Reed, 2006)



Allen et al. (2016) illustrated argumentation notation related to different types of evidence that can be presented in a court of law (see Figure 18). The concepts are related to Wigmore (1931) diagrams and adds to the collection of diagrammatic concepts as outlined by Row and Reed (2006). Allen et al. (2016) illustrates that a circle with a diamond underneath it represents real evidence. Real evidence is something that the jury can examine for themselves, such as a murder weapon.

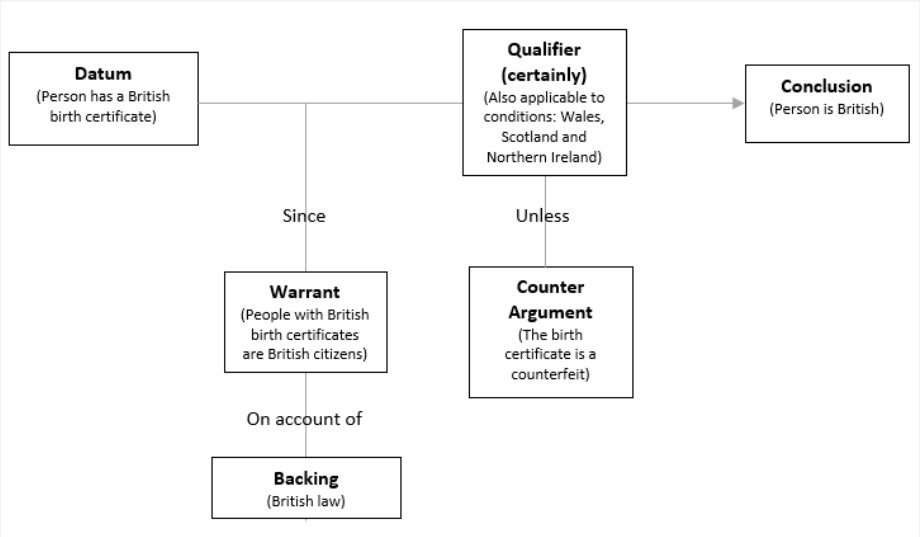
A square with a diamond underneath it represents the testimony of a witness at trial, such as the testimony of a forensics expert. A circle with the letter 'G' underneath it represents a generalisation about how things are in the world, for example, presumably a person described to have a very outgoing personality, who suddenly ceases all contact with family and friends for a long time, can be considered deceased.

Figure 18 - Chapter 2: Evidential argumentation diagrammatic concepts. Adapted from Allen et al., (2016)



A square with a diamond underneath it represents the testimony of a witness at trial, such as the testimony of a forensics expert. A circle with the letter 'G' underneath it represents a generalisation about how things are in the world for example, presumably a person described to have a very outgoing personality, who suddenly ceases all contact with family and friends for a long time, can be considered deceased.

Figure 19 - Chapter 2: The layout of Toulmin's (2003) argumentation scheme. Adapted from Verheij (2005).



Toulmin's (2003) diagrammatic argumentation notation can be illustrated with the following example (see Figure 19): The datum serves as evidence, for example, a birth certificate stating England as the country of birth and can be offered as the grounds of acceptance for the conclusion that the person in question is certainly British. The relevance (or the applicability) of the evidence can be with a warrant, which links the evidence to other ground truths such as: all people with a birth certificate which states that they were born in England, are legally regarded as British citizens. The acceptance for the use of the warrant can be backed up (backing) with law documents outlining that a person with a birth certificate, stating England as the country of birth, is a British citizen. The qualifier outlines the applicability of the link from the datum to the warrant by outlining the conditions under which the link is relevant, so that the only people from England, Wales, Scotland and Northern Ireland could be considered as British citizens.

If a challenger would like to challenge the acceptability of the conclusion, then the challenger needs to do so on the basis that the evidence is invalid, for example, the birth certificate is a counterfeit or that the relevance of the law (backing) should be interpreted differently.

3.3. Argumentation Schemes

The argumentation diagrammatic concepts from Thomas (1986), Wigmore (1931) and Toulmin (2003) may represent the layout of an argument, but it may not be obvious by looking at the

diagram alone if an argument is a strong argument or a weak argument. Figuring out the strength of an argument forms part of argumentation theory. Walton et al. (2008) describes argumentation theory as a "rich interdisciplinary area of research spanning philosophy, communication studies, linguistics, computer science and psychology". This rich interdisciplinary area produced a need for different formal argumentation models which specifies, amongst other things, what the semantics for software programs dealing with logic should be, how natural language text should be generated, how to support legal reasoning and how to facilitate multi-agent dialogue and negotiation over the internet (Walton et al., 2008). One of the tools that support argumentation theory, is argumentation schemes. Argumentation schemes are defined as, "forms of argument (structures of inference) that represent structures of common types of arguments used in everyday discourse, as well as special context like those in legal argumentation and scientific argumentation" (Walton et al., 2008). Argumentation schemes covers three forms of argument types namely deductive, inductive and abductive (also known as defeasible or presumptive arguments).

Deductive arguments or deductive entailment is described by Govier (2014) as the "most complete relationship of logical support. If, and only if, one statement entails another, then it is impossible for the second statement to be false when the first statement is true". Govier (2014) continues to state that deductive validity is a "characteristic of an argument in which the premises deductively entail the conclusion. In a deductively valid argument, it is not possible for the conclusion to be false when the premises are true." Govier (2014) outlines those deductive arguments are usually mapped in a linked argument structure or a serial argument structure.

Govier (2014) supplies an example of a deductive argument as follow:

> *Premise*: Joe is in the cabinet
> *Premise*: All the cabinet ministers have a university degree
> *Conclusion*: Therefore, Joe has a university degree

Inductive arguments or inductive support is described by Govier (2014) as, "support from experience to a conclusion about other experience, based on the assumption that relevant similarities in the world will persist. When there is inductive support, the premises do not deductively entail the conclusion." The inferences are based on "generalising from a sample to a much larger group" (Govier, 2014), where the proponent assumes that the "unobserved cases will resemble the observed ones" (Govier, 2014). Inductive arguments are also referred to as defeasible arguments because they can be defeated (proven wrong) when further information is presented (Frankish and Ramsey, 2012:p131).

Govier (2014) supplies an example of an inductive argument as follow:

> Premise: All students I have met who have graduated from school X got good grades in mathematics.
> Conclusion: So probably, all students who have graduated from school X got good grades in mathematics.

Abductive arguments are described by Walton et al. (2008) as arguments that are "not very strong by itself, but may be strong enough to provide evidence to warrant rational acceptance of

its conclusion, given that its premises are acceptable. Such an argument can rightly carry weight, or be a plausible basis for acceptance, on a balance of considerations in an investigation or discussion that is moving forward, as new evidence is being collected. The investigation can then move ahead, even under conditions of uncertainty and lack of knowledge, using the conclusion tentatively accepted."

Inductive and abductive arguments can be refuted by a challenger, based on a set of critical questions that can be posed to a proponent, which forms an important part of argumentation schemes. Walton et al., (2008) describes it as follow, "One of the features of argumentation schemes that is key to evaluating whether an argument fitting a scheme should be judged strong or weak is the list of associated critical questions – questions that can be asked (or assumptions that are held) by which a non-deductive argument based on a scheme might be judged to be (or presented as being) good or fallacious." (Walton et al., 2008).

Walton et al., (2008) provides an extensive list of argumentation schemes and the critical questions that goes with each. Below follows an example of an inductive and an abductive argumentation scheme, each with their set of critical questions:

(a) Inductive argument from witness testimony (example adapted from Walton et al., 2008:p310);

> *"Premise*: Witness $\mathcal{W}$ is in a position to know whether $\mathcal{A}$ is true or not.
> *Premise*: Witness $\mathcal{W}$ is telling the truth (as $\mathcal{W}$ knows it)
> *Premise*: Witness $\mathcal{W}$ states that $\mathcal{A}$ is true (false)
> *Conclusion*: $\mathcal{A}$ may be plausibly taken to be true (false)" (Walton et al., 2008).

Critical Questions (Walton et al., 2008):

- "Is what the witness said internally consistent?
- Is what the witness said consistent with the known facts of the case (based on evidence apart from what the witness testified to?)
- Is what the witness said consistent with what other witnesses have (independently) testified to?
- Is there some kind of bias that can be attributed to the account given by the witness?
- How plausible is the statement $\mathcal{A}$ asserted by the witness?" (Walton et al., 2008).

(b) Abductive argumentation with critical questions (example adapted from Walton et al., 2008:p330);

> *"Premise*: Agent $\mathcal{A}$ has a character quality of a kind that has been defined.
> *Conclusion*: Therefore, if $\mathcal{A}$ carries out some action in the future, this action is likely to be classifiable as fitting under the character quality" (Walton et al., 2008).

Critical Questions (Walton et al., 2008):

- "What is the character quality in question?
- How is the character quality defined?
- Does the description of the of the action in question actually fit the definition of the quality?" (Walton et al., 2008).

It can be seen from the examples above, that the critical questions are used to examine what is assumed, thus making it explicit. This resolves ambiguity and vagueness which is described by Govier (2014) as, “language is used ambiguously if, in the context in which a word or phrase appears, it could have one of several distinct meanings. [And] a word is used vaguely if, in the context in which it appears, we cannot determine what things the word would apply to.”

Ambiguity and vagueness can lead to fallacy and fallacy of equivocation within argumentation schemes (Govier, 2014). Fallacy is outlined by Govier (2014) as an “argument based on a common mistake in reasoning, a sort of mistake that people tend not to notice. Fallacies are poor arguments but often strike people as cogent”. Govier (2014) continues by stating that fallacy of equivocation is when, “fallacy [is] committed when a key word in an argument is used in two or more senses and the premise appears to support the conclusion only because the senses are not distinguished. The argument is likely to seem correct if the ambiguity is not noticed.”

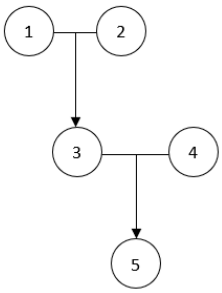
Below illustrates an example of fallacy (adapted from Govier, 2014:p66):

“Argument: Micah White says he has ‘endured persecution’ for his beliefs, but an atheist is, by definition, one who lacks beliefs.

The proponent is arguing that:

1 - Premise: Micah White is an atheist
2 - Premise: All atheists lack beliefs
3 - Implicit conclusion: So, Micah White lacks beliefs
4 - Premise: Anyone who lacks beliefs cannot be persecuted for his beliefs
5 - Implicit conclusion: Therefore, Micah White cannot be persecuted for his beliefs.” (Govier, 2014)

The argumentation structure would be as follow:



The fallacy of equivocation is *“between the move from (3) and (4) and (5)”* (Govier, 2014) as the word belief implies religious beliefs, but it not stated as such. The conclusion (5) is therefore not sound, as atheist may have other beliefs that do not pertain to religion.

3.4. Argumentation Cogency

Fallacy and critical questions address the need to explicitly express what is being argued or being considered when stating the premises. Following on from Walton et al.’s (2008) argumentation schemes and critical questions, Govier (2014) introduced three criteria (referred to as ARG

conditions) that a challenger can use as grounds to question the proponent's argument, namely; **A**cceptability, **R**elevance and **G**rounds for adequacy. Govier (2014) defines acceptability as referring to the condition when "there is good reason to accept the premise" or "to believe the premise" even when the premise "is not known to be true". Govier (2014) defines relevance as referring to the condition when "the premise is relevant to the conclusion". Govier (2015:p87) elaborates by explaining that the relevance of a premise, is for the premise to "state evidence", "offer reasons that support the conclusion" or when it can be "arranged into proof from which the conclusion can be derived." Govier (2014) defines ground for adequacy as referring to the condition when "the premises are considered together, the premises gives sufficient reason to make it rational to accept the conclusion" Govier (2014:p87).

Govier (2015:p114) states that both relevance and grounds for adequacy are needed for the conclusion to be "properly connected to the conclusion" in order for the argument to be considered "cogent". She explains the meaning of cogent to be when "the premise of an argument is rationally acceptable and [when], in addition, they provide rational support for the conclusion" (Govier, 2005:p89).

Govier (2015) points out that cogent is different to soundness, as what is used in formal logic. A sound argument is so that the premise cannot be true, whilst the conclusion is false, as is the case with deductive entailment. Govier (2005) points out that rationally acceptable does not have to mean true. She therefore argues that her ARG conditions satisfies cogency in that it "has a premise that is rationally acceptable and that it supports the conclusion in a way that is relevant and provides good grounds" (Govier, 2014:108).

One way of expressing cogency, as per Govier's (2014) definition, can be with using narrative. Pennington and Hastie (1992) argued that showing mere evidence is not enough in a court of law and that narrative (story telling) played a key role in conveying the facts to the jury. Jurors are engaged in an "active, constructive comprehension process" (Pennington and Hastie, 1992) that requires trial information to be organised in a "coherent mental representation" (Pennington and Hastie, 1992). Pennington and Hastie (1992) outline that this mental activity of constructing a representation, occurs because "comprehension is inherently a constructive process, even for the simplest [type of] discourse". Stories during trial proceedings are described as consisting out of a "causal chain of events, in which events are connected by causal relationships of necessity and sufficiency" (Pennington and Hastie, 1992). Stories consist out of a hierarchical structure where sub-structures (or units) are referred to as "episodes" (Pennington and Hastie, 1992). These episodes are used to aid with the comprehension of the causal chains and relationships.

For narrative to serve as an effective comprehension tool, Pennington and Hastie (1992) argued that the proponent's story must meet four certainty principles (coverage, coherence, uniqueness, and goodness-of-fit). The likelihood of a challenger accepting the proponent's interpretation of the evidence as a plausible explanation and reconstruction of trial events, increases when these four certainty principles are met. Coverage refers to "the extent to which the story accounts for evidence presented at trial" (Pennington and Hastie, 1992). The more coverage the story has, the more the likelihood that the interpretation of the evidence will be accepted by a challenger. Coherence not only contributes to the acceptability of the

interpretation of the evidence via the story, but also to the level of confidence that a challenger will have towards their decision in accepting the interpretation of the evidence.

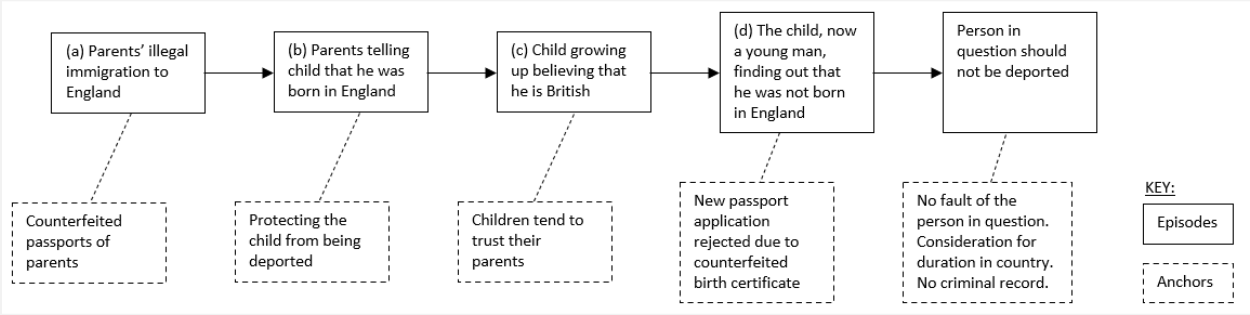
Figure 20 - Chapter 2: Cartoon illustrating the power of narrative in a court setting

Pennington and Hastie (1992) have broken the theory of coherence into consistency, plausibility and completeness: "Consistency concerns the extent to which the story does not contain internal contradictions. Plausibility concerns the extent to which the story is consistent with knowledge of real or imagined events in the real world. Completeness refers to the extent to which a story has all of its parts. These three components combine to yield the coherence of a story" (Pennington and Hastie, 1992). A decision can be reached when the story is unique. This means that if more than one coherent story is constructed from the evidence, then there will be doubt to which story to use for the decision-making process. When the story can be successfully classified into a best-matched verdict category, then goodness-of-fit has been reached.

The impact of narrative on the interpretation of the evidence can be illustrated with the following example: Even though all the evidence points to a counterfeited birth certificate for the person in question, the defence can convey this information to the judge in such a way to depict the person in question as a victim of his/her parent's decisions. In other words, the person in question did not know that their parents counterfeited the document and believed the documents to be true and within the law. And since the person in question has been brought up in England since the age of one, the law should be lenient and take into consideration the person's good behaviour until the age of twenty-one and reward the person with British citizenship.

Bex et al.'s (2010) built upon Pennington and Hastie's (1992) research through their hybrid theory to make arguments more rigorous. Their hybrid theory concentrates on explaining the causal connections between events, in a judicial case, with narrative and then anchors the facts in general and acceptable common-sense rules. This ensures that each episode of the story can be backed up by evidence, thus adding to the story's coherence.

Figure 21 - Chapter 2: Depiction of Bex et al.'s (2010) hybrid theory



Bex et al.'s (2010) hybrid theory can be illustrated as follow (see Figure 21): The events that led to the counterfeited birth certificate could be; (a) The parents illegally immigrating to England; (b) The parents telling the child that he was born in England; (c) The child growing up believing that he is British; (d) The child, now a young adult, finding out that the birth certificate is a counterfeit.

Each event can be grounded in evidence or acceptable common-sense rules for example: (a) counterfeit passports of the parents; (b) The parents did not want anybody to find out about their illegal status, especially to protect the child from being deported; (c) There was no reason for the child to distrust the information which the parents offered; (d) The young adult should not be held legally responsible for the parents actions and the law should assist him rather than deport him, especially based on the person's duration in the country and their good conduct over the years.

3.5. Problems

3.5.1. Diagrammatic Ambiguity

Representing arguments with the help of argumentation notations can cause problems. One such problem is with the way in which nodes are linked in convergent and linked diagrams as it can cause ambiguity when interpreted. In convergent and linked diagrams, the ambiguity lies within how intuitive it is to decide if both premises are needed to support a conclusion. Questions that could arise are as follow: If one premise is removed, would the conclusion still be considered valid? Does each premise offer a degree of support in relation to the conclusion? Govier (2014) refers to these types of arguments as conductive arguments and that they are commonly seen during evidential reasoning scenarios. Govier (2014) outlines a conductive argument as an "argument in which premises (typically several in number) are put forward to support a conclusion convergently. Typically, in conductive arguments we deal with matters on which there are various considerations pros and cons that count for and against the conclusion."

Researchers (Yanal, 1984; Thomas, 1986; Rowan, 1986; Freeman, 2011) have tried to clarify the ambiguity between convergent and linked diagrams: Thomas (1986) describes a convergent structure as, "two premises that do not support the conclusion in a united way". Thus, one premise does not "need" (Thomas, 1986) the other premise in order to support the conclusion.

Thomas (1986) went further by stating that if one premise is false in a convergent structure then it should not undermine the reasoning of the second premise's support in relation to the conclusion. Rowan (1984) refers to convergent structures as "disjointly supporting premises" and that there is no "logical connection" between the premises in support of the conclusion.

Thomas (1986) describes the necessity for linked structures when the reasoning process requires the "logical combination" of two or more premises. Thus, both premises "need" (Thomas, 1986) each other to support the conclusion. The premises should "fit together" (Thomas, 1986) to support and justify the conclusion. Rowan (1984) uses terminology such as "conjoint" and describes that each premise in the set should contribute to the support for a conclusion. Yanal (1984) refer to linked structures as "conceptually similar", "in the same line of thought", "logical dependent", "fill in the logical gaps" and "support each other".

Freeman (2011) pointed out that the description used by Thomas (1986), Rowan (1984) and Yanal (1984) to differentiate between convergent and linked diagrams, make use of natural language and thus do not resolve the ambiguity contained within the constructs. One of the examples that Freeman (2011) outlines, is on the ambiguity of the phrase "logic support" and what it could refer to when interpreting convergent and linked diagrams. Freeman (2011) demonstrates that people can interpret the term "logical support" as either meaning "a reason for" or "therefore".

Freeman (2011) argues that people who interpret the arrow link from premise to conclusion as meaning "a reason for", then that person is making a relevance claim. Each premise given has relevance and would be offered by a proponent in response to a challenger's question, "How did you get there?" People who are making the relevance claim would therefore favour structuring the premises as convergent. Freeman (2011) goes further and explains that people who interpret the meaning of the arrow from premise to conclusion as meaning "therefore", then that person is making a modal claim. Each premise is offered as weight to strengthen the support for the conclusion and would be offered by the proponent in response to the challenger's question, "How sure are you?" People who are making a modal claim would thus favour structuring the premises as linked.

3.5.2. Using Argumentation Linked-Diagrams in Software

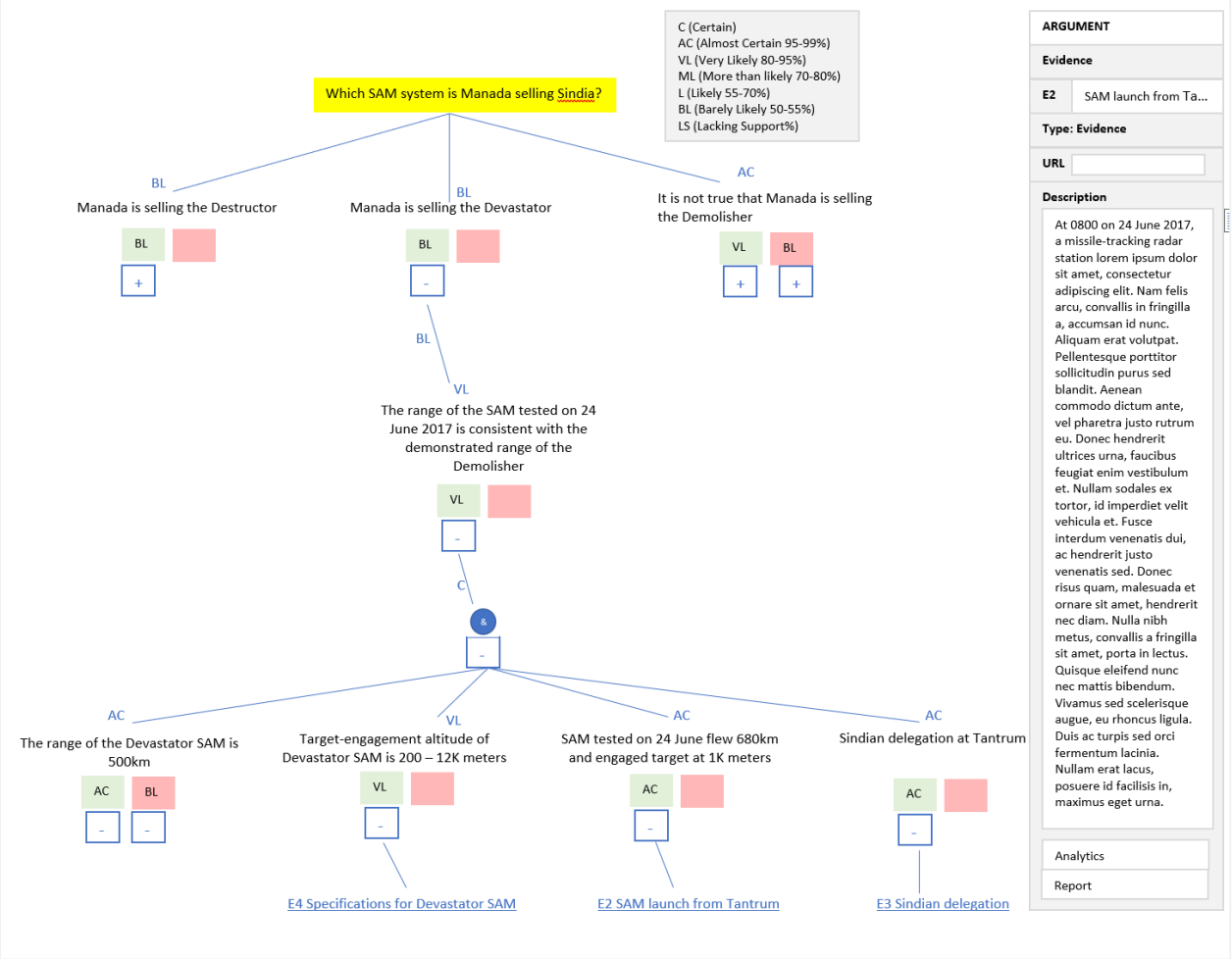
The sections that follow outline various applications that have incorporated linked argumentation diagrams as part of the user-interface:

3.5.2.1. Cogent

Cogent (Tecuci et al., 2018) is a program to aid intelligence analysts with coping with the complexities of evidential reasoning. Examples of such complexities are incomplete, contradictory, ambiguous and missing information (Tecuci et al., 2018). Cogent works in three non-serial phases. The intelligence analyst would, given the information, create questions which serves as hypotheses. The artificial agent would then search for evidence that support or counter the hypotheses. Lastly, given the evidence found, the artificial agent would estimate the probability of the hypotheses. The probability is based on the calculated credibility and relevance

of the information. The artificial agent would update 'evidence support' and probabilities as the human analyst create questions and find information for or against the hypotheses.

Figure 22 - Chapter 2: Cogent. Adapted from Tecuci et al. (2018)

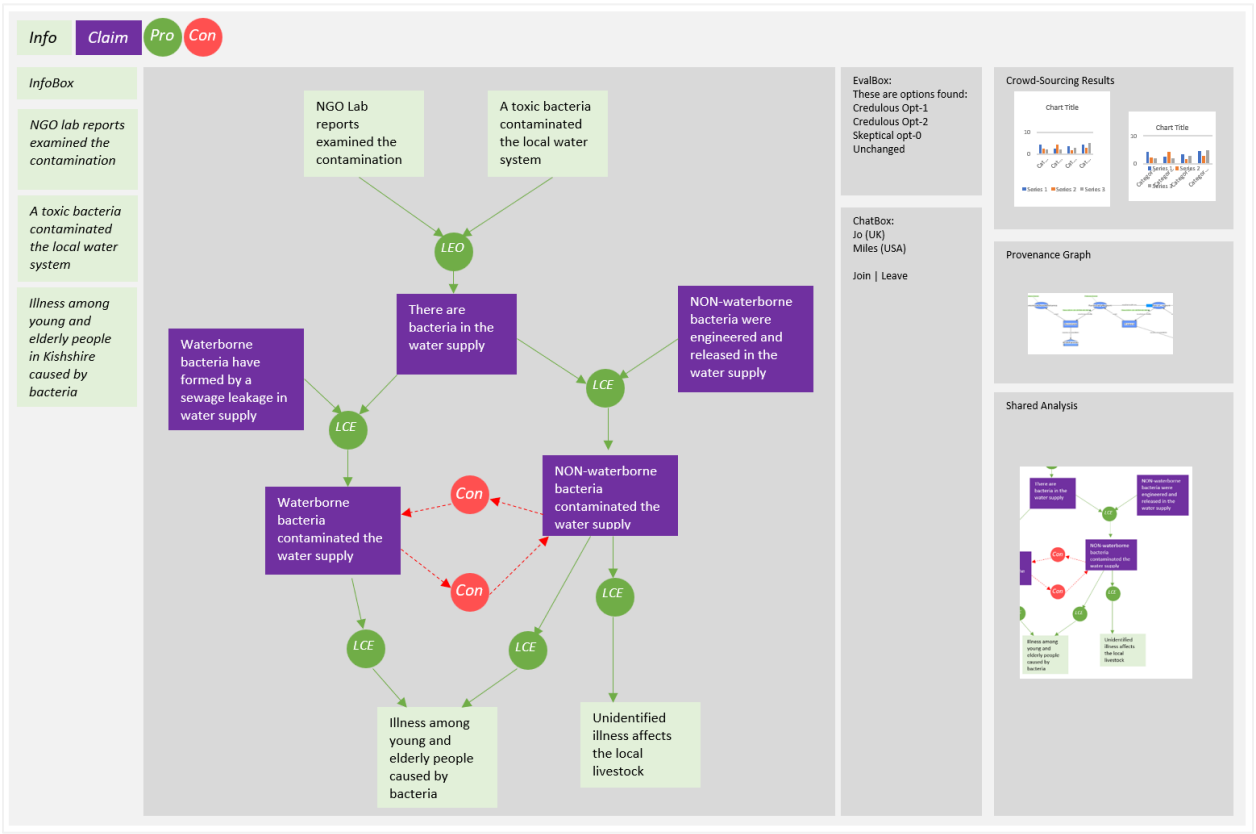


3.5.2.2. CISpaces

CISpaces (Tonilio et al., 2015) is a program to help analysts perform sensemaking in collaboration with other analysts. CISpaces is a collaborative agent-based tool based on the procedural phases of Pirolli and Card (2005). CISpaces' front-end interface allows for the analysis of information and the backend interface allows for collaboration. The front-end consists of InfoBox which streams collected information from reports and the WorkBox for constructing hypotheses. CISpaces uses a standard argumentation schema and includes many other types of nodes. Premises are called Info-nodes and claims are called Claim-nodes. Each node has a provenance chain which captures the manipulation a node has gone through. Nodes and links that support a claim is green and the counterarguments have a red colour. ChatBox allows for communication with other analysts and the ReqBox shows shared analysis via collaboration.

Tonilio et al.'s (2015) research is concerned with the three artificial agents (sensemaking, crowdsourcing and provenance) that underlies the user-interface. The sensemaking agent makes use of argumentation schemes (Walton et al., 2008) to guide human analysts with a critical review of evidence. The crowdsourcing agent interprets requests for information between human analysts. The provenance agent evaluates information to inform on credibility of sources.

Figure 23 - Chapter 2: CISpaces. Adapted from Tonilio et al. (2015)



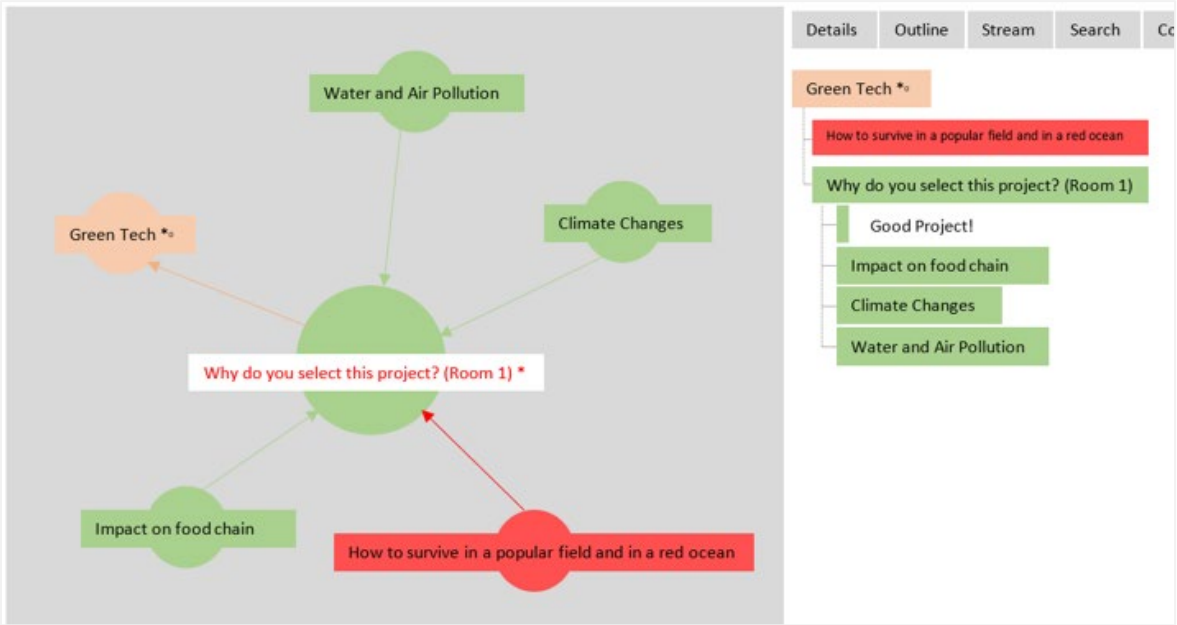
3.5.2.3. DebateGraph

DebateGraph[4] is a cloud-based collaboration tool for sharing ideas, arguments and actions related to specific topics (Wyner et al., 2015). It has at least 15 different nodes representing various issues or arguments, where green is representative of a supportive argument and red an opposing argument. The direction of the arrows shows which node it supports and the thickness of the arrow how strongly it supports the connected node. Extra information can be added to the nodes, for example, links to videos or documents and even cross links to other diagrams. Task nodes, that follow on from a reached decision, is also supported along with various other citations and comments.

[4] https://debategraph.org/

Although DebateGraph uses a standard argumentation schema, it has included many other types of nodes that are not normally associated with standard argumentation notations.

Figure 24- Chapter 2: DebateGraph example (adapted from DebateGraph.org, 2022)



3.5.2.4. Compendium

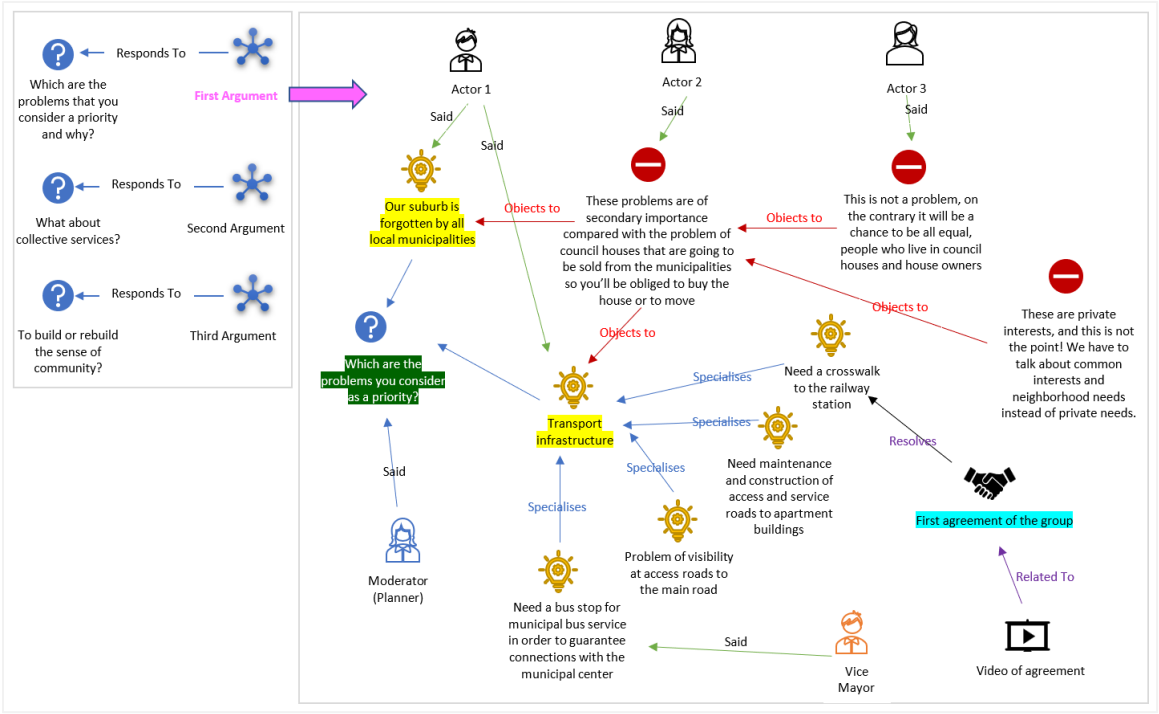
Compendium[5] is a visual hypermedia tool that can be used to map out information and arguments in different domains. De Liddo and Shum (2007) used Compendium to aid with the critical questions that are raised during the Participatory Planning Processes (PPP) within urban planning and designing.

With so many different and dispersed groups involved with PPP, it was difficult for decision makers to track who was involved and how the data was interpreted by different stakeholders. Compendium supplied a real-time dialogue mapping solution for the consultations, where each of the actor's comments, ideas, questions and arguments for and against other comments, were mapped out.

The mapping schema is similar to argumentation linked diagrams, where nodes represent propositions and the arrows link propositions to a conclusion. Compendium includes many other nodes not normally found in the standard argumentation schema, such as information about actors, questions, ideas, red nodes for counter arguments or disagreements and handshake nodes for agreements. Agreement nodes may be similar to a conclusion reached, as it signifies when two or more people concluded that they agree on a topic or task.

[5] http://www.compendiuminstitute.org/

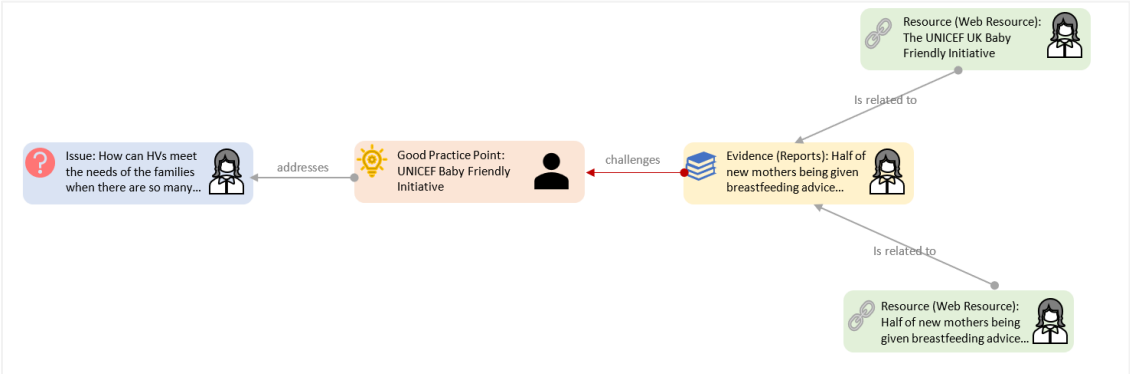
Figure 25 - Chapter 2: Compendium Participatory Urban Planning. Adapted from De Liddo and Shum (2007)



3.5.2.5. Evidence Hub

Evidence Hub (De Liddo and Shum, 2013) is a combination of Collective Intelligence (CI) and argumentation. Collective intelligence aims to harness the collective knowledge of online users on specific topics such as health and education. The argumentation section of Evidence Hub aims to help online users with understanding the issues that are being discussed or debated, along with the solutions, claims, evidence and relevant resources. The argumentation module of Evidence Hub is based on the research of Walton (2009) and Walton et al. (2008) on argumentation theory and argumentation schemes, respectively.

Figure 26 – Chapter 2: Discourse Network around the selected topic in yellow. Adapted from De Liddo and Shum (2013)



The argumentation visualisation within Evidence Hub provides network graphs to show the discourse network in relation to an object, which can represent a person's understanding, an evidential link or a related topic. Discourse and social analytics provide visualisation to allow for insights on the degree of connected ideas (compared thinking) and the creation of new knowledge or connections (information broker).

Figure 27 - Chapter 2: Compared thinking activities. Adapted from Adapted from De Liddo and Shum (2013)

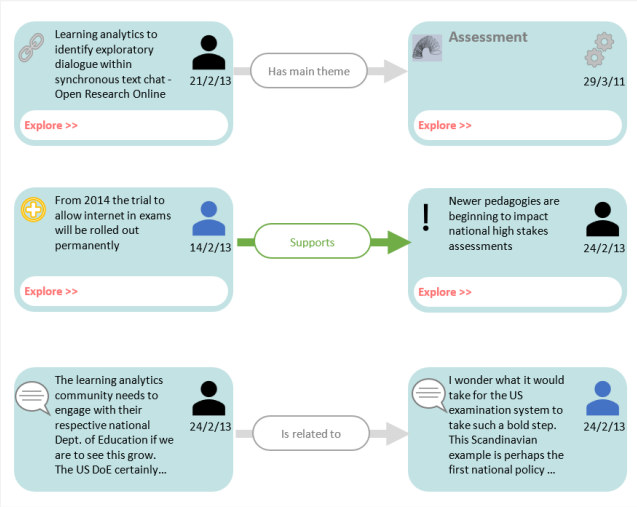
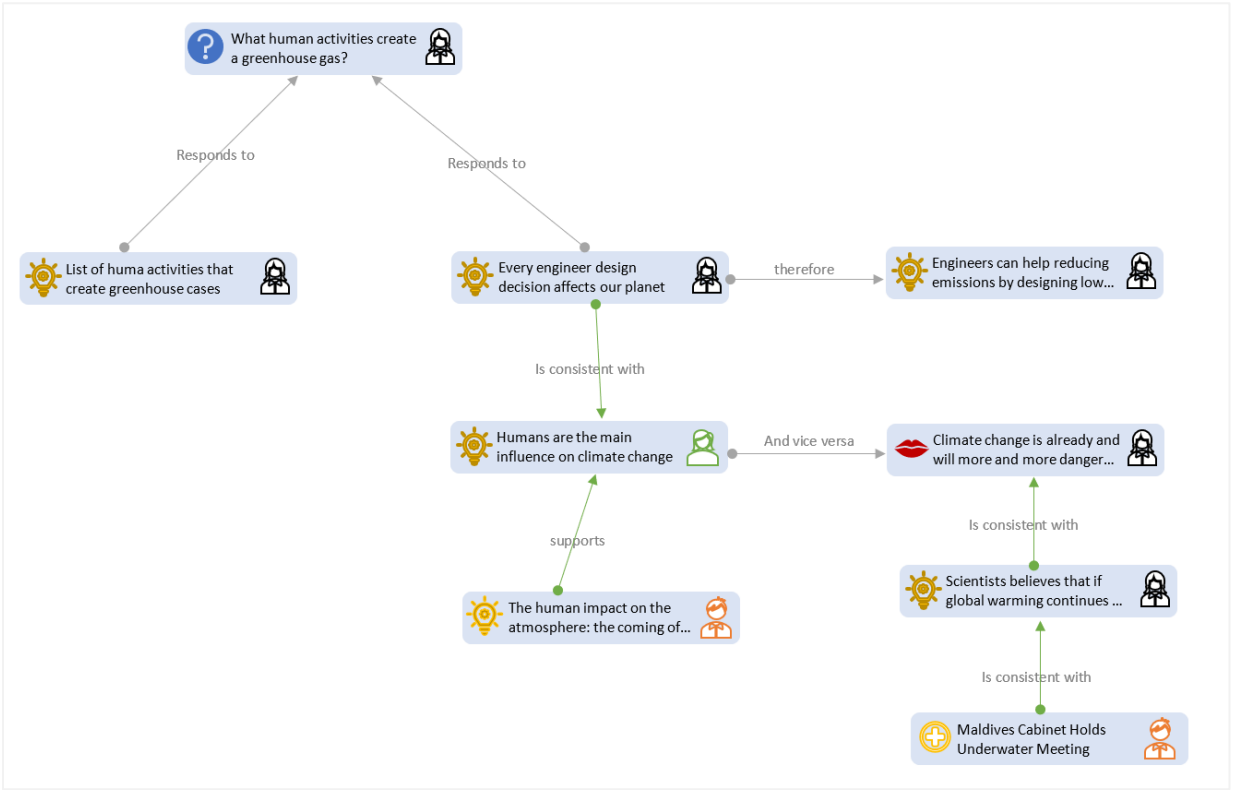


Figure 28 - Chapter 2: CCI Concept map as schema representation. Adapted from De Liddo et al. (2012)

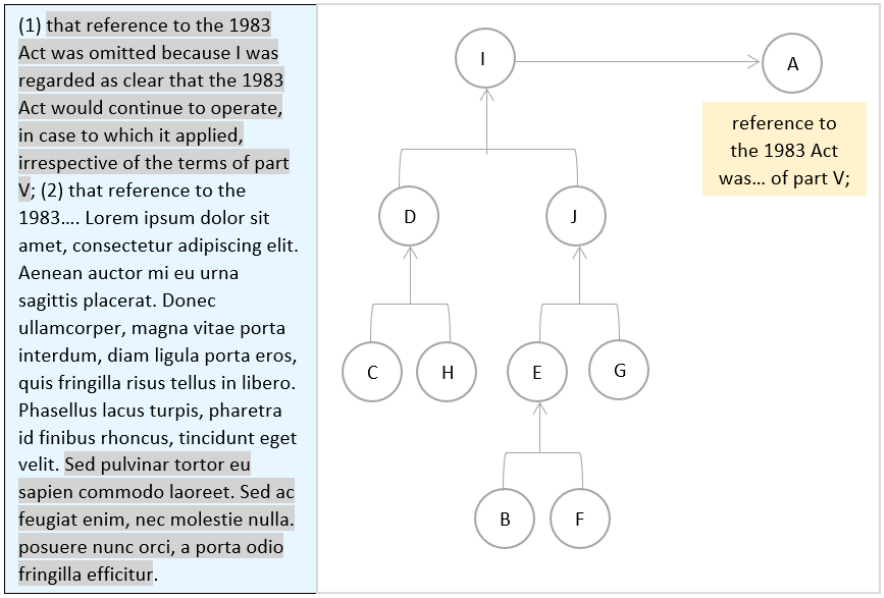


Contested Collective Intelligence (CCI) is a subset of CI, where the focus is on representing disagreements through discourse analysis. De Liddo et al. (2012) used the first four data flow boxes (external data, shoebox, evidence file and schema) from Pirolli and Card's (2005) Notional Model for Sensemaking as a reference for their CCI System. The Xerox Incremental Parser (XIP) supports shoeboxing by automatically extracting sentences with contrasting ideas from external data sources. Cohere then presents the key issues to participants who can annotate and discuss ideas which supports the evidence file. Meaningful discourse networks (concept and social) are then created serving as schematisation.

3.5.2.6. Araucaria

Araucaria argument mapping (Reed and Row, 2004) is legacy java software which allow scholars and linguists to construct arguments from text or allow the software to construct the argument based on various text inputs. It uses the standard argumentation diagramming nodes and allows for the nodes to be expanded to show each node as text. It also allows for the user to create their own argumentation scheme sets. Reed and Row (2004) used java so that other researchers could easily imbed the Araucaria software modules into their own applications.

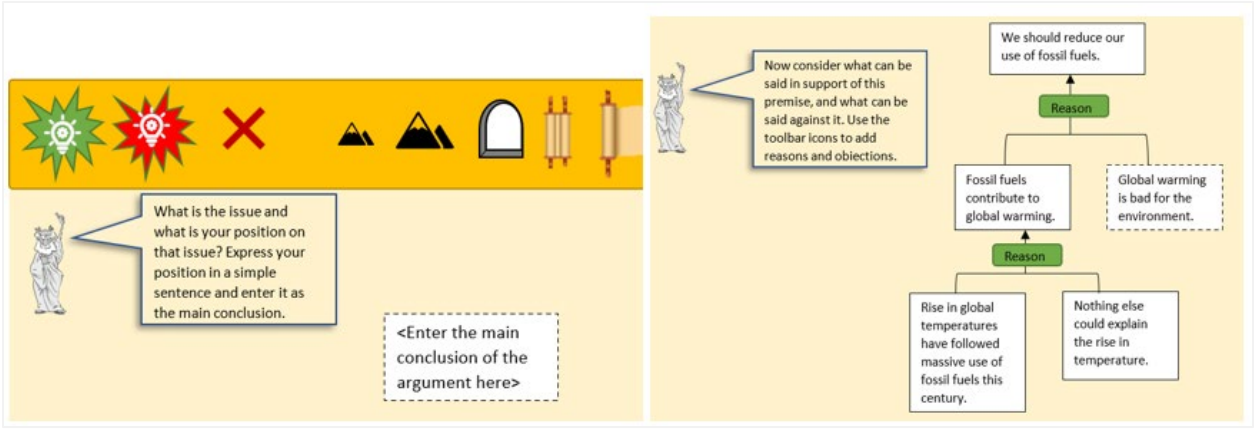
Figure 29 - Chapter 2: Araucaria map. Adapted from Reed and Row (2004)



3.5.2.7. Reason!Able

Reason!Able (van Gelder and Rizzo, 2001) is another legacy software tool with the aim to teach reasoning to school children and university students. The software allows for students to construct arguments and to evaluate the strength of the reasons given.

Figure 30 - Chapter 2: Reason!Able. Adapted from van Gelder and Rizzo (2001)



Other legacy applications exist within the AI and Law spaces and were predominantly created to support the development and evaluation of the performance of the underlying artificial agents and the logic they use. These software prototypes have been around since at least the 1980's and served as the foundation of many algorithms used in current research. A couple of these applications for the reader's reference are; SWALE (Kass et al., 1986), ECHO (Thagard, 1989), ALIBI (Eldeen et al., 1993), PEIRCE (Fox and Josephson, 1994), MARSHAL PLAN (Schum, 2001), ADVOKATE (Bromby and Hall, 2002), Family_Winner (Keppens and Zeleznikow, 2002), Assumption-Based Truth Maintenance System (ATMS) (Keppens & Zeleznikow, 2003) and ALIAS (Ciampolini & Torroni, 2004).

What can be seen from the applications in this section, is that each of the user-interfaces make use of the standard argumentation notation (boxes and arrows). Each of the applications extended the standard argumentation notation by including extra nodes (such as questions) and have added extra visual meanings (such as using a red colour for a counterargument a green colour for a supporting argument). Each application has variations of the three sub-spaces (data, analysis and hypothesis) that corresponds to Wong and Varga's (2012) conceptual visual analytics framework. Each application addresses a different problem related to sensemaking and/or collaboration and uses the user-interfaces to validate the effectiveness of the underlying logic of the artificial agents, programming or logic.

The contributions that these researchers have made to argumentation is without a doubt valuable to each of their research areas. What is not clear from their research, is if the targeted user-base informed the design of the user-interfaces or if the researchers have come up with a particular design that would allow them to test their underlying artificial agents and logic.

CISpaces (Tonilio et al., 2015) made use of Pirolli and Card's (2005) notional model of sensemaking to inform them of the data and process flows that intelligence analysts use. Contested Collective Intelligence (CCI) (De Liddo et al., 2012) specifically used Pirolli and Card's (2005) first four process flows to support the extraction of meaningful information from the raw data and to place it in the shoebox for further manipulation. Pirolli and Card's (2005) 'process

boxes' are however high-level descriptions, so it would be useful to extend Pirolli and Card's (2005) model to include more details on what intelligence analysts actually do within each of those boxes that could inform further argumentation research as seen with CISpaces and CCI.

This chapter outlines who criminal intelligence analysts are and how their work involves the use of analytical techniques. It was highlighted how cognition influences the way people make sense of information and how that leads to cognitive biases, which affects the reasoning process. Argumentation is a means to question the strength of a person's reasoning. The reasons for and against a conclusion can be diagrammatically expressed.

The next chapter explores how criminal intelligence analysts externalise their arguments. This argumentation process is referred to as the process of creating defensible assessments and involves criminal intelligence analysts' rationale.

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Chapter Three
Externalisation of Analytical Rationale

1. Overview

The literature review section outlines organisational models, intelligence models and analytical techniques that were put in place to aid criminal intelligence analysts with producing intelligence in a uniform manner across the police force. This was done so that the intelligence that criminal intelligence analysts produce could be more robust and verifiable by the decision-makers. Researchers further produced sensemaking models and frameworks to aid with the understanding of how criminal intelligence analysts think and work. In doing so, their research helped with the mitigation or reduction of cognitive biases. All of these models are relevant to some aspect of the criminal intelligence analysts' analytical process as outlined in Table 6:

NIM (ACPO/Centrex, 2005,2007) and NIM's Intelligence Model (Gibbs et al., 2015) do not outline the details on how criminal intelligence analysts formulate their analytical reasoning. The NIM model is more aimed at ensuring that all the resources are in place for criminal intelligence analysts to produce value-adding (Ratcliffe, 2016) intelligence products for downstream processes. The intelligence model (Gibbs et al., 2015) serves as a high-level overview of the different sections that the intelligence process is made up of.

APP (College of Policing, 2013) have done an excellent job at creating a repository of tools and techniques that criminal intelligence analysts can utilise to enhance their professional development. APP does however not outline how criminal intelligence analysts' analytical reasoning process work or how it is being externalised. SAT (Heuer and Pherson, 2015) is an excellent toolkit to make the intelligence process more robust and to mitigate cognitive biases but does not cover criminal intelligence analysts' analytical reasoning process.

Elm et al.'s (2005) Broadening and Narrowing model is descriptive of the techniques that criminal intelligence analysts use to cope with data overload and does not supply insights on the analytical reasoning process. The sensemaking triangle (Wong and Kodagoda, 2015, 2016; Gerber et al., 2016) explains how criminal intelligence analysts develop their understanding when information is missing and ambiguous, but it covers tacit processes and omits how to make the tacit process tangible. Pirolli and Card's (2005) Notional Model of Sensemaking is widely known, but their model only supplies high-level boxes explaining how criminal intelligence analysts work and make sense of information. It does not cover analytical reasoning during the sensemaking process.

All of these models are great at explaining what criminal intelligence analysts should be doing analytically and even how the sensemaking process takes place. The gap from these models is that it does not cover the process that criminal intelligence analysts follow to capture and externalise their analytical rationale. If we were asked to transfer the existing working practices of criminal intelligence analysts' analytical rationale-formulation process into NPDS (APCC/NPCC, 2020) or similar initiatives – what would we implement? Feedback from experienced criminal intelligence analysts from West Midlands Police force revealed that they do not make use of the concept of argumentation. They do make use of the concept of creating defensible assessments.

Table 6 – Chapter 3: Comparison of models and frameworks in relation to the criminal intelligence analysts' analytical process

NIM (ACPO/Centrex, 2005,2007)	**NIM Intelligence Model (Gibbs et al., 2015**	**Intelligence Model (Cope, 2004)**	**APP Analytical Process (College of Policing, 2013)**	**Notional Model of Analytical Sensemaking (Pirolli and Card, 2005)**	**Structured Analytical Techniques (Heuer and Pherson, 2015)**	**Convergent, Broadening / Narrowing Intelligence Analysis Framework (Elm et al., 2005)**	**The sensemaking triangle (Wong and Kodagoda, 2015, 2016; Gerber et al., 2016)**
5. Information Sources 9. TT&CG	Direction, Collection	- Acquisition of information	Getting started - *TOR* -Decide how to complete the work	1. External data sources			
6. Information and intelligence recording	Collation, Evaluation (5x5x5)		Getting started - collation and evaluation				
7. Research, Development and Co-ordination	Analysis	- Analysing intelligence	Analytical Techniques: - Making sense of complex data - Generation and evaluation of scenarios - Creative thinking and hypothesis generation - Hypothesis Testing	2. Search and Filter 3. Search for information 4. Shoebox 5. Read and Extract 6. Search for relations 7. Evidence file 8. Schematise 9. Search for Evidence 10. Schema 11. Build Case 12. Search for support 13. Hypotheses 14. Tell story 15. Re-evaluate	- Decomposition and visualisation - Scenarios and indicators - Idea generation Hypothesis generation and testing - Assessment of cause and effect - Challenge analysis - Conflict management and decision support	- Down-Collect - Conflict and Corroboration - Hypothesis Exploration	- Deduction, induction and abduction - Anchoring, laddering and questioning - Intuition, Insight and leap-of-faith
8. Intelligence Products	Dissemination	- Review and prioritising - Evaluation	Effective Analysis - Intelligence with added value - Reports	16. Presentation			

Criminal intelligence analysts further revealed that their defensible assessments capture their rationale during the analysis process and that they use something called a day-book, to record their rationale. They indicated that everyone in their department followed the same process of keeping a day-book.

This chapter elicits the knowledge from an experienced criminal intelligence analyst from West Midlands Police force on how the day-book is used to record and to express the analytical rationale-formulation process.

2. Research Questions

Chapter one outlined Research Question 1 as:

If we were asked to transfer the existing working practices of criminal intelligence analysts' analytical rationale-formulation process into NPDS or similar initiatives – what would we implement? To answer this research question, this chapter explores the following sub-research questions:

- RQ1.1: What affordances does a day-book provide to a criminal intelligence analyst?
- RQ1.2: What process do criminal intelligence analysts follow to record their rationale?

3. Research Method

A semi-structured interview was used to elicit knowledge from the subject matter expert (SME) as part of the Cognitive Task Analysis (CTA) approach (Crandall et al., 2006). The transcript was analysed using the Qualitative Conventional Content Analysis approach (Hsieh and Shannon, 2005). The reflective coding process was performed on a line-by-line basis (refer to chapter2, section 2.5 for a description of methods).

The researcher sent an email to the main research representative at West Midlands police force to request a semi-structured interview with the criminal intelligence analysts. The email outlined that the researcher wanted to discuss the purpose of the day-book and wanted to find out what was typically recorded in such a book. The representative responded via email that the request was approved and outlined a date and time when the interviewee would be available, along with the telephone number to call on the day. The representative outlined that a telephone interview would best suit the department, as the criminal intelligence analysts were terribly busy and that one interviewee should be sufficient, as they all followed a similar process within the department.

A small, quiet conference room was booked at the research facility. In the middle of the table was a phone which had the ability to make conference calls, and which had a built-in microphone and speaker, so that the interview could be conducted hands-free. A voice recorder was obtained from the media department and tested to ensure that it could pick up the voices from the conference telephone.

On the day of the interview, the interviewer (researcher) placed the pre-tested recording device close to the conference phone's speaker. The interviewer had a writing pad with semi-structured open-ended questions that were prepared during the days leading up to the interview. The writing pad was also used to make notes during the interview process. The interviewer called the number supplied and the interviewee was already available and ready for the interview to start. Excluding introductions, the interview lasted forty minutes in duration.

The interview recording was copied onto a Microsoft Windows laptop and was transcribed by the researcher after the interview finished. The researcher transcribed the recording by listening to it with the Windows Media player software and by typing the spoken word into a Microsoft Word document. The word document was laid out in a tabular format with headers; timestamp, speaker, content and line number. Intermittent timestamps were included to make it easier to find the relevant places within the recording. The speakers were added to make it easier to figure out who was speaking, which would later aid with the analysis process. The line numbers (as in the row numbers of the table) were added to make it easier to reference the applicable area in the interview when reporting the findings.

Below is an example of the transcript.

Time	Speaker	Interview	Line #
1:38	1	So what can you tell us about the day book? Why do you guys have day books?	1.
	2	Basically, we have day books so that we can log what we are doing everyday	2.
		[inaudible] what tasks we are doing. That's the fundamental reason for it.	3.
	1	ok	4.
	2	I have one… people call them blue books sometimes as well. I have one	5.
		daybook which I just put in all the things that I'm going to on that day, but just	6.
		a list basically as I do them. Because I work on different investigations I have	7.
		other books relating to those investigations where I put things in more detail.	8.
	1	Okay, so is that two different books or just everything in one book?	9.

The reflective coding process was cyclical. The researcher went through the transcript to identify open codes. Thereafter, the identified codes were divided into categories. Codes within each category were compared and reclassified as the cyclical coding process continued. Tree diagrams (see Figure 31 and Figure 33) were constructed and relationships between categories were inferred where appropriate.

The results from the analysis are outlined in the sections that follow. The relevant interview snippets are referenced in brackets and the respective entries can found in Table 7 and Table 8 along with the coding of the emerging themes.

4. Results

4.1. RQ1.1: What affordances does a day-book provide to a criminal intelligence analyst?

The criminal intelligence analyst revealed that the department made use of two distinct types of books; a blue-book and the day-book (A1, A2). It does not appear to be mandatory for criminal

intelligence analysts to keep day-books, but they are encouraged to do so when they start their employment. The purpose of these books is to document the rationale of criminal intelligence analysts analytical process (B1). Criminal intelligence analysts are considered favourable by their superiors when they are seen to write things down in their day-book during briefings (B3). Criminal intelligence analysts make use of day-books for each case that they are working on (B2). This would suggest that criminal intelligence analysts' use of day-books have become part of the organisation's culture and is an integral part of the criminal intelligence analysts' analytical process.

The blue-book resembles a business diary or a to-do list (A2). Criminal intelligence analysts use the blue-book to record (or to make a memo) of what they plan to do during the day for the different investigative cases that they are involved with (A2). This memo serves as a high-level overview of what they are planning to do on a particular case, rather than the full set of analytical results of the investigative process (A2). Other activities of the day, that are not related to any case, are also recorded in the blue-book (A2). An example of an activity that is considered as not being related to a case, would be that the criminal intelligence analyst took part in this research interview (A2). This suggest that the blue-book also serves as a time-keeping medium.

The day-book is a case-specific book that criminal intelligence analysts use to capture their analytical results (A2). The books are thin, so it is possible for criminal intelligence analysts to have multiple books for a particular case (A3). Making use of day-books are important to criminal intelligence analysts, because they can use it as a medium to capture their rationale that influenced their decision-making process and to justify their analytical actions, such as requesting more telephone information from their Investigative Officer (IO) about a particular person of interest (B1, E1, H1). Criminal intelligence analysts refer to this as a rationale timeline – a reminder of what they have done on a given day and why (E1).

Investigative work can be disjointed (B4), which means that criminal intelligence analysts often must work on multiple cases in parallel (B4). Investigative work is disjointed, because criminal intelligence analysts must wait for the requested information to be supplied to them and the overall investigative process can take a long time before it is solved (B1). The day-book aids criminal intelligence analysts with keeping the momentum of the analysis going, as they can flip through the day-book when the requested information arrives (B4). This allows them to reconstruct what their thoughts were at the time when they requested the information(B4). It also aids with the flow and flexibility of switching between cases, because they can see what information they were waiting for and what they wanted to do with the added information (B4). It can also aid criminal intelligence analysts with getting back into the flow of the analysis work, if they listed what their actions should be when they get back from holidays or even just the weekend (B4).

Even though criminal intelligence analysts keep two distinct types of books, both books are admissible in a court of law as evidence, if the defence should request it (C1). A likely reason for keeping two distinct types of books, may be that the day-book is case-specific and hence more relevant to court proceedings (A2). Criminal intelligence analysts reckon that they are rather impartial and the fact that everything that they have written down is disclosable, does not seem to interfere with what they record in the day-book (C2). If they do not find what the TOR hopes

to conclude, then they would write that in the day-book (I2). An example would be that the TOR states to find if a particular person was near a location as it may be what the IO hoped for. If it was found by the criminal intelligence analyst that the person was not near the location, then the entry in the day-book would say so.

The day-book is private to the criminal intelligence analyst, as all the entries are specific to the case that they are assigned to (D1). It would not be a problem for the IO to look over the criminal intelligence analyst's shoulder at what they have written down, but as it is the criminal intelligence analyst's handwriting, it may be more comprehensible to the criminal intelligence analyst who's book it is (D2). The day-book is part of the case and hence is locked away in a secure drawer, when the criminal intelligence analyst is not using it (D3).

The criminal intelligence analyst revealed that a physical day-book has advantages and disadvantages over an equivalent electronic medium. The ease of portability makes it a favourable medium for criminal intelligence analysts to record their rationale, as they can easily take it to a briefing and share information with their IO, as they flip through the pages (E3). As mentioned previously, the criminal intelligence analyst revealed that the current organisational culture is so, that it would be considered more favourable to see a person writing in a book than typing on a software tablet during briefings (E4). The impression of ease and speed of data entry is another possible advantage of a physical book over a software medium (such as a tablet), especially if criminal intelligence analysts do not consider themselves proficient in using such electronic mediums (E4).

Criminal intelligence analysts find it easier to reference a physical book, as a physical book is constantly open and visible on their desk, while their computer screens are usually cluttered with multiple spreadsheet and other software programs (E3). The main disadvantage of a physical book is that entries are recorded in a linear fashion, while the thinking and investigative process is more fluid and abrupt (E2, F1). An example is that the criminal intelligence analyst may have recorded a request for information on page 27, but then only receives the requested information a week later, which means that they need to continue their entries about the request from page 33 onwards. An electronic medium would mean that they could have all related entries collated in one place, regardless of when they receive the information.

Table 7 – Chapter 3: Interview question 1.1: Purpose of the day-book. Codes and interview snippets

Category	Sub-category	Ref.	Interview snippets	Open Codes	Memo
Function	Logging tool (day)	A1	"(Interviewee:2-3) Basically, we have day books so that we can log {logging tool} what we are doing everyday {daily} [inaudible] what tasks {tasks} we are doing. That's the fundamental reason for it. {justification}"	*Logging *Daily *Tasks *Justifications	Keeping two types of books
Entry Type	Task (day) Justification (day)				
Utility	Daily				

Book Type	Blue-book Day-book	A2	"(Interviewee:10-18) I have the one, the one blue day book {book type} which in today's entry I've just got that I'm going to do {to-do list} something and just briefly {task summary} what it is in one of the operations. And then another entry for some other work that I'm currently doing on a different operation {case-shared} and then I'll have that I spoke to you on the phone {meeting entries}. So just a list of what I'm doing today {planning}. And then for each investigation {case-specific} I have another book which is a day-book {book type} really, but because it's to do with the investigations it is disclosable {regulations}, so it can go as part of the evidence {regulations} in court if you like. But in that I write down everything {logging} related to what I have done {analysis}. Well more or less everything. {discretion}"	*Book type *To-Do list *Task summary *Case-shared *Meeting entries *Planning *Case-specific *Regulations *Logging *Analysis *Discretion	Links with Law Using discretion on which entries to make
Entry Type	To-Do List (blue) Meetings (blue) Case-shared (blue) Case-related (day) Disclosable (day) Evidence (day) Analysis (day)				
Function	Logging Tool (blue) Planning Tool (blue)				
Entry Type	Analysis (day) Justifications (day) Outcomes (day) Case-specific (day)	A3	"(Interviewee:42-47) For some of them I've got about five different books, just because I don't actually have so many pages {physical limits}, but listing all the things I've done {analysis} and the reasons {justifications} for doing them. And basically, what my findings are {outcomes}. And if I have to do anything like a mind map {analysis} then I'll do that in there as well. So, for me that, that essentially is what my day book is for me and I'll fill it in every day {daily} that I do anything on that particular investigation {case-specific}."	*Physical limits *Analysis *Justifications *Outcomes *Daily *Case-specific	Need to use many books in big cases
Limitations (physical)	Thin books (day)				
Utility	Daily (day)				
Organisational	Encouraged to use	B1	"(Interviewee:112-122) You know what. I don't know [if the day-books are mandatory] {Rules}. I was thinking about this. When I first started, somebody just said – oh yeah, we do this and we just keep a note down of what we do all the time. I don't know if it is mandatory or not. I mean, I think that it would be… not very, it would… unless there is an	*Rules *Tacit limits *Nature of cases *Reasoning *Decision-making *Outcomes *Audit	Books are part of organisation's culture Subjective Support:
Limitations (Investigation)	Lengthy in nature				

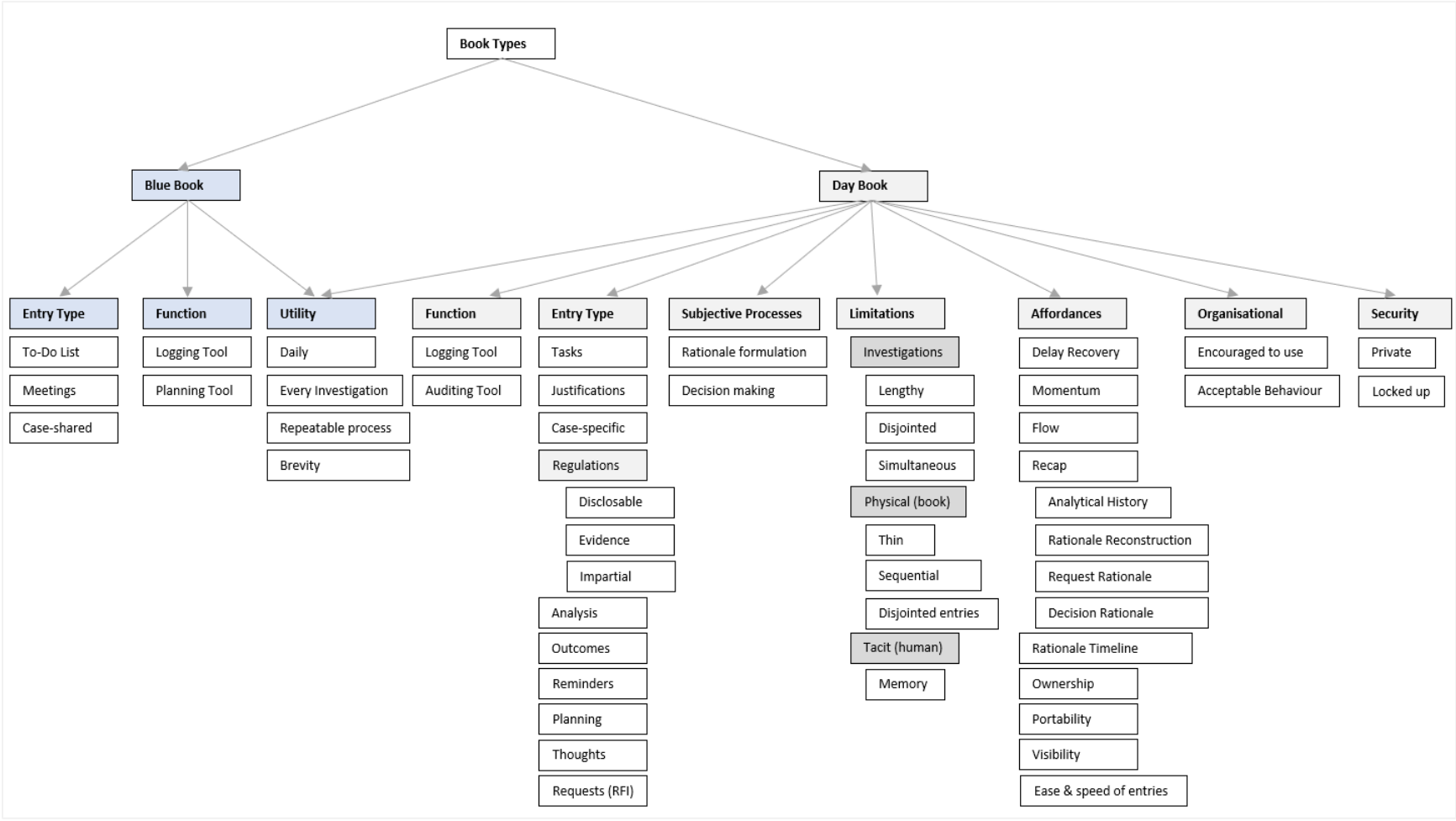
Limitations (tacit) Subjective processes Function Entry Type	Human memory Rationale formulation Decision-making Auditing Tool (day) Analysis (day) Justifications (day) Outcomes (day)		alternative, I don't think that it would be good to not do it. Because you can't possibly remember everything that you do {tacit limits}. Especially with some of these investigations because they go on for quite a long time {nature of cases}. And there needs to be some rationale {reasoning} around your decision-making process {decision-making} and what you found {outcomes} – I think. I mean, even if you are working on the tactical process, I think you still need to be able to demonstrate if required or at least have something that you can go back to {audit}, to say what you actually did {analysis} and why you did it. {justification}"	*Analysis *Justification	Jog memory (from tacit limitations) Capture rationale & decision-making (from subjective processes)
Utility	Every investigation (day) Repeatable process	B2	"(Interviewee:66-68) …really that is what I do in this day book. And it is the same for every operation {every investigation} that I work on. Same process anyway {repeatable process}.	*Repeatable process *Every investigation	
Organisational	Perceived acceptable behaviour	B3	(Interviewee:542-544) And, I don't know. I think people accept it more to see you sitting there [in a briefing] writing something in a book, than they would seeing you tapping away on a tablet {approved behaviour}.	*Approved behaviour	Approved part of organisation's culture
Affordance	Delay recovery Momentum Flow Recap (analytical history) Recap (rationale reconstruction)	B4	"(Interviewee:71-95) Yeah, so actually that [recovering from a delay] is pretty important {delay recovery}. And do you know like if you're off for example you go on holiday, before I go on holiday I always write where I have got up to {reminders, entry type}. And often on a Friday I'd put what I need to do next as my last entry {planning, entry type}. So, it is also a bit of a to-do list if you like {to-do list}. It [disjointed nature of cases] can be – yeah. Yeah, especially… especially the investigative stuff {nature of investigation}. It is because you do have	*Delay recovery *Reminders *Entry type *Planning *To-do list *Nature of investigation *Delay type *Momentum *Planning *Flow *Recap *Analytical history	Nature of cases

Entry Type	Reminders Planning Thoughts Requests		to wait for data to come back {delay type}. Not always phone data. Sometimes other sorts of information and then I mean you just can't sit and wait and do nothing. I move on to some other work that I've got in a different operation, because you generally have more than one at a time {nature of investigation}. Always more than one at a time. So, it helps in order to be able to flexibly move from one piece of work to another {momentum}. As long as you know log what … as long as you've written down what you've been doing, what your thoughts were {entry type}, and what you think you are waiting for {entry type}, or what you've got to do next with it when it arrives {planning}, it is easy cause you can go back to your day book and refer to that and then continue on {flow}. Yeah, it [momentum] is important for that. Cause you need to flip back through everything and look back through all your excel spreadsheets {recap, analytical history}. Yeah, because that [reconstructing] would be, that would be quite time consuming really {recap, rationale reconstruction}."	*Rationale reconstruction	
Limitations (investigations)	Disjointed Simultaneous cases				
Regulations	Disclosable	C1	"(Interviewee:131-133) Not that I know of [being asked to submit day-book for court proceedings], but this is what… we are actually told this, that in terms of everything that you write down during an investigation that is all disclosable {regulations, disclosable} to the defence if they should want to request it."	*Regulations *Disclosable	Disclosability and Impartiality
Regulations	Impartial Evidence	C2	"(Interviewee:136-140) No [laughs] not really, no [that disclosability does not affect what they write down]. I still write down everything I did, because whatever I've done is what I've done and whatever my thoughts are I mean it's, I don't think that I'm particularly impartial {regulations, impartial}. There is always a reason for whatever I've done or whatever I'm going to do, so it wouldn't bother me if it went to court {regulations, evidence}. I mean it probably makes me do it a little bit neater than I would do."	*Regulations *Impartial *Evidence	
Security	private	D1	"(Interviewee:381-385) Yeah, [the day-book is] pretty much [private]… I mean… I don't actually give it to anybody else {private}. If someone comes up to talk to me about a job and it is their job – the officer, and he wants to know something	*Private *Recap *Analytical History	Privacy and security

Affordances	Recap (analytical history)		and I go – Oh yeah I remember doing that, hang on a minute, and I'll flip back through it and I'll say – look, yeah we did this or we looked at that {recap, analytical history}. But I wouldn't give it away to anyone else.		
Affordances	Ownership	D2	"(Interviewee:381-397) It is my writing so… I mean you recognise things don't you? Your own, the way you wrote something on a particular day or what it looked like. I mean, they [IO] could look back if they want to, but I think it would be easier for me to do it {ownership}.		
Security	Locked up	D3	(Interviewer:546-550) And... do you lock the book up in the evening when you go home? (Interviewee) Yeah, we have locked drawers and locked office with a keypad entry and all that sort of stuff, so yes {Security, locked-up}. (Interviewer) Ok, so it needs to be kept secure? (Interviewee) Yeah.	*Security *Locked up	
Affordances	Recap (request rationale) Recap (decision rationale) Rationale Timeline	E1	"(Interviewee:49-60) It is important for me, because it means that I can go back to, I can go back to different dates and see what I have done on different dates and then if someone asks me a question about it, so you know that data, why did you ask us for this data, I can't remember and then I can go back in my book and find why I have asked for that particular data and a particular phone number, because I've written it in there {recap, requests rationale}. A part of a decision-making process really {recap, decision rationale}. So, it lists what I have done and my decision making based on what I have done in my analysis and my findings, but only briefly {brevity}. I mean most, obviously most of the stuff that we do is electronically captured, but it, it, I suppose it is more a timeline really around what I have done in a particular investigation {rationale timeline}."	*Recap *Request rationale *Decision Rationale *Rationale timeline	Affordances
Utility	Brevity				
Limitations (physical)	Sequential Disjointed entries	E2	(Interviewer:483-504) so if you just had a list of sorts of the subtasks and you could expand those to get the details (Interviewee) Yeah that would, yeah that would be quite... useful actually, I think. Especially if you want to go back and look at anything. Only in terms of... logical thinking around a particular task, because it's... it would be good to have it all in one place obviously in the day book it is not {limitations, sequential}, because you've got the beginning, and then you get onto that task maybe task number 3	*Limitations *Sequential *Disjointed entries	- thought process is not linear, but book is

			on page twenty-seven... And then you may do a bit more of that, but then you might have to go back to something else, because you haven't received something you need like some data you need and then do you know what I mean? I then you continue on page thirty-three so it makes it so that it's not so efficient as it might have been {limitations, disjointed entries}. (Interviewer) So that is a really important disadvantage of a physical day-book - Is that you can... you write things sequentially, but you don't work sequentially. (Interviewee) No not, no not all the time. Very rarely really.		
Affordances	portability visibility	E3	(Interviewer:505-524) I think my last question is that you can easily replicate the day book in say Microsoft Office Word, so is there any reason why you would prefer to do it on pen and paper like in a day book and not use an electronic version? (Interviewee) I don't know. It is a very good question. Hmm... I think... I don't know. The only advantage I would say is that for me is that my book is always open and my computer always have many files open, so... maybe it is easier to write it, because it is not on there, because it is a physical thing {visibility}. But, I don't know. I can't really think of any absolute, overall advantage to having it in a book... (Interviewer) Can you walk around with it? (Interviewee) Yeah, if I'm going to see somebody about this investigation and then I'm going to see them, they going to see me, then yes I'd take and if I go to at... yeah…that's the thing isn't it, if you go to briefings...That's true. The briefing may be... I don't know some... conference room upstairs {portability}. I suppose if you were going to do it electronically you would have to take some sort of portable equipment with you. (Interviewer) Yeah. You'd have a tablet or something like that. (Interviewee) Yeah and we don't have those.	*Visibility *Portability	Physical vs Software
Affordances	Ease and speed of entries	E4	(Interviewee:542-544) And, I don't know. I think people accept it more to see you sitting there writing something in a book, than they would seeing you tapping away on a tablet {acceptable behaviour}. Actually, I don't think that my typing skills are that brilliant {ease and speed of entries}.	*Ease and speed of entries	Organisational Culture
Organisational	Acceptable behaviour				

Figure 31 - Chapter 3: RQ1.1 Tree Layout for Open Coding



4.2. RQ1.2: What process do criminal intelligence analysts follow to record their rationale?

4.2.1. How entries are made into the day-book:

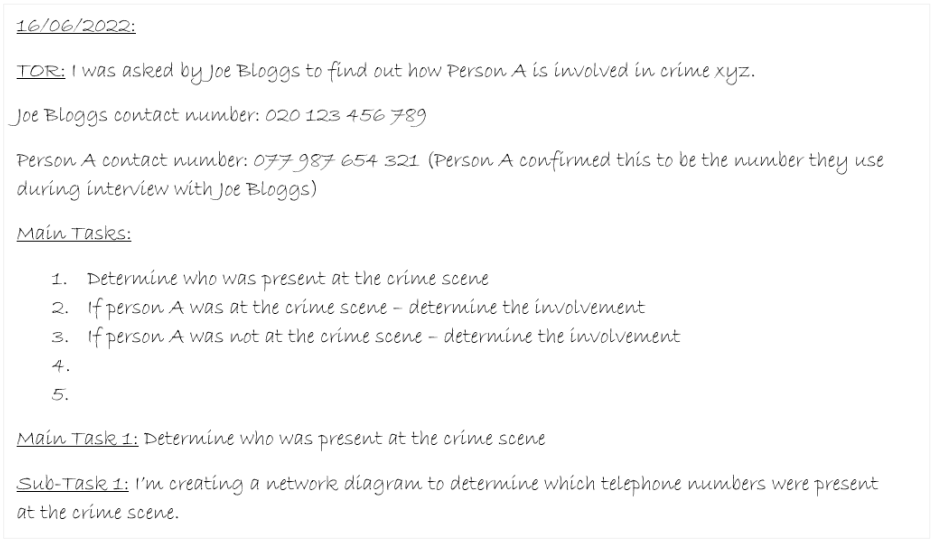
3.2.1.1. Getting Started

The investigative process starts when criminal intelligence analysts are briefed by Investigative Officers (IO) on what is needed from them with regards to the investigation (F1). This can take place in a briefing room or as part of a one-to-one discussion (F1). The briefing serves as an opportunity to define the Terms of Reference (TOR) (F1, F2). The TOR are the questions that are put to criminal intelligence analysts – the things that they need to find out in relation to the investigation (F3). Criminal intelligence analysts would make a note of the TOR in the day-book, along with general information such as relevant contact numbers (G2). Daily, criminal intelligence analysts would update the day-book with the analysis they have completed in relation to the TOR. This would not be the full analysis per se, as they would use electronic mediums, such as spreadsheets, to record the full analysis of the information (G2). Outputs from several types of software programs, for example mind mapping software, would go into the day-book (G3). Noting down the TOR is important, as it serves as a reminder of the wider objective that criminal intelligence analysts should keep in mind to stay on target (F4).

Criminal intelligence analysts would like to think about the request and write the main tasks that they think would answer the TOR, in their day-book. This would give them a framework to work with – a way to tackle and resolve the problem (F4). As criminal intelligence analysts start with the main task, they would divide it into smaller sub-tasks and the justification for why they are performing the tasks (B1).

At this point in time, the day-book would have the TOR, relevant information such as contact numbers, a couple of main tasks and a sub-task with the relevant justification for performing the tasks. Figure 32 is an illustration of what it might look like.

Figure 32- Chapter 3: Depiction of a possible day-book entry



3.2.1.2. Recording of Rationale

Creating tasks and subtasks are a continuing process and expands as the analysis progresses (F4, H1). An example of the way in which the analysis can expand is by finding a relevant telephone number in the analysis and then requesting more telephone data from the IO for that number to perform further analysis, once the new data is received (H1). The purpose of noting down the justification for performing the various tasks and subtasks, is so that criminal intelligence analysts have a way to record and externalise their rationale (B1, E1, H1, H3). Criminal intelligence analysts' rationale are the reasons behind their decision-making. And criminal intelligence analysts' decision-making has to do with what they decided to analyse and why, and how the outcomes from the tasks and subtasks form the basis as a justification for performing the next set of tasks and subtasks (E1, H1). By externalising their rationale, criminal intelligence analysts can easily jog their memory about what they did and why did it (B1, B4, E1, H3, H6).

Criminal intelligence analysts do not perform a task without having a good reason for doing so and externalising that reason serves as their justification. There could be times during the analysis process that the IO asks the criminal intelligence analysts to perform further analysis. This request can come in the form of an email and the criminal intelligence analyst would note down in their day-book that they have been tasked to do more work. To increase efficiency, the criminal intelligence analyst would make a copy of the email request within the day-book to avoid searching for it later (H2). This allows criminal intelligence analysts to have all the relevant information about the case in one place, thus saving time to look for information.

The ability to have a medium that can jog criminal intelligence analysts' memory or the ability to allow them to recap their rationale, is important when they are being questioned about their analytical actions and decisions (H3). If it is recorded in the day-book, then they can go back to the relevant entries as a reminder and then explain what they have done and why (H3). It can also support criminal intelligence analysts with finding new lines of enquiry or remind them of unexplored lines of enquiry (H6).

The outcomes of tasks are briefly written down in the day-book. It is not the full analysis, but rather a brief summary of what criminal intelligence analysts found. The ability to have a medium where the justification of a task and thereafter the outcome of each task is collated, allows the analyst to reflect on their work and the problem that they are trying to solve. These reflections can give rise to new questions which drives further investigation (F4). The criminal intelligence analyst would write down these questions in the day book as it is part of their thought-process and thus their reasoning process (H4). So, the day-book captures the questions that were put to them, the questions that they have based on their reflections and considerations and the questions that they want to ask other people (H4).

Criminal intelligence analysts also note down their hypotheses as part of their justification for performing a particular task. The outcome of the task can then be compared against the hypothesis they had, thus serving as a test to see if they are on the right track (H5). An example of a hypothesis is when criminal intelligence analysts' find a telephone number for a person who is not at the crime scene, but who is in contact with someone who is. Criminal intelligence analysts can then hypothesise that the person is a facilitator and can decide if it is worth requesting further telephone information to prove or disprove their theory or hypothesis (H5). If

they did request further telephone information, then they can test the hypothesis by analysing the added information and check if the person is indeed a facilitator or just a relative.

Criminal intelligence analysts make use of their day-books throughout the analytical process (H7), so it forms an integral part of their work process.

3.2.1.3. Delivering Effective Analysis

In the literature chapter, APP outlines that criminal intelligence analysts should deliver effective intelligence (College of Policing, 2013), which means that it should add value to the investigative process. Criminal intelligence analysts adhere to this by producing products and exhibits that are justified. It can be considered as justified, because criminal intelligence analysts can show their rationale behind every analytical step they took and decision they made, along with references to various underlying information as proof.

The process of recording proof in the day-book takes place as follow: The outcomes of tasks and subtasks are substantiated by different formatted materials, for example, formatted phone numbers in an Excel spreadsheet or a network diagram from mapping software (F6, F7, I2, I3). Each of these outcomes (the spreadsheet analysis and the diagram) are referred to as products (F6, F7) or intelligence (I2). Criminal intelligence analysts keep track of these products through a numbering system for example *AL1* (F6). This numbering system is referred to as a product list (F7). The product reference numbers are noted down as part of the outcomes, so that criminal intelligence analysts can refer to it, to see what the analytical evidence is that substantiate their rationale (F6, F7).

Criminal intelligence analysts would then use the day-book and the product list to create exhibits (I4), which represents a collation of their analysis in relation to the TOR (F7). Criminal intelligence analysts would keep the day-book open whilst creating the exhibits, which shows that it is an integral part of the process which allows them to recap their rationale (J1, J3). The exhibits along with the statements of what criminal intelligence analysts were asked to do, is sent to court (J2). Other analytical roles might only have the requirement to summarise their findings in reports without the need to create exhibits (J4).

Table 8 - Chapter 3: Interview question 1.2: How the day-book is used in combination with the investigative process. Codes and interview snippets

Category	Sub-category	Ref.	Interview snippets	Open Codes	Memo
Briefings	Group One-to-one	F1	(Interviewee:520) "The briefing may be...some conference room upstairs... {briefings group} (Interviewee: 516-518) Yeah, if I'm going to see somebody about this investigation and then I'm going to see them, they going to see me, then yes I'd take [the day-book] and if I go to at... yeah... that's the thing isn't it, if you go to briefings... {briefings one-to-one}	*Briefings Group *Briefings one-to-one	Structure Overview

Category	Sub-category	Ref.	Interview snippets	Open Codes	Memo
TOR	Starting Point	F2	(Interviewee:19-20) So I'd start off with the TERMS of REFERENCE (TOR) of the investigation. What the officer wants me to do {starting point, TOR}.	*Starting point *TOR	
TOR	What was asked to do	F3	(Interviewer:188-208) Yeah, I was just trying, sort-of trying to get the handle on, on how an entry might be structured or how… you mentioned that you write down the terms of reference {TOR}, so what it is that you have been asked to do. (Interviewee) Yeah. (Interviewer) So that's kind of the questions that's been put to you. (Interviewee) Yes {questions to answer}, and then… (Interviewer) And then I think you said that you'd write down the things that you… the things that you do… {analysis} (Interviewee) Yeah (Interviewer) And the outcomes of those things {outcomes}. (Interviewee) Yeah. (Interviewer) So, a kinda answer to the question… sort of thing {relationship}. (Interviewee) Ahu. (Interviewer) Does that sort of capture the structure? Or is it more open than that? (Interviewee) It just… it's just sort of the start, that's the thing, so it will always start with what I was asked to do {starting point}. And then the first bit of work that I've done {analysis} and then what I've found from that {outcomes}, I mean it's, it's probably better if it was structured in a more… I mean if you think if you're doing this in an electronic way, you'd probably structure it better actually. It a bit difficult though if you are writing in the book I think.	*TOR *What was asked to do *Analysis *Outcomes *Relationship *Starting Point *Limit (keeping structure)	There is a relationship between TOR and outcomes
Relationship	Outcome and TOR				
Limits (physical)	Keeping Structure				
Main Task	Brief Description	F4	(Interviewer:209-265) Yeah, how would you in an ideal world, do you think, how would you, if you are doing it electronically, how would you structure it? (Interviewee) Maybe you'd have… like the task. A section for the task – what the task is {brief description}. What you're going to look at. Then maybe… a section on from that which is what you have actually done {outcome}. All the different parts of that task that you have done {subtasks}. And then the findings from that {subtask outcomes}. Of the… alright the tasks within the… wider objective {TOR}. I suppose. And then the outcomes of those. And then… The outcomes and then maybe then what you did next all sort of leading… I was just thinking it's like a… say you just got some excel spreadsheet, you've got a section for this,	*Brief Description *Outcome *Subtask *Subtask Outcome *TOR *Decision-Making *RFI *Linkage *Cyclical process *Recap rationale	There is a linkage between tasks (laddering) Cyclical: Do same subtask for different offenders

Category	Sub-category	Ref.	Interview snippets	Open Codes	Memo
Sub-Task	RFI Cyclical		a section for that and a section for the other all relating to that task. (Interviewer) So, you'd have the overall task. And then you would… that would be broken down into some sub-tasks… (Interviewee) Yeah (Interviewer) And then each of those would have an outcome. (Interviewee) Yeah, and then you'll have some decision-making {decision-making} around that, like some… say if, ok, someone have asked you to look at the activities of these people around this particular offence, you may get… often get telephone data related to those different individuals {RFI} – the people believed to be involved. So, I would carry out some analyses and map those and it {follow on, laddering}… suppose each one of those is a separate task within the big task. And you could do Person A and they were nowhere near the crime scene, so that would be an outcome {outcome}. You do the same for person {cyclical}, all the rest of the people some may be there {subtasks}, some may not be {outcome}, but maybe person A when you actually look at who they are phoning, which is another task {subtask}, they, they may not be there, but they maybe they're in contact with the person who is at the crime scene {anchor, question} and then… that would lead on to the analytical part of it trying to put together what potentially might have happened? (Interviewer) So, are you saying that might lead on to a new question? (Interviewee) Yeah, it might lead on to a question whereby you'd want to know who Person A actually is if you don't know {task}. I mean it could be a relative in which case they'd phone them every day and in which case you may need more telephone data {RFI} to work out if it is just somebody they call every day anyway. And all of that would be here, in my book, but if it is electronically sorted by putting boxes if you like … or whatever structure… it would be a lot easier to go back to and a lot easier to follow the thought processes {recap rationale}. (Interviewer) I mean maybe if it is almost like if you have got the overall task and there… you can break that down into subtasks. (Interviewee) yeah. (Interviewer) And then there are new tasks which arise as you find out new		
Sub-task outcome	Anchors Questions				
Electronic	Easier to recap rationale				

Category	Sub-category	Ref.	Interview snippets	Open Codes	Memo
			things. (Interviewee) Yes. (Interviewer) Which would also presumably be part of the overall task… (Interviewee) Yeah.		
Electronic	Hyperlinked	F5	(Interviewer:373-377) So wouldn't it be great if you had some electronic system that could allow you to click on that [product reference]… (Interviewee) And hyperlink to your… yeah, that be good [laughs] Yeah, that would be really good {hyperlinked}.	*Hyperlinked	
Products	Product List Product Reference	F6	(Interviewee:358-372) I mean I could say well I did all of this {analysis} and I can show you the entry where I did that and it refers {linked} to spreadsheet number ten which has this data on it and all that yeah. Yeah, all of the things… all the products {products} that I come up with, be it a map {product type} or a call schedule {product type} or whatever, yeah, I will always reference them and then I keep another spreadsheet {product list} [laughs] with a list of… an electronic spreadsheet with them all listed on, what they all are and what their numbers are, so… Say my products and things I'd show the officers, saying okay these people are calling each other on this day and I might reference that as AL1 … And then on another spreadsheet, I've got AL1 to 57 of all the things that I have ever done like that… So, a spreadsheet might be referenced AL1… (Interviewer) It's given a number and that reference, AL1, will appear in your spreadsheet of spreadsheets which refers to it, but presumably does it… that also occurs… appears in your day book? (Interviewee) Yeah, because, I can, I'll put like – I did this map {product type} with this data {product type} and it is AL27 {product reference}. (Interviewer) Right. Right. So, would that in a sense that it is sort-of a reference back to the findings as it were? (Interviewee) Yeah, I suppose it is like a [laughs] circular reference really, but yes…	*Analysis *Linked *Products *Product Type *Product list *Product Reference	Analysis is the actual work that results in different products. Products are referenced to be able to refer back to relevant analysis.
Product Type	Maps Call Schedule				

Category	Sub-category	Ref.	Interview snippets	Open Codes	Memo
Products	Recap	F7	(Interviewer:439-448) The exhibit for example might be a map right and I've already created that using mapping software. But I would use my list, my list of everything I produced, my product list if you like, the exhibit itself and then I might go back to my daybook to look at... something, maybe what I've written on the day that I created that map {recap}. I mean it depends... I don't generally need to but I probably would.	*Recap	
Briefings	Group One-to-one	G1	(Interviewee: 516-518) Yeah, if I'm going to see somebody about this investigation and then I'm going to see them, they going to see me, then yes I'd take [the day-book] and if I go to at {one-to-one}... yeah... that's the thing isn't it, if you go to briefings...{group}	*One-to-one *Group	Briefing/Debriefing
TOR	Starting point Overview Relevant info What asked to do Progress Case-Specific Brevity	G2	(Interviewee:19-20) So I'd start off with the TERMS of REFERENCE (TOR) of the investigation. What the officer wants me to do. {starting point, TOR}. (Interviewee:24-30) So I write all the information {TOR}. What the job is about {TOR, overview}, what they want me to do in the first instance. I might put in the relevant phone numbers {TOR, relevant info},. I mean obviously I won't write everything {TOR, brevity}, because a lot of it I'll use spreadsheets, electronic spreadsheets, to capture all the information, but in there I'll just put a general thing about the job, what I've been asked to do {TOR, what asked to do} and then on a day-to-day basis I'll write in it what I have actually done {TOR, progress} in relation to that investigation. {TOR, case specific}	*TOR *Starting point *Overview *Relevant info *What asked to do *Progress *Case specific *Brevity	Terms of Reference (TOR) Objective Daily tool Tracking tool Purpose for investigation
Product Type	Mind-map	G3	(Interviewee:44-45) And if I have to do anything like a mind map {product type}, then I'll do that in there as well.	*Product Type	
Analysis	Task description Outcome description Confidence level Anchor, task	H1	(Interviewee:31-37) So I may put that I've formatted {analysis} some telephone data for this telephone number which belongs to this person and then if I carry out some analysis on it I'll put – I analysed this to see if person A is calling person B {task description}. And then I might, I'll probably put the brief results {outcome description} of my analysis in there as well. And that I've identified that this number seems {confidence level} to be relevant and then I'll put something like – Suggested to the officer that he obtains phone data for that number {anchor, task}, so in there I've got all my decision	*Analysis *Task Description *Outcome description *Confidence level *Anchor, task	Tasks & Sub-tasks Output informs confidence level

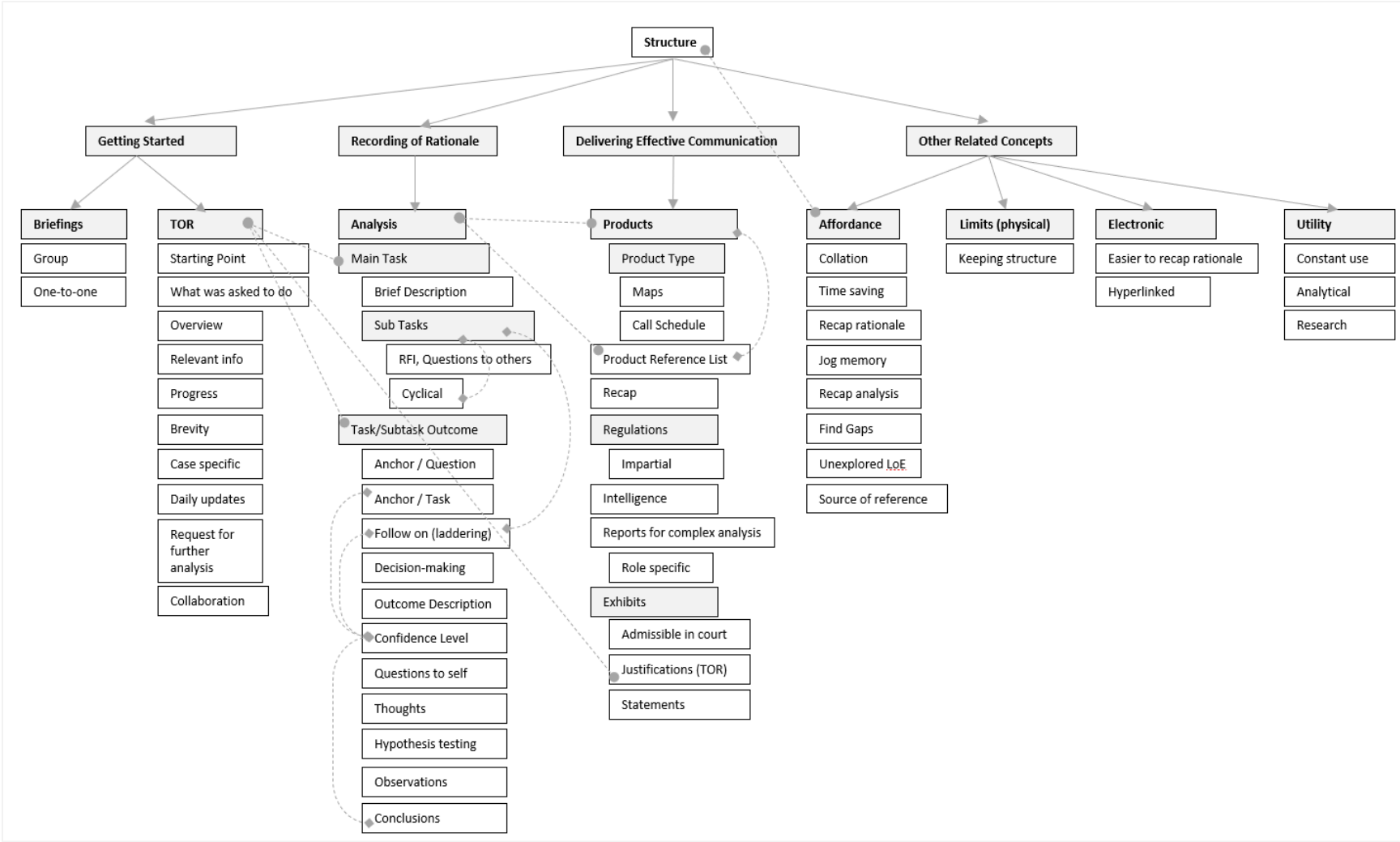
Category	Sub-category	Ref.	Interview snippets	Open Codes	Memo
			making I suppose {decision-making}. You would call it.		
TOR	Request for further analysis	H2	(Interviewee:39-41) And sometimes if I receive an email from the officer in the job asking me to do more work {request for further analysis}, I'll pull it off and stick it in the day book {collation} [laughs] it is easier than going back to the email all the time trying to find the correct email {time saving}.	*Request for further info *Collation *Time saving	Keeping everything together. Copy of email in daybook to save time.
Affordances	Time saving Collation				
Affordances	Jog memory Recapture rationale	H3	(Interviewee:160-161) Yeah, but if I, if I thought, oh where did I… how did I get to that? {jog memory} I can look back in it and find how did I get there {rationale recap} in the first place. Sometimes that does happen.	*Jog Memory *Rationale recap	
Analysis	Questions Thoughts Questions to others	H4	(Interviewee:184-186) Yeah, will do yeah [write questions in day-book] {questions}, because that's my thoughts {thoughts} about something so, yeah. And even questions that I need to ask somebody {questions to others}.	* Questions * Thoughts * Questions to others	
Analysis	Outcomes Hypothesis testing Anchoring Confidence level	H5	(Interviewee: 275-290) I mean it is hypothesis testing around like for example the phone number that isn't at the crime scene but is in contact with somebody who is {outcome, anchor} … You can test the hypothesis that this is a facilitator {hypothesis testing} for example… Or… that it is not a facilitator, it is just a relative or somebody else {laddering, confidence-level}. And I suppose we, we do, do that quite frequently, but not in any formal way. (Interviewer) Is the hypothesis documented? (Interviewee) Yeah, it would be written in my day book. Yeah, and then I'll… decide what I'm going to do around that {decision-making}.	*Outcome *Hypothesis testing *Anchor *Confidence level *Decision-making	Clarifying the hypothesis increases confidence of anchor through laddering
Affordances	Jog memory Recap analysis Find gaps Unexplored LoE Collation	H6	(Interviewee: 299-312) If I didn't [get any results], yeah, I'd look [back through the day-book entries] {jog memory} … I use it definitely to see what I have done already {recap analysis}, just to make sure that I haven't missed anything, but intended to do… {find gaps} But, if we are really stuck and we can't find something, it either means that it isn't there or not looking in	*Jog memory *Recap analysis *Find gaps *Unexplored LoE *Collaboration *Collation	

Category	Sub-category	Ref.	Interview snippets	Open Codes	Memo
TOR	Collaboration		the right direction {unexplored LoE}. And then in those instances I would probably… talk to the officer in charge, which I do quite a lot anyway {collaboration}. (Interviewer) And you record all those conversations back into the day book {collaboration}, saying that you have spoken to the officer… (Interviewee) Yes, I will do, yeah. Or I'll write an entry saying that I've received an email on this date (Interviewer) Ok, and you actually copy the contents of the email over to the day book? (Interviewee) Yeah, briefly, but if it is a long one, I often print it out, otherwise it takes me ages to write it out. And list it there for reference {collation}.		
Utility	Constant use Analytical Research	H7	(Interviewer) So, when would be the time… if we were watching the way you're working, when would be the time… when we saw you making most use of the day-book? (Interviewee) Mmmm, all the time {constant use}. Although… probably… ok… one of the operations that I'm doing at the moment – this morning I have written an entry to say that I have received a spreadsheet from someone else with phone numbers in it and I've got to go through those and look through those numbers, and intelligence systems is not very analytical {analytical} it is more research {research}. So, this morning I have written that this is what I'm going to do and because it takes so long to look through them all, I haven't written anything else since I wrote that. Because it takes a long time, I haven't written anything else. I mean if I come up with something that's not [council name] or something useful, then I'll write that down in my day-book {observations}. If it's not a phone number for a bank or something like that which, so far everything has been not very interesting. In terms of phone numbers, but if I come across something interesting then I'll ...definitely write that down. And when I've finished, I'll just write a summary {outcome description}. of what I've found even though I'm saving that data in a spreadsheet.	*Constant use *Analytical *Research *Observations *Outcome description	
Analysis	Observations Outcome Description				
Regulations	Impartial	I1	"(Interviewee:149-153) I don't think this really shows [what the IO wanted to see]… something that I was asked to look at to see if somebody was near	*Impartial *Conclusion	products and intelligence An outcome can be final and then it

Category	Sub-category	Ref.	Interview snippets	Open Codes	Memo
Outcomes	Conclusion		somewhere a particular time… and they're probably hoping that that person was near there a particular time, I put in there, I have looked at data and it doesn't show that {impartial} {outcome, conclusion}. To me it doesn't look like that, so that is what I have put.		is a conclusion rather than an anchor
Products	Products Intelligence Reports for complex analysis Exhibits	I2	(Interviewee:164-169) No, not, not in this role [do we create reports], because we'll create exhibits, core exhibits generally. Well first of all, we'll create much charts {products} etc. for… they may be for intelligence purposes first {intelligence} and I suppose some of them yeah you might write a report if it is particularly complicated {reports for complex analysis}, but that will be for the people working on the investigation more than anyone else and then that might go onto the creation of exhibits {exhibits}.	*Products *Intelligence *Reports for complex analysis *Exhibits	First products, then Intelligence, then reports, then exhibits
Products	Product List Product Reference	I3	(Interviewee:358-372) I mean I could say well I did all of this {analysis} and I can show you the entry where I did that and it refers {linked} to spreadsheet number ten which has this data on it and all that yeah. Yeah, all of the things… all the products {products} that I come up with, be it a map {product type} or a call schedule {product type} or whatever, yeah, I will always reference them and then I keep another spreadsheet {product list} [laughs] with a list of… an electronic spreadsheet with them all listed on, what they all are and what their numbers are, so… Say my products and things I'd show the officers, saying okay these people are calling each other on this day and I might reference that as AL1 … And then on another spreadsheet, I've got AL1 to 57 of all the things that I have ever done like that… So, a spreadsheet might be referenced AL1… (Interviewer) It's given a number and that reference, AL1, will appear in your spreadsheet of spreadsheets which refers to it, but presumably does it… that also occurs… appears in your day book? (Interviewee) Yeah, because, I can, I'll put like – I did this map {product type} with this data {product type} and it is AL27 {product reference}. (Interviewer) Right. Right. So, would that in a sense that it is sort-of a reference back to the findings as it were? (Interviewee) Yeah, I suppose it is like a [laughs] circular reference really, but yes…	*Analysis *Linked *Products *Product Type *Product list *Product Reference	Specific to products

Category	Sub-category	Ref.	Interview snippets	Open Codes	Memo
Product	Find links to work done	I4	(Interviewer:439-448) The exhibit for example might be a map right and I've already created that using mapping software. But I would use my list, my list of everything I produced, my product list {links to work done} if you like, the exhibit itself and then I might go back to my daybook to look at... something, maybe what I've written on the day that I created that map {recap rationale}. I mean it depends... I don't generally need to but I probably would.	*Recap rationale	Links back to analysis
Exhibit	Recap Rationale	J1	(Interviewee:436-444) ...The exhibit for example might be a map right, that I've already created using mapping software. But I would use my list, my list of everything produced, my product list if you like, the exhibit itself and then I might go back to my day-book to look at something, maybe what I've written on the day that I created that map {recap rationale}.		Exhibits and reports
Exhibit	Admissible in court Statements Justifications Recap rationale Recap analysis	J2	(Interviewee:171-179) The exhibits are yeah [sent to court on request] {admissible in court}. They will… they will go to court. So, you may use your day book then to say this day I was asked to do this {justification, TOR}... depends on, people write statements {statements} in different ways actually, but in my statements I always put that I was **asked** on a certain date to do a particular thing by an officer. And a day book is good for that, because I can refer back to where I was tasked to do that particular whatever it is that they've asked me to do {recap rationale, analysis}.	*Admissible in court *Statements *Justifications *Recap rationale *Recap analysis	
Affordance	Source of reference	J3	(Interviewer:427-428) At the end of a case... really what we do is... we produce exhibits for court and write a statement and while I'm doing that – yes I would [keep the day-book open] {source of reference}.	* Source of reference	
Reports	Role specific functions	J4	(Interviewer:427-428) For other people though in other roles, in other analytical roles it might... it would probably use more for report writing I would say {role specific}.	*Role specific	

Figure 33 - Chapter 3: RQ1.2 Tree Layout for Open Coding with relationships between categories



5. Discussion

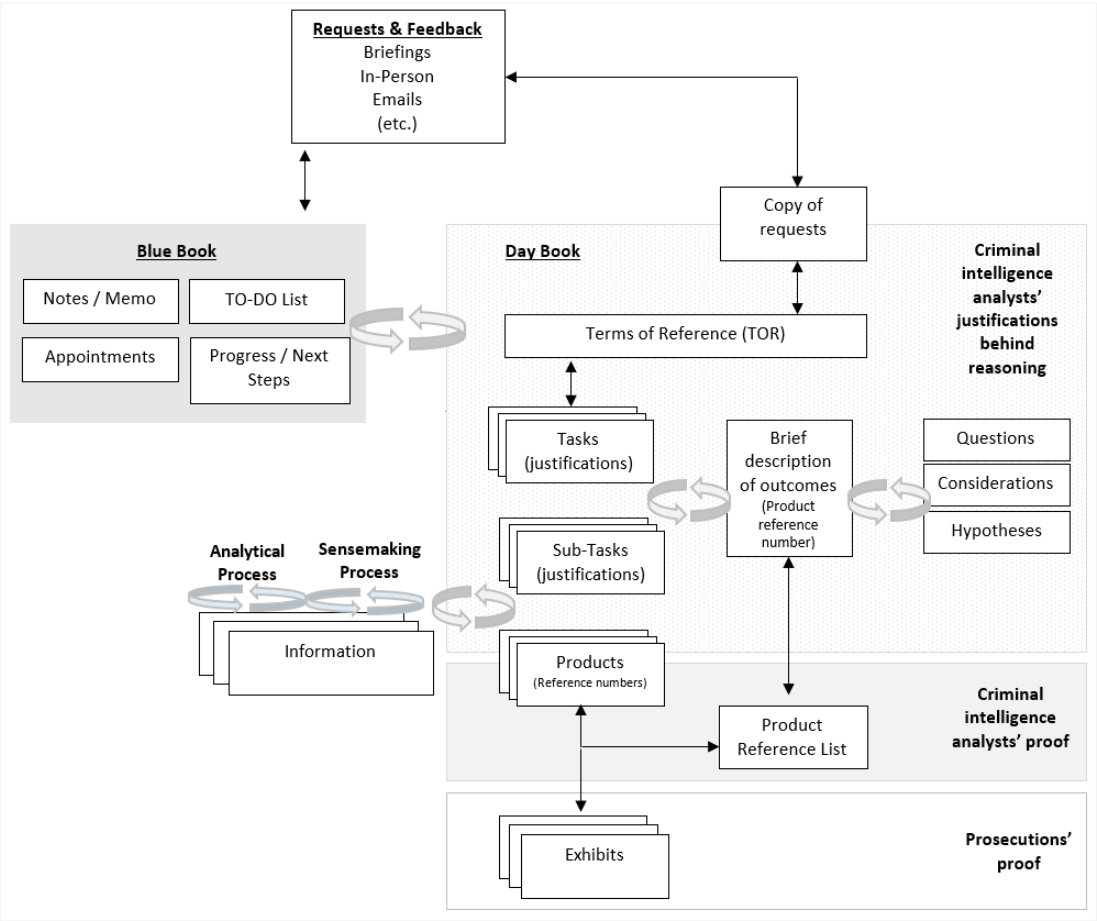
Criminal intelligence analysts refer to the process of recording their rationale as a defensible assessment, rather than the process of creating arguments:

(a) An assessment of what? An assessment of the quality of the analytical work that they are performing in relation to the investigation.

(b) Defensible how? Defensible to the degree that the TOR is supported by the justifications that they have written down for performing specific analytical tasks and the decision-making that followed from the task outputs.

(c) Written down how? Figure 34 has been constructed from the research results outlined in this chapter and explains the process on how criminal intelligence analysts make entries into the day-book: Criminal intelligence analysts use two physical mediums to record (write-down) their rationale namely the blue-book and the day-book. The blue-book serves as a business diary and helps criminal intelligence analysts with overall timekeeping in relation to the various investigations that they are working on. It is therefore used alongside the day-book and updated as the investigation progresses. The day-book is case-specific and records criminal intelligence analysts' rationale and the justifications behind their rationale. In other words – it records what they are doing and why.

Figure 34 - Chapter 3: Overview of the day-book process



Investigative Officers (IO) can ask criminal intelligence analysts to use the relevant information to answer specific questions in relation to the investigation. These requests can happen at the beginning of the investigation in a briefing room and can expand and update as the investigation progresses. Updates or feedback can happen in person or via electronic mediums such as emails. Criminal intelligence analysts make a copy or a summary of the IO's requests in their day-books and these requests are known as the Terms of Reference (TOR). The TOR serves as the wider objectives that criminal intelligence analysts need to work towards. To answer the TOR, criminal intelligence analysts write down tasks and sub-tasks in their day-books. These are the tasks that they want to perform to answer the TOR. Criminal intelligence analysts write down why they want to perform the tasks and what they are hoping to achieve by performing it. These serve as justifications for what they are doing and why. Each of the tasks involves the analysis of the underlying information, so criminal intelligence analysts will follow various analytical and sensemaking processes as outlined in the literature chapter. Criminal intelligence analyst's write down a brief description of the task outcomes.

The justification for performing the task and the outcome of the task form the basis of criminal intelligence analysts' considerations on how best to proceed with the investigation. It may also lead to questions that criminal intelligence analysts have about the investigation or questions that they need to ask the IO. It may also lead to the generation of hypotheses. The considerations, questions and hypotheses lead to criminal intelligence analysts writing down further tasks and subtasks that progress the investigation.

Criminal intelligence analysts' proof lies in the outputs that they have written down and the underlying products that they produced during the analytical and sensemaking processes. Each task outcome is cross-referenced with a product list which points to a specific product. Products can be anything from formatted spreadsheets to network diagrams and timelines. Criminal intelligence analysts therefore have tasks with a justification for performing the task, the outcome of the task which is underpinned or anchored in proof or evidence.

At the end of the investigative process, the criminal intelligence analyst would collate their findings to produce exhibits, which would form the basis for the prosecutions' proof.

When considering argumentation in the words of criminal intelligence analysts as a defensible assessment, then the justification that they supply is to prove that their analysis is correct and that the analytical process that they followed is fair, unbiased and relevant to the TOR. Criminal intelligence analysts want to prove that the level of confidence that they have in their findings is supported by the analytical process that they followed. In doing so, criminal intelligence analysts produce the necessary facts or evidence that the prosecution can use as a justification for the state to prove that a person is, without a reasonable doubt, guilty of a particular crime. Both sides (referring to criminal intelligence analysts and the prosecution) need to use the understanding of crime and criminals to produce or present enough evidence in a court of law for the evidence to 'stick'.

If we were to ask the prosecution what they are arguing for, then the prosecution would say that they are arguing for a conviction. If we were to ask criminal intelligence analysts the same question, then from the day-book process we can infer that they would say that they are arguing

for the acceptance/belief/confidence that their findings and interpretations are correct for the conviction to 'stick'. The argument that each side make is therefore used for the purpose of satisfying different criteria or agendas.

By the end of the day, both sides do prove the same thing, person x is guilty of y, but one side is creating the evidence that the other side will use as proof. Proof for the prosecution is the exhibits that criminal intelligence analysts produced. Proof for criminal intelligence analysts are the products they produced during the analytical process that underpin the outcomes, the interpretations they made from the outcomes and the level of confidence that they have on how correct those outcomes are. This may be why the criminal intelligence analyst did not mention the argumentation terminology of premise or conclusion during the interview, but made use of task, outcome and justification. The researcher refers to this as the task-outcome-justification combination.

Criminal intelligence analysts are not arguing that Joe Bloggs was at the crime scene, they are arguing that their analysis is good enough to infer that Joe Bloggs was at the crime scene. It is up to the IO to find witnesses and for the prosecution to convince the jury through argument and narrative, that Joe Bloggs was at the crime scene. Granted that this may be a subtle difference, maybe even as subtle as changing the terminology of premise and conclusion to the task-outcome-justification combination, but it may be important for researchers to note – what is your user group really arguing for?

From the results outlined in this chapter, it is the researcher's belief that criminal intelligence analysts are trying to prove that their analysis is correct, so that their intelligence and exhibits can be trusted by downstream processes such as criminal trials. Their 'argument' is therefore different to the 'argument' that the prosecution is making. Some of the differences to consider are as follow:

» Criminal intelligence analysts: Do these tasks produce an outcome that support the justification?
- Prosecution: Do these premises support the conclusion?

» Criminal intelligence analysts: Do I need all of these sub-task outcomes or only some of these sub-task outcomes to support the main task's outcome?
- Prosecution: Do I need all of these premises or only some of these premises to support the conclusion?

» Criminal intelligence analysts: How coherent is my analysis from each sub-task for the outcome of the main task to be accepted?
- Prosecution: How coherent are the causal relationships between premises explained for the conclusion to be accepted?

The difference in what someone is trying to prove, may be a reason why so many software programs include argumentation nodes that are not part of the standard view of argumentation, for example, the inclusion of questions (for examples see section: *Using Argumentation Linked-Diagrams in Software*).

The recording of criminal intelligence analysts' analytical rationale may be implicitly implied by models and guidelines from NIM and APP. It might be useful to have a section in NIM and APP on how criminal intelligence analysts can record the analytical rationale that drive their decision-making and why they made those decisions, rather than just having ways and methods in which criminal intelligence analysts can perform the analysis. This chapter contributes to NIM by outlining what the current rationale-formulation process is.

This chapter answered Research Question 1 (as described in Chapter 1) in the following way:

Research Question 1: If we were asked to transfer the existing working practices of criminal intelligence analysts' analytical rationale-formulation process into NPDS or similar initiatives – what would we implement?

Answer*:* Criminal intelligence analysts currently make use of a physical medium known as a day-book to record their analytical rationale in the format of task-justification-outcome combination. Figure 34 can be used by developers as-is, to transfer the physical medium of capturing the analytical reasoning-formulation process into a soft-copy to create defensible assessments.

This chapter serves as an initial study which reveals the task-justification-outcome combination during the externalisation of criminal intelligence analysts' rationale-formulation process. The next chapter extends the concepts that were found in this chapter by exploring how the task-justification-outcome combination can relate to formal argument constructs and how the rationale-formulation process happens, in terms of structures used and increasing criminal intelligence analysts' confidence-levels.

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Chapter Four
Formulation of Analytical Rationale

1. Introduction

Earlier chapters revealed how criminal intelligence analysts externalise their analytical rationale using a physical medium known as a day-book. Their analytical rationale consists of; (a) supplying reasons/justifications for performing specific tasks; (b) by being confident that the outcomes of those tasks sufficiently contribute to their understanding of a criminal situation and; (c) that the outcomes are sufficiently underpinned by various products that serve as evidence. Criminal intelligence analysts thus produce an analytical assessment that support their understanding of a criminal situation and that assessment can be defended with the analytical rationale that they externalised.

An externalised account of criminal intelligence analysts' analytical rationale is only half the story. The motivation for this chapter is to understand the other half of the story, which is to understand how criminal intelligence analysts develop their analytical rationale from the onset of a criminal investigation when they receive the Terms of Reference (TOR), until completion when the exhibits are sent to court.

The literature section outlined that arguments have at least (a) a starting and end point (b) that there is a relationship between the starting and end point (c) that there is some structure and grouping involved (d) there is some form of judgement or rationality involved in the relationship between the start and end point. From the results of the previous chapter, it is seen that the start and end point can refer, on a granular scale, to the tasks/justifications and the outcomes of those tasks. On a holistic scale, it can refer to the TOR and the exhibits that answer and support the TOR. It can also be seen that the relationship between the task and outcome is as such, so that the outcome honours the justification or the reason for performing a particular task. From the results it was less clear how criminal intelligence analysts' confidence in their analytical rationale develop and which structures they employ to help with developing their analytical rationale. This chapter tries to answer those questions.

2. Research Questions Overview

Chapter one outlined the following three research questions as follow:

Research Question 2 (RQ2): How do criminal intelligence analysts develop confidence in their analytical rationale, so that they are confident that the intelligence products that they produced sufficiently address the Terms of Reference?

Research Question 3 (RQ3): Which structures do criminal intelligence analysts employ to assist with developing their analytical rationale?

Research Question 4 (RQ4): How relatable is the analytical reasoning process with formal argumentation?

RQ2 is addressed in Study Part 1 and RQ3 is addressed in Study Part 2 below. RQ4 is embedded in within Study Part 1 and 2.

3. Study Part 1

RQ2: How do criminal intelligence analysts develop confidence in their analytical rationale?

3.1. Research method

To answer this research question, the researcher made use of the Cognitive Task Analysis (CTA) technique. The elicitation of knowledge from experienced criminal intelligence analysts were obtained through the Critical Decision Method (CDM). Thereafter, the analysis of the data obtained through CDM was analysed using mixed methods.

3.1.1. Knowledge elicitation using Critical Decision Method

The researcher organised a meeting with experienced criminal intelligence analysts from the Belgium police force. Access to these criminal intelligence analysts were made possible through the VALCRI project. The interviews took place in a conference room on the police premises. The participants were notified beforehand that they were going to be asked to recall a memorable case that they have worked on. It was not a requirement for the case to have been in a solved status, only that the case had enough details to talk about. The participants were invited to bring along any materials that would help them recall the case, such as timelines and maps. These materials were confidential and were not recorded or replicated in any way.

The researcher made use of the following equipment during the interviews; an A3 spiral bound book, yellow sticky notes, a pencil, a voice recorder and a video camera on a tripod. The book, sticky notes and pencil were used to capture the participant's key decisions during a memorable case. The voice recorder was used to capture the voice of the participants. The video recorder served as a backup if the voice recorder should fail and was placed in such a manner to only capture the entries in the book. The participants' faces were not recorded.

Only one participant was interviewed at a time and each interview lasted around sixty minutes in duration. The participant was greeted by the researcher and the procedure of the study was explained. A consent form was handed to the participant which requested permission to be interviewed and for their voice to be recorded. One signed copy was handed to the participant and the researcher kept a second signed copy for her records.

The structure of the interview was as follow:

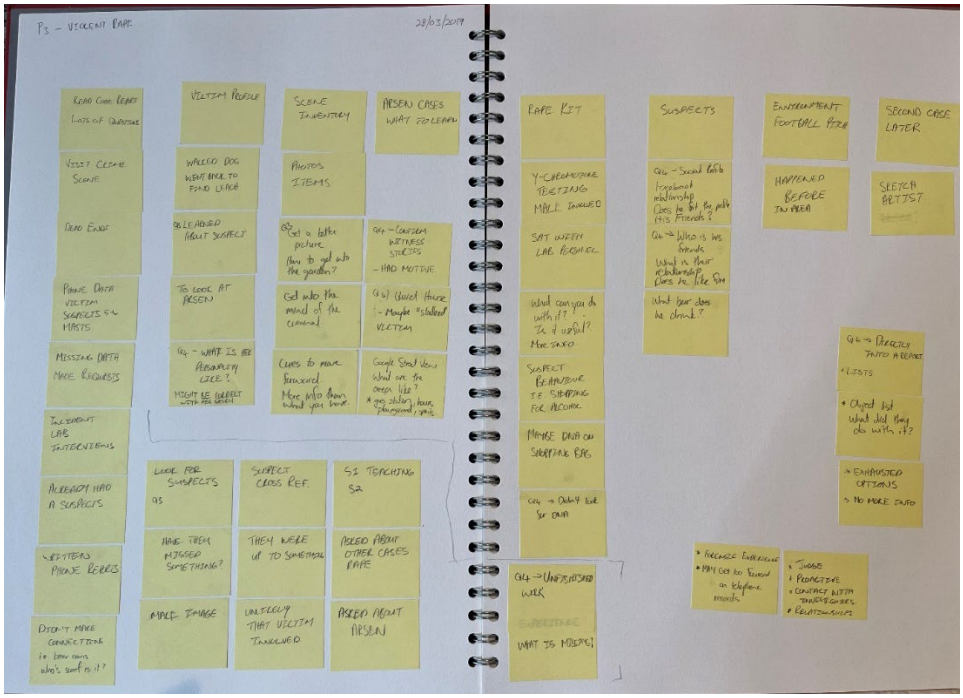
- Step 1: Get an overview of the case with key areas: The researcher informed the participant that she wanted to start with an overview of the case and the participant should point out the key areas that affected the participant's reasoning and decision-making. As the participant provided an overview of the case, the researcher wrote down the key areas that the participant concentrated on as part of the participant's reasoning process. Each key area was written down on a sticky note and placed in a horizontal line

to form a timeline of the case. The participant was sitting next to the researcher and could observe what was being written down and was invited to comment or correct the researcher. The researcher chose to write down the key areas in her own handwriting, so that the notes could be legible and understandable after the interview.

- Step 2: Delve deeper into each key area: After an overview was provided, the researcher informed the participant that she wanted to go deeper into each key point in order to get more details. This process resulted in columns of sticky notes. The researcher led with open-ended questions to elicit knowledge from the participant. Typical questions were as follow; What made this a key area? What did you try to accomplish here and why? What other activities did you do here and why? What happened after you completed this activity? What else did you think of here? What have you learned by doing this activity? Where/how did you get the information at this point? What difficulties or problems did you face during this activity? How confident were you at this point about what was going on? What were you thinking about here?
- Step 3: Repeat: The final step is to repeat step 2 until the participant is unable to add any further details to any of the sections. This is to ensure that all possible knowledge has been elicited from the participant. When a key area had too many sticky notes to go down any further vertically, the researcher made a pencil mark to separate the areas and continued to expand the area horizontally.

Figure 35 is an example of the output of the CDM for one of the participants.

Figure 35 - Chapter 4: Study 1: Example of CDM



At the end of the interview, the researcher thanked the participant for the participant's time and for sharing his/her knowledge so generously. The voice recorder and the video recorder were

stopped to compartmentalise the data of each interview. The researcher took a short break between interviews whilst the availability of the next participant was determined, and participation organised.

Limitations:

At the completion of the interviews, sadly and possibly ironically, the researcher fell victim to theft and all of the recording equipment were stolen on her way back to the research facility. The research data was not backed up to the cloud and the only surviving item was the A3 book. It was not financially possible to re-do the interviews and the notes in the book was not enough to conduct the necessary analysis as required. It was however a valuable learning experience on how to conduct CDM interviews and to interact with the criminal intelligence analysts in person.

In order to complete the research for this chapter, the researcher made use of similar CDM interviews that were conducted by senior researchers at a prior date. They too made use of CDM, and the interviews were conducted with experienced criminal intelligence analysts from West-Midlands police and the Belgium police forces. This is seen as a positive, as the participants for these interviews covered both volume crime analysis as well as serious crime. The interviews on the stolen equipment only covered serious crime.

3.1.2. Analysis using mixed methods

The researcher used Qualitative Directed Content Analysis (Hsieh and Shannon, 2005) to find existing concepts from the literature within the transcripts as a deductive coding process (Corbin and Strauss, 2014; Khandkar, 2009). A subset of the emerging theme approach (Wong, 2003) was used as an inductive coding process (Corbin and Strauss, 2014; Khandkar, 2009). The emerging theme approach is considered a subset as it only made use of step 2 (Theorise New Structures and Themes). Coding was done on a per-section basis, rather than line-by-line.

This deductive coding process was used in the odd stages 1, 3, 5 and 7 of the analysis. The inductive coding process was used for the even stages 2, 4, and 6 of the analysis where codes and relationships were derived from the odd stages. The analysis process is therefore a progressive process where deductive stage 1 (literature) leads to inductive stage 2 (inferring meaning) which leads to deductive stage 3 (use the inferred meaning to find the next set of relevant literature to use as codes) and so on. The final stage 8 of the analysis uses axial coding to create categories and subcategories (Strauss and Corbin, 1998). Each stage is explained in the sections that follow.

Stages:

The **first stage** of analysis on the data set was an exercise to investigate if concepts from the literature were present, in particular; broadening and narrowing strategies (Patterson et al., 1999; Elm et al., 2005); anchoring, laddering and associative questioning strategies (Wong and Kodagoda, 2015); and the concepts from Pirolli and Card's (2005) notional model of sensemaking.

Patterson et al.'s (1999) and Elm et al.'s (2005) work were chosen as it contributes to the understanding of the broadening and narrowing strategies that criminal intelligence analysts could employ to either branch out for more information or to focus in more detail on a specific topic. This provides links to the foraging activities that Pirolli and Card (2005) outlined in their notional model of sensemaking.

The concepts from Pirolli and Card's (2005) notional model of sensemaking were chosen, as it supplies an outline on how criminal intelligence analysts progress from foraging activities on the initial information, to the shoe-boxing of evidence, to the population of larger structures or schemas, to the formulation of hypotheses which eventually, through a complex set of cyclical loops, lead to the presentation of intelligence.

Wong and Kodagoda's (2015) work were chosen as it contributes to the understanding on how anchoring is used by criminal intelligence analysts to create initial starting points (known as anchors) to start the investigation when evidence is limited or ambiguous. Criminal intelligence analysts can develop and elaborate their understanding (known as laddering) through various analytical tasks. Criminal intelligence analysts make use of associative questioning to adjust their initial anchors. Wong and Kodagoda's (2015) work tie in with the sensemaking loops that Pirolli and Card (2005) described. Wong and Kodagoda's (2015) concepts are also very much in line with the concepts of Klein et al.'s (2007) data frame theory, where frames are created, elaborated and questioned.

Frames are illustrative of criminal intelligence analysts' initial understanding of a criminal case, so by searching for Wong and Kodagoda's (2015) concepts, one naturally includes Klein et al.'s (2007) concepts. Gerber et al. (2016) expanded the ideas of Klein et al. (2007) and Wong and Kodagoda (2015) by explaining how criminal intelligence analysts use leaps-of-faith, insight and intuition to create those first anchors or frames to progress the criminal case when evidence is limited or ambiguous. Gerber et al.'s (2015) explained that these concepts are more tacit and thus more difficult to infer from a data set. The researcher of this thesis believed that she would not contribute further understanding to Gerber et al.'s work and thus did not include it.

Figure 36 - Chapter 4: Study 1: First Stage of Analysis - Linking the literature to the data set

Literature link	Interview snippets
- [1] Narrowing & Broadening - [2] Step 5 – Read and Extract - [2] Step 6 – how are they related? - [3] Anchoring & Laddering	[A1.1]: (P3:127) …Look at the times of the offending if it was all overnight tight time period. [A1.2]: (P3:146-148) … the method of entry was through the back of the houses and it was forced entry, so we had a pretty good idea that it was the same offenders. [A1.3]: (P3:124) …looked at about three or four different areas to see to see if there was any trend in the location…times, similar MO, matched property stolen. [A1.4]: (P9:38) …all the dots with the same MO…get all case numbers…call records… and do it all over for each …you go deeper into this… you always have the same gang. [A1.5]: (P2:188-190) …they had an appointment and it was always the same way, it was always… first the advertisement then the phone call, then the appointment, then another appointment and then the deal. [A1.6]: (P2:419-422) …It comes back all the time that there's the guy who is with him is wearing glasses that is driving the car and the other one is not driving the car… so you can make the connection

Upon completion of the first stage of analysis on the data set, the literature concepts were linked to the relevant interview snippets. An example is illustrated in Figure 36. The relevant literature is numbered so that [1] references Patterson et al.'s (1999) and Elm et al.'s (2005) work, [2] references Pirolli and Cards' notional model of sensemaking (2005) and [3] references Wong and Kodagoda's (2015) work. Each relevant interview snippet is referenced with a numbering system that starts with a letter and followed with a number within square brackets, for example [A1.1]. This is to assist with referencing the relevant interview snippet within the results section.

In the **second stage** of the analysis, the researcher tied each strategy from the literature to a task that the criminal intelligence analyst performed as illustrated in Figure 37. This is an inferencing task on the researcher's part. The question that the researcher asked was, "Based on the interview, what task did the criminal intelligence analyst perform at this stage?"

Figure 37 - Chapter 4: Study 1: Second Stage of Analysis – Identifying tasks

Task	Literature link	Interview snippets
Task to establish the MO of multiple crime reports	- [1] Narrowing & Broadening - [2] Step 5 – Read and Extract - [2] Step 6 – how are they related? - [3] Anchoring & Laddering	[A1.1]: (P3:127) …Look at the times of the offending if it was all overnight tight time period. [A1.2]: (P3:146-148) … the method of entry was through the back of the houses and it was forced entry, so we had a pretty good idea that it was the same offenders. … (rest of data)

By using the identified task and the literature links, the researcher inferred the likely justification (or analytical rationale) for performing the task as illustrated in Figure 38. The question that the researcher asked was, "Based on the interview snippets and the task, how would the criminal intelligence analyst justify the need for performing this task?"

Figure 38 - Chapter 4: Study 1: Second Stage of Analysis – Inferring the analytical rationale

Task	Task Rationale / Justification	Literature link	Interview snippets
Task to establish the MO of multiple crime reports	Can temporarily link cases and assume that same offenders are involved as justification for further analysis	- [1] Narrowing & Broadening - [2] Step 5 – Read and Extract - [2] Step 6 – how are they related? - [3] Anchoring & Laddering	[A1.1]: (P3:127) …Look at the times of the offending if it was all overnight tight time period. [A1.2]: (P3:146-148) … the method of entry was through the back of the houses and it was forced entry, so we had a pretty good idea that it was the same offenders. … (rest of data)

The researcher then used the identified task, rationale and literature to infer how the task's outcome would influence the criminal intelligence analysts' confidence level as illustrated in Figure 39. The question that the researcher asked was, "How would the criminal intelligence analyst's confidence level be influenced after performing this task?"

Figure 39 - Chapter 4: Study 1: Second Stage of Analysis – Inferring the effect of the task outcome on the criminal intelligence analyst's level of confidence

Task	Task Rationale / Justification	Task Outcome / Achievement	Literature link	Interview snippets
Task to establish the MO of multiple crime reports	Can temporarily link cases and assume that same offenders are involved as justification for further analysis	Cases are linked, therefore increased confidence in their anchoring point that justifies them to go deeper into the analysis	- [1] Narrowing & Broadening - [2] Step 5 – Read and Extract - [2] Step 6 – how are they related? - [3] Anchoring & Laddering	[A1.1]: (P3:127) …Look at the times of the offending if it was all overnight tight time period. [A1.2]: (P3:146-148) … the method of entry was through the back of the houses and it was forced entry, so we had a pretty good idea that it was the same offenders. … (rest of data)

In the **third stage** of the analysis, the researcher then went back to the literature to find a possible link that could tie the tasks and outcomes to argumentation concepts.

The researcher found that Pirolli and Card's (2005) notional model of sensemaking made references to a top-down approach where:

- Pirolli and Card's (2005) step 15 (are we sure?) can be associated with the level of confidence that criminal intelligence analysts have regarding their understanding about the information and the criminal case. Each task that criminal intelligence analysts perform is done to increase their confidence in what they believe to be happening in the criminal case.

- Pirolli and Card's (2005) step 12 (how do we know?) can be associated with the outcomes from the tasks and can be offered as proof to a challenger such as the decision-makers.

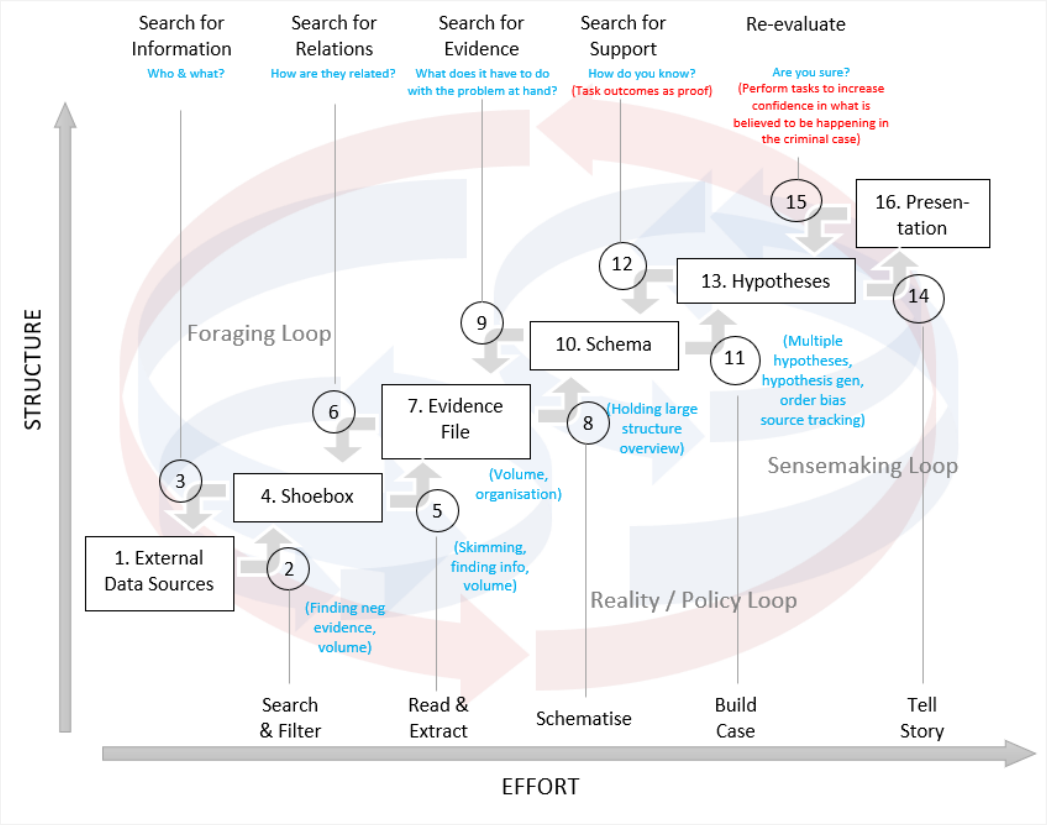
Currently these questions are only part of the re-evaluative process (top-down approach), after analysis is complete and the decision-makers ask questions about the analysis. By changing the wording of each top-down approach from 'we' to 'you' – it can become part of the bottom-up approach.

Pirolli and Card's (2005) top-down approach can therefore be used by criminal intelligence analysts as part of their bottom-up approach to create defensible assessments and to link Pirolli and Card's (2005) model to argumentation.

Criminal intelligence analysts can enter into an 'argumentation loop' by asking themselves Pirolli and Card's (2005) questions; 'are you sure?' and 'how do you know?'.

The argumentation loop is not currently part of Pirolli and Card's (2005) Notional Model of Sensemaking, but the results in this chapter outline how it could form part of Pirolli and Card's (2005) model as shown in red within Figure 40.

Figure 40 - Chapter 4: Study 1: Notional Model of Analytical Sensemaking with the argumentation loop related to confidence and proof. Adapted from Pirolli and Card (2005)



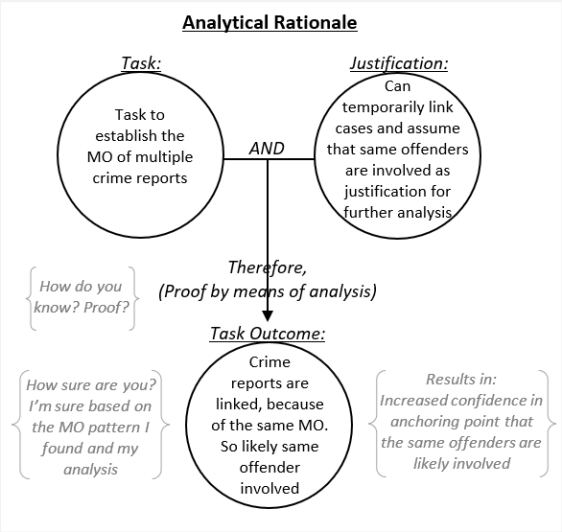
Pirolli and Card's (2005) steps 12 and 15, also links criminal intelligence analysts' confidence-level to the argumentation question of 'how sure are you?' which are typically illustrated through a linked-notation in argumentation maps (Freeman, 1991). Linked-notation indicates that *all* premises are needed to support the conclusion. Similarly, a linked-notation can be used to illustrate that all of the analytical tasks that criminal intelligence analysts perform, are needed to accept the analytical outcome. The researcher therefore included Pirolli and Card's (2005) step 12 and 15 to the analysis and were able to link the tasks in the data set to the concepts of argumentation as illustrated in Figure 41.

Figure 41 - Chapter 4: Study 1: Third Stage of Analysis – Including links to Argumentation

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to establish the MO of multiple crime reports	Can temporarily link cases and assume that same offenders are involved as justification for further analysis	Cases are linked, therefore increased confidence in their anchoring point that justifies them to go deeper into the analysis	- Are you sure that you are clear about the pattern here, so that you can link the cases? - Proof is the justification in relation to the observations that suggest that they are linked	- [1] Narrowing & Broadening - [2] Step 5 – Read and Extract - [2] Step 6 – how are they related? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring & Laddering	[A1.1]: (P3:127) …Look at the times of the offending if it was all overnight tight time period. [A1.2]: (P3:146-148) … the method of entry was through the back of the houses and it was forced entry, so we had a pretty good idea that it was the same offenders. … (rest of data)

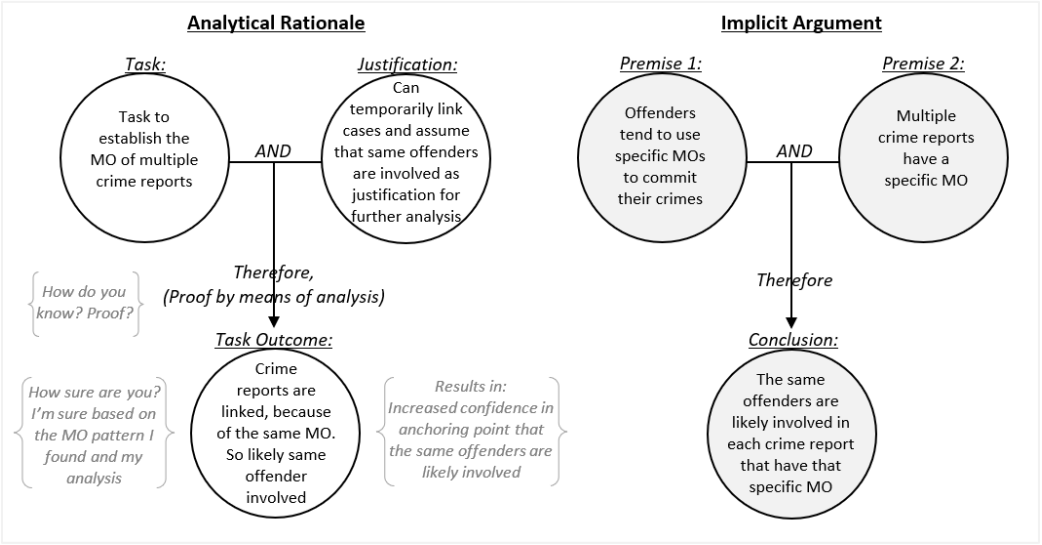
The **fourth stage** of the analysis was to construct a linked diagram for the task, the justification and the outcome to represent the analytical rationale.

Figure 42 – Chapter 4: Study 1: Fourth Stage of Analysis - Depiction of analytical rationale



The researcher then went back to the literature in an attempt to determine how the analytical rationale could be linked to argumentation concepts. Govier (2014) demonstrated how arguments can have implicit conclusions and implicit premises. Implicitness can make an argument look cogent, but unless all of the conclusions and premises are made explicit – the ambiguity and vagueness can lead to fallacy of equivocation. The researcher went back to the analytical rationale (see Figure 42) and asked the question, "What is being argued here implicitly?". This question led to the construction of a possible implicit argument that would correspond to the analytical rationale.

Figure 43 – Chapter 4: Study 1: Fourth Stage of Analysis - Depiction of an implicit argument that corresponds to the analytical rationale



In most cases within the results section, the implicit arguments are generalised (see Figure 43). The generalised term 'offenders' can be substituted with something specific such as 'Jo Bloggs' so that premise 1 would read as, 'Jo Bloggs tends to use a specific MO to commit his crimes', and the conclusion to read, 'Jo Bloggs is likely involved in each crime report with that specific MO'.

The **fifth stage** of the analysis involved the researcher to go back to the literature to identify possible cognitive biases that could occur as part of the identified analytical rationale. The cognitive biases that were considered is based on those identified in the literature (see chapter 2, section 2.3) from Heuer (1999), the United States Government Centre for the Study of Intelligence (2009) and the SIRIUS program (MITRE, 2016).

In the **sixth stage** of the analysis, the researcher considered the identified analytical rationale along with the identified cognitive biases and inferred possible 'critical questions for analytical rationale' that could mitigate those identified cognitive biases.

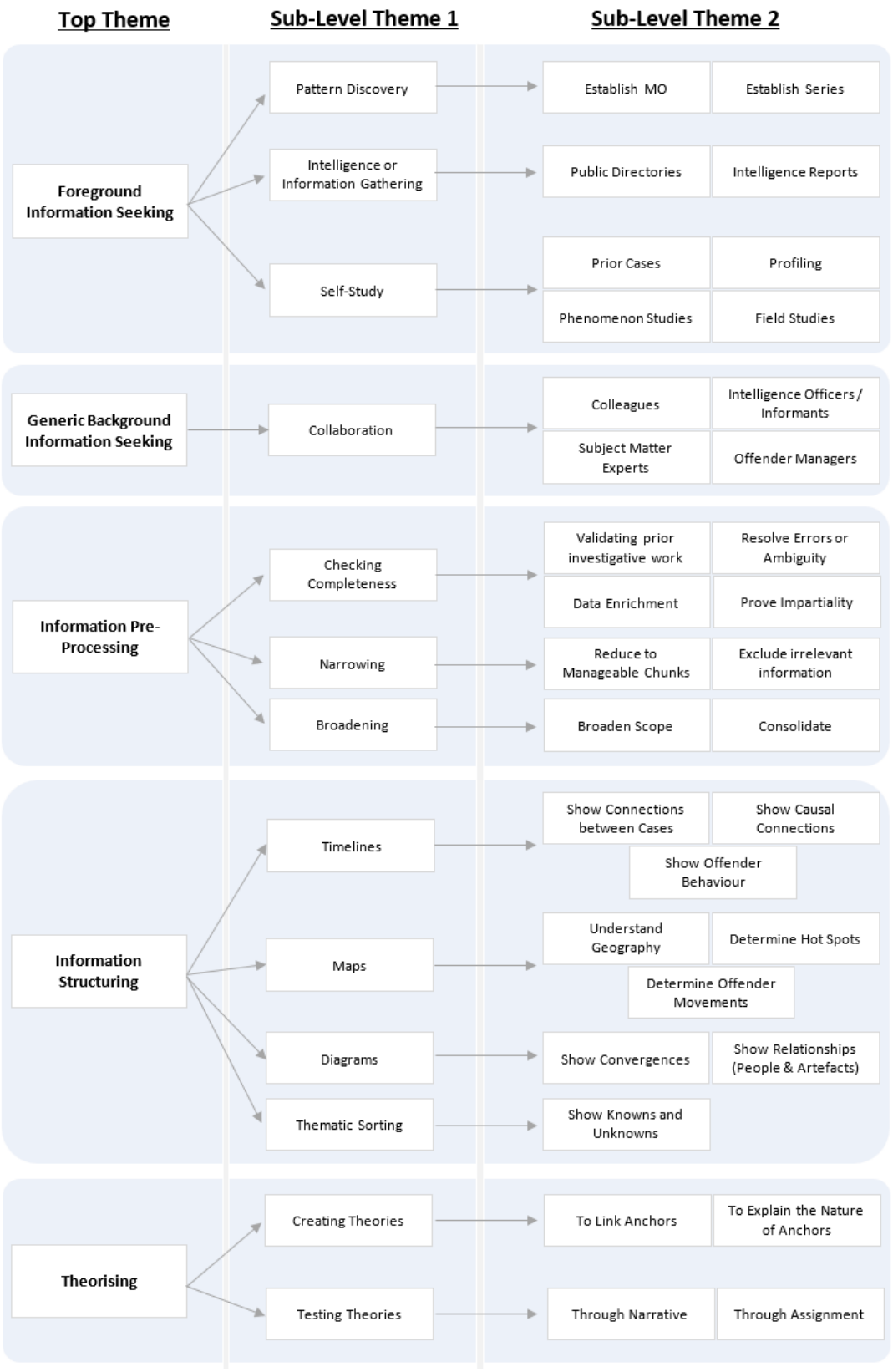
As part of the sixth stage, the researcher went back to the literature to identify the possible critical questions (Walton et al., 2008) that would suit the identified implicit argument for the analytical rationale.

The **seventh stage** of the analysis was to thematically group the various tasks according to the type of analytical activity the criminal intelligence analyst was conducting. An example is illustrated in Figure 44. This classification led to a three-tier structure where the top-level themes emerged as: Foreground Information Seeking, Generic Background Information Seeking, Information Pre-Processing, Information Structuring and Theorising (see in Figure 45). This exercise provides researchers with a different lens to consider the various stages within Pirolli and Card's (2005) notional model for sensemaking.

Figure 44 – Chapter 4: Study 1: Seventh stage of Analysis – Thematic sorting

NVivo Top Theme	NVivo Sub Theme 1	NVivo Sub Theme 2	Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Foreground Information Seeking	Pattern Discovery	Establishing MO	Task to establish the MO of …	Can temporarily link cases and assume …	Cases are linked, therefore increased confidence …	- - Are you sure that you are clear about the pattern here, so that …	- [1] Narrowing & Broadening - [2] Step 5 – Read and Extract …	[A1.1]: (P3:127) …Look at the times of the offending … (rest of data)

Figure 45 - Chapter 4: Study 1: Three-tier hierarchy of identified NVivo themes



3.2. Results

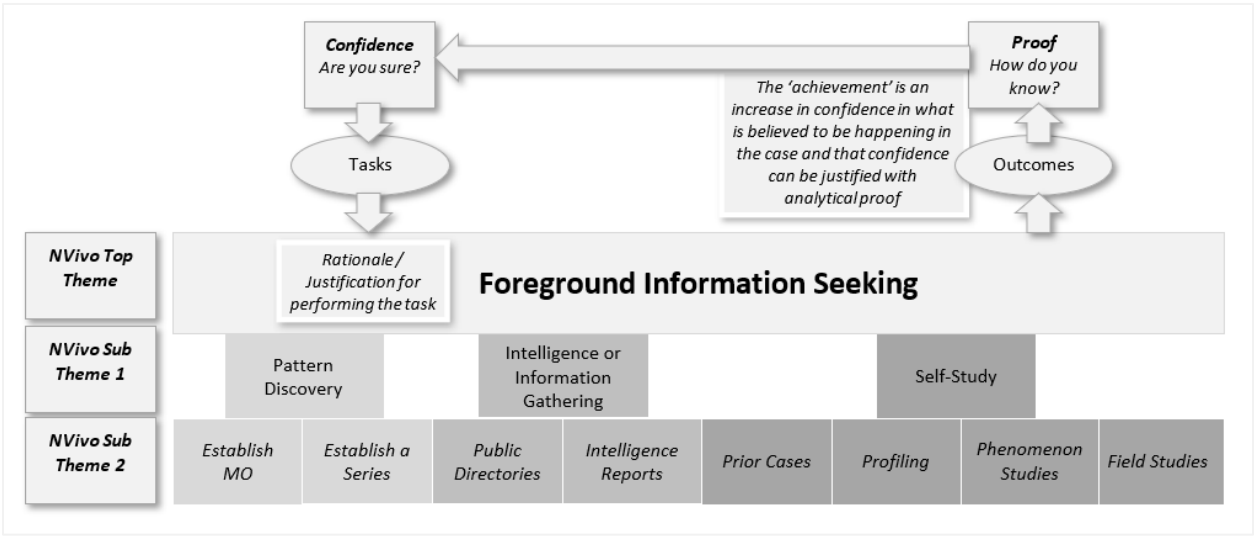
A sub-section of the results reported here, is published in the 13th Bi-annual International Conference on Naturalistic Decision Making.[6] The researcher performed the analysis for that paper and concentrated on what criminal intelligence analysts were trying to achieve through the various analytical tasks that they were engage with. It was the first attempt by the researcher to try and understand how criminal intelligence analysts develop their rationale. The co-authors helped with structuring the paper and proof-reading.

The results that follow is the continuation of that research paper and has subsequently evolved to concentrate on tasks, justifications, outcomes and implicit arguments. This change in focus was made possible by the new understanding on how criminal intelligence analysts currently formulate their rationale, as discussed in chapter three.

(A) Foreground Information Seeking

The NVivo emerging theme of foreground information seeking refers to those activities where criminal intelligence analysts are actively working with the information that they have in front of them. This NVivo emerging theme would equate to the foraging loop within Pirolli and Card's (2005) Notional Model of Sensemaking, where information moves from external data sources to the shoebox and eventually to the evidence file. The processes involved would equate to searching for information and to read and extract prominent information relating to offenders and their offending patterns. Figure 46 provides an overview of what Foreground Information Seeking entails.

Figure 46 - Chapter 4: Study 1: Foreground Information Seeking - Overview



[6] How analysts think: navigating uncertainty – aspirations, considerations and strategies
Groenewald, Celeste, Wong, B. L. William, Attfield, Simon, Passmore, Peter J. and Kodagoda, Neesha (2017) How analysts think: navigating uncertainty – aspirations, considerations and strategies. NDM13 Naturalistic Decision Making and Uncertainty: Proceedings of the 13th International Conference on Naturalistic Decision Making, 20-23 June 2017, Bath, UK. In: 13th Bi-annual International Conference on Naturalistic Decision Making (NDM13), 20-23 June 2017, University of Bath, Bath, United Kingdom. ISBN 9780861971947.

The results listed in each NVivo category outlines the play between Elm et al.'s (2005) Broadening and Narrowing strategies and Wong and Kodagoda's (2015) anchoring, laddering and associative questioning concepts.

(AA) Pattern Discovery

(AA1) Establishing the MO

Criminal intelligence analysts can have a task to read through the details of different crime reports to establish and extract an offending pattern (narrowing) known as the Modus Operandi (MO). The MO describes when, where and how offenders prefer to offend. Engagement with this type of task is justified with the reasoning that the discovery of an offending pattern can serve as a starting point (anchor) for further analysis (laddering). Further analysis could be in the form of linking cases together (broadening) based on the MO, to get a deeper understanding of which offenders could possibly be involved and how they are involved. Once criminal intelligence analysts establish a pattern, they have more confidence in their understanding of what is happening in the crime reports and the likelihood of the same offenders being involved. They can have confidence that their understanding is underpinned with analytical proof, based on the completed task of establishing an offending pattern.

Table 9 – Chapter 4: Study 1: NVivo coding of interview snippets for: Foreground Information Seeking –> Pattern Discovery –> Establishing the MO

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to establish the MO of multiple crime reports	Can temporarily link cases and assume that same offenders are involved as justification for further analysis	Cases are linked, therefore increased confidence in their anchoring point that justifies them to go deeper into the analysis	- Are you sure that you are clear about the pattern here, so that you can link the cases? - Proof is the justification in relation to the observations that suggest that they are linked	- [1] Narrowing & Broadening - [2] Step 5 – Read and Extract - [2] Step 6 – how are they related? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring & Laddering	**[AA1.1]:** (P3:127) …Look at the times of the offending if it was all overnight tight time period. **[AA1.2]:** (P3:146-148) ... the method of entry was through the back of the houses and it was forced entry, so we had a pretty good idea that it was the same offenders. **[AA1.3]:** (P3:124) …looked at about three or four different areas to see to see if there was any trend in the location…times, similar MO, matched property stolen. **[AA1.4]:** (P9:38) ...all the dots with the same MO…get all case numbers…call records… and do it all over for each …you go deeper into this… you always have the same gang. **[AA1.5]:** (P2:188-190) …they had an appointment and it was always the same way, it was always… first the advertisement then the phone call, then the appointment, then another appointment and then the deal. **[AA1.6]:** (P2:419-422) …It comes back all the time that there's the guy who is with him is wearing glasses that is driving the car and the other one is not driving the car… so you can make the connection **[AA1.7]:** (P2:558-559) …and I see his name coming back...so I can put one person with the same name on the chart and put them together to create a link.

By referring to Table 9, the task for the criminal intelligence analyst in each interview snippet was to establish if an offending pattern existed; In AA1.1 the criminal intelligence attempted to establish if the offending occurred over a particular period of the night. In AA1.3 the criminal intelligence analyst attempted to use different variants of the MO details (referring to geography, time and offending behaviour) to establish an offending pattern. In AA1.5, AA1.6 and AA1.7 the criminal intelligence analyst used the sequence of events along with offending behaviour to establish the offending pattern. In AA1.2 and AA1.4 the outcome of the task of discovering an offending pattern afforded the criminal intelligence analyst with the ability to link multiple crime records together. By doing so, the criminal intelligence analyst had confidence in who the likely offenders were and where to direct the next set of analytical activities. AA1.4 is illustrative of the amount of analysis that could go into establishing if an offending pattern exists or not.

In each of the interview examples, the criminal intelligence can test their level of confidence with their understanding of the criminal case, by asking Pirolli and Card's (2005) step 15 question – 'Are you sure [that you are clear about the pattern here, so that you can link the cases]?'.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can use the outcomes of the pattern discovery tasks as justifications for suggesting that different crime reports are linked based on the MO and therefore permits further analysis into those offenders.

Figure 47 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the pattern discovery tasks lead to the conclusion that crime reports are linked

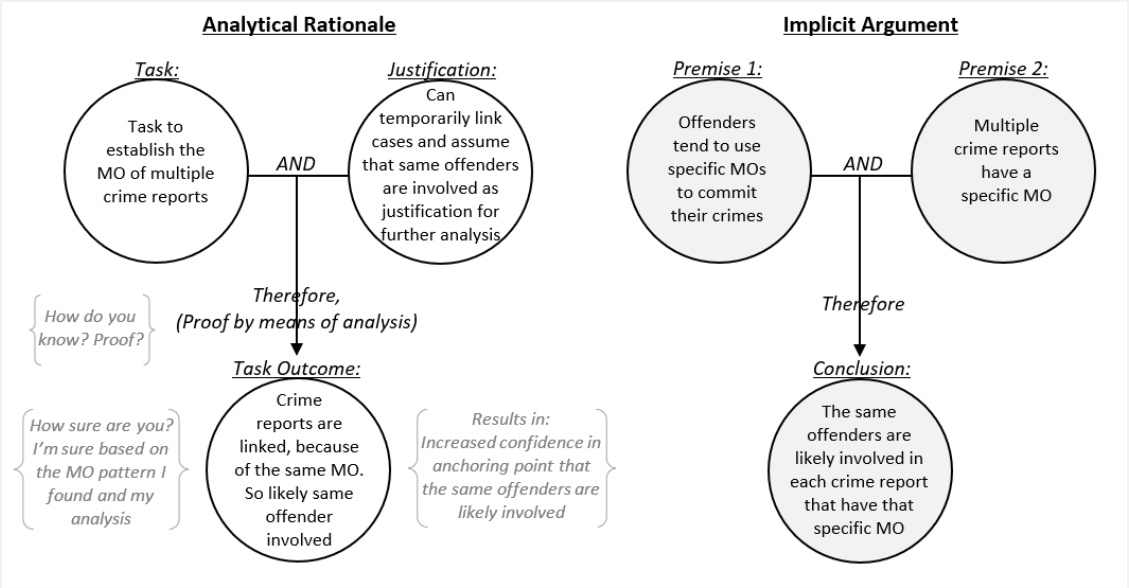


Figure 47 depicts a linked-diagram indicating that the task and the justification support the task outcome. The solid connector lines between the nodes indicate a high level of confidence that the cases are linked based on the MO and that it is likely that the same offenders are involved.

The example of the implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Offenders tend to use specific MOs to commit their crimes
Premise 2: Multiple crime reports have a specific MO
Therefore,
Conclusion: The same offenders are likely involved in each crime report that have that specific MO

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Making sense of complex data - Comparative Case Analysis (identifies similarities between incidents)
- Making sense of complex data - Crime pattern analysis (identify emerging and current trends, linked crimes or incidents, hotspots of activity and common characteristics of offending behaviour. Uses maps, graphs, charts and tables.)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Oversensitivity to Consistency bias (Placing too much emphasis on patterns within small sample information without reflecting on the reason for the patterns)
- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)

Possible critical questions for Analytical Rationale:

- Are the observed patterns, really patterns?
- How many offenders fit this pattern?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [MO-1], [MO-2]… [MO-x] that would tend to undermine the force of the [pattern] cited?
    - Is there some other case that is also similar to [pattern], but is different to not be [pattern]?

(AA2) Establishing a Series

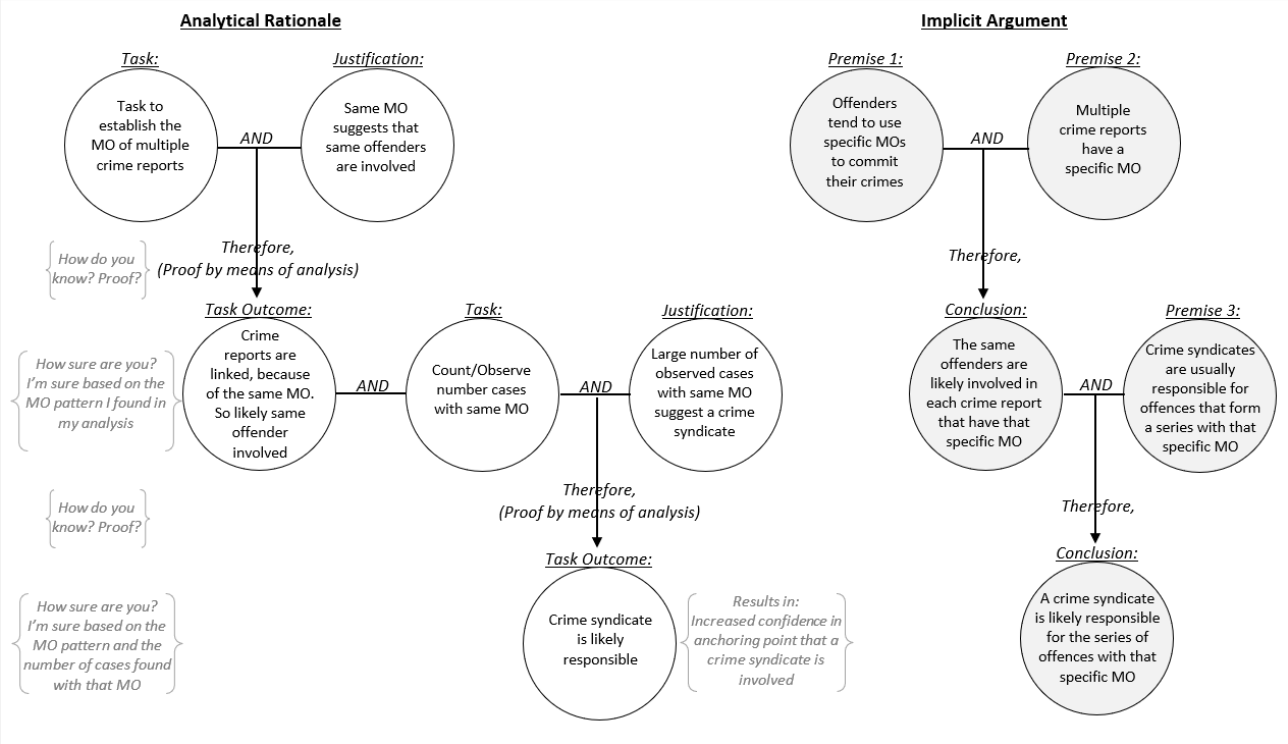
Following on from the previous section, criminal intelligence analysts can have a task of determining if the outcomes of multiple MO pattern discovery tasks are actually indicative of a bigger problem (broadening). Engagement with this type of task is justified with the reasoning that repeating occurrences of a specific MO can serve as a starting point (anchor) for further analysis (laddering) into determining if the crime patterns are suggestive of a crime syndicate being responsible for the offences. Once criminal intelligence analysts establish that a crime syndicate is in play, then they have more confidence in their understanding of what is happening

in the crime reports and can adapt their analysis accordingly. Criminal intelligence analysts can have confidence that their understanding is underpinned with analytical proof, based on the completed task of establishing that a crime syndicate is in play. This is illustrated in [AA2.1].

Table 10 - Chapter 4: Study 1: NVivo coding of interview snippets for: Foreground Information Seeking –> Pattern Discovery –> Establishing a Series

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Use the number of occurrences to establish if a crime syndicate is at play	Can temporarily assume that a crime syndicate is involved based on number of cases with same MO	Increased confidence in their anchoring point that justifies them to go deeper into the analysis or look at a broader problem such as a crime syndicate	- Are you sure that the pattern here suggests a crime syndicate? - Proof is the number of cases that were found with the same MO	- [1] Broadening - [2] Step 5 – Read and Extract - [2] Step 6 – how are they related? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring & Laddering	[AA2.1]: (P9:36) ...we need to know if it is a series... If it is an organisation behind it.

Figure 48 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the pattern discovery tasks lead to the conclusion that a crime syndicate is at play



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that the pattern here suggests a crime syndicate]?' to determine how confident they are that a series of crimes reflect a bigger crime problem.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can use the outcomes of the MO pattern discovery tasks along with the crime reports forming a series, as justifications for suggesting the possibility of a crime syndicate at play.

Figure 48 depicts a linked-diagram indicating that the MO of the cases along with those cases forming a crime series, is needed to suggest that a crime syndicate is at play. The solid connector lines between the nodes indicate a high level of confidence that the cases are linked and that they form a series.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Offenders tend to use specific MOs to commit their crimes
Premise 2: Multiple crime reports have a specific MO
Therefore,
Conclusion: The same offenders are likely involved in each crime report that have that specific MO
Premise 3: Crime syndicates are usually responsible for offences that form a series with that specific MO
Therefore,
Conclusion: A crime syndicate is likely responsible for the series of offences with that specific MO

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Making sense of complex data - Comparative Case Analysis (identifies similarities between incidents)
- Making sense of complex data - Crime pattern analysis (identify emerging and current trends, linked crimes or incidents, hotspots of activity and common characteristics of offending behaviour. Uses maps, graphs, charts and tables.)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Oversensitivity to Consistency bias (Placing too much emphasis on patterns within small sample information without reflecting on the reason for the patterns)
- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Representativeness bias (Tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data.)

Possible critical questions for Analytical Rationale:

- Are the observed patterns, really patterns?
- How many offenders fit this pattern?
- Are the observed cases with this pattern significant enough to suggest a broader problem?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [MO-1] and [MO-2] that would tend to undermine the force of the [pattern] cited?
    - Is there some other case that is also similar to [pattern], but is different to not be [pattern]?
- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [observed pattern] and [number of pattern occurrences]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, C, that is causing both [observed pattern] and [number of pattern occurrences]?

(AB) Intelligence or Information Gathering

(AB1) Public Directories

Criminal intelligence analysts can have a task to search public directories (broadening) to attempt to establish the identities of offenders (narrowing). Engagement with this type of task is justified with the reasoning that the discovery of potential offender names can serve as a starting point (anchor) for further analysis (laddering). Further analysis could be in the form of understanding where and why potential offenders are gathering in specific locations (see interview snippet AB1.1).

Once criminal intelligence analysts establish potential offender names, they have more confidence in their understanding of what is happening in the crime reports and they can have confidence that their understanding is underpinned with analytical proof, based on the completed task of making use of public directories to identify potential offenders. This activity can also serve to justify why criminal intelligence analysts are investigating specific individuals (reality/policy loop).

Table 11 - Chapter 4: Study 1: NVivo coding of interview snippets for: Foreground Information Seeking –> Intelligence or Information Gathering –> Public Directories

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to search the public directory for a matching name against the phone number	The name against the phone number is potentially the offender	Increased confidence in anchoring point that identified name is possibly the offender	- Are you sure that you have sufficiently identified the possible offender? - Poof is the additional analysis from the new information from directories	- [1] Broadening and Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 5 – Read and Extract - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	[AB1.1]: (P9:18) ...all phones are under the same [telephone] mast and then we can go to [omitted] telephone directory and look up names.

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you have sufficiently identified the offender]?' to determine how confident they are that they are investigating the correct people.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can use the outcomes of the public directory search, as justifications for suggesting that specific individuals are being investigated.

Figure 49 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the searching the public directory provides possible people of interest to investigate

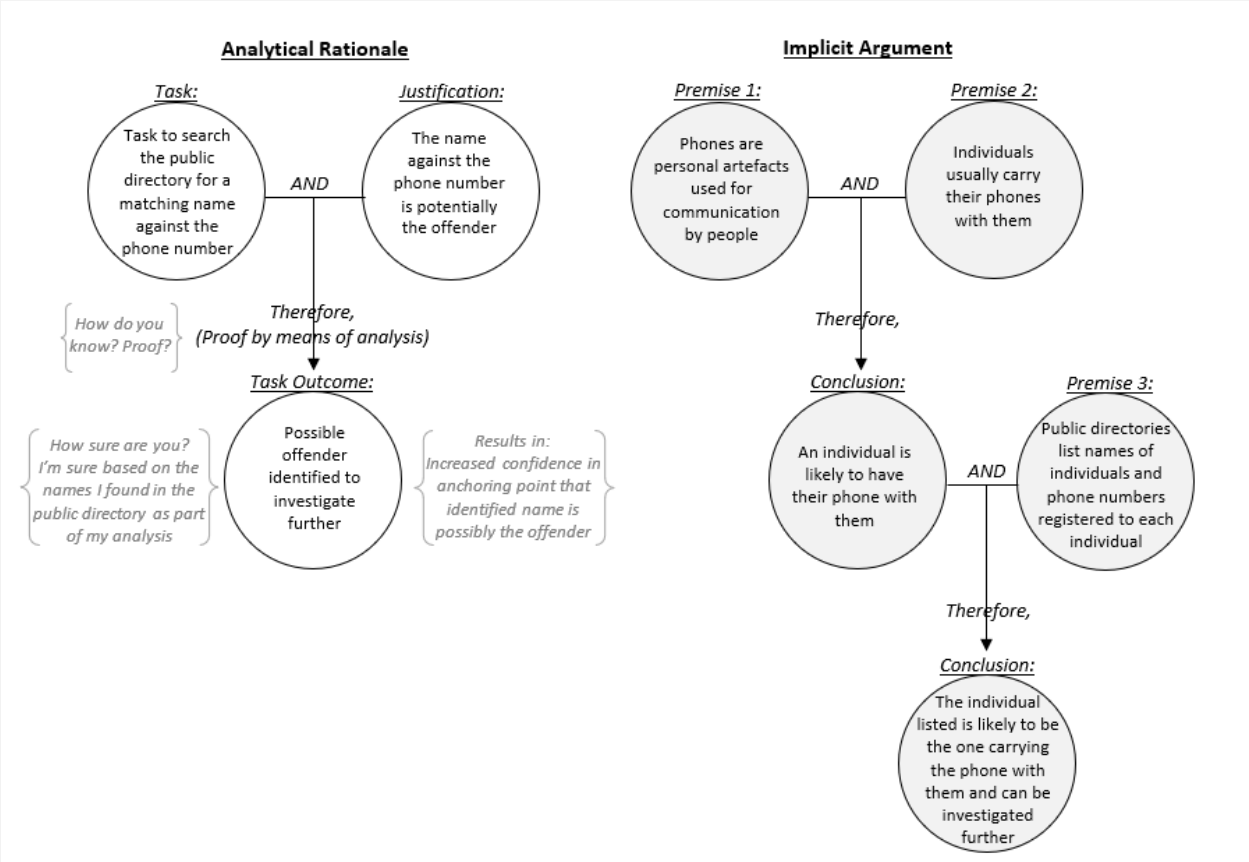


Figure 49 depicts a linked-diagram indicating that the public search permits further investigation into specific individuals. The solid connector lines between the nodes indicate a high level of confidence that the individual is involved.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Phones are personal artefacts used for communication by individuals
Premise 2: Individuals usually carry their phones, with them
Therefore,
Conclusion: An individual is likely to have their phone with them
Premise 3: Public directories list names of individuals and phone numbers registered to each individual

Therefore,
Conclusion: The individual listed is likely to be the one carrying the phone with them and can be investigated further

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Making sense of complex data - Network Analysis (uses association charts to link relationships between people, locations, objects etc.)
- Hypothesis generation and testing - Diagnostic Reasoning (evaluate a single item of evidence in multiple hypotheses)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)

Possible critical questions for Analytical Rationale:

- Is there reason to believe that the identified name did not carry the phone?
- Is the public directory up to date?

Possible critical questions for Implicit Argument:

- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [identified name and phone] and [phone at offence location]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, C, that is causing both [identified name and phone] and [phone at offence location]?

(AB2) Intelligence Reports

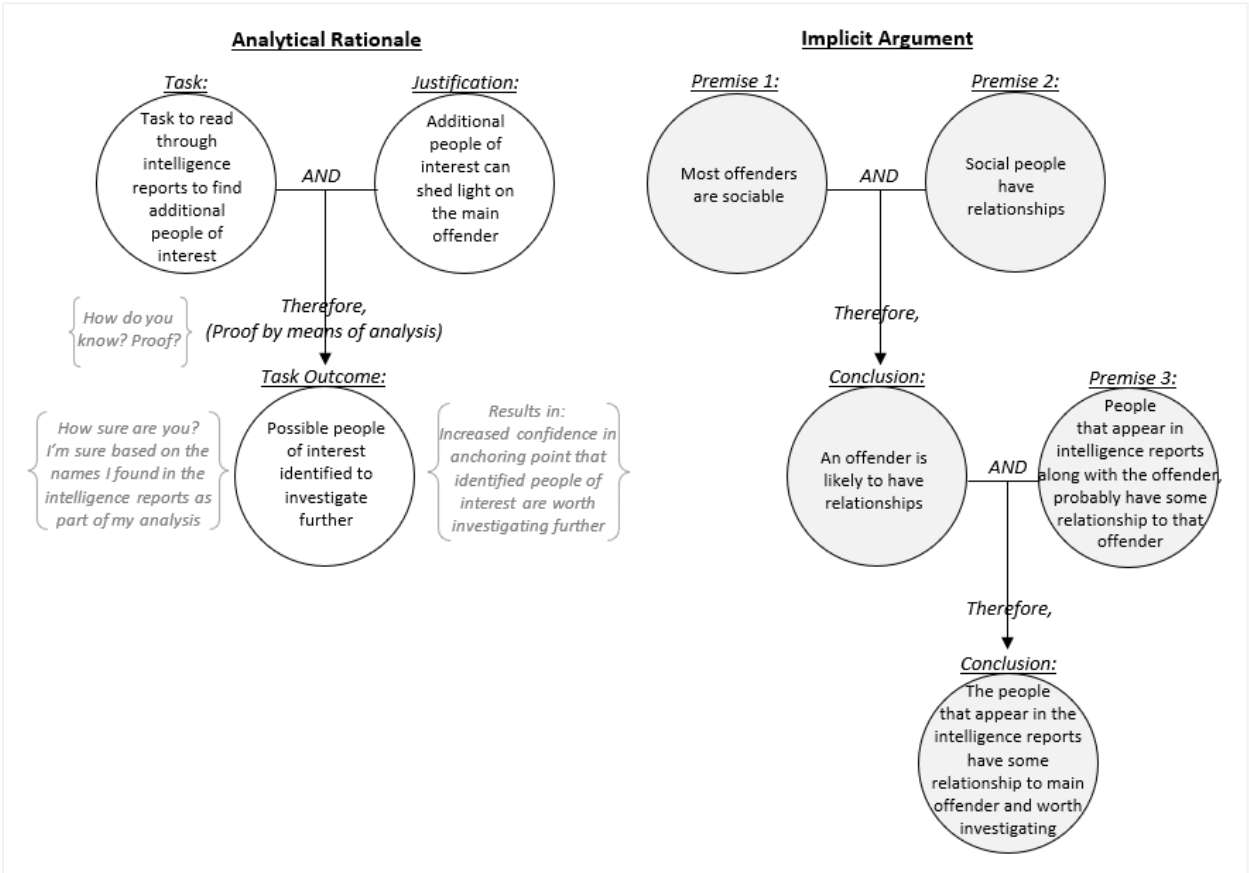
Criminal intelligence analysts can have a task to search through intelligence reports (broadening) for additional information that might link other individuals to an offender or a criminal situation. Engagement with this type of task is justified with the reasoning that additional information could highlight other people of interest (anchors) that could lead to the apprehension of main offender (laddering). Once criminal intelligence analysts establish other people of interest, then they have more confidence in their understanding of the main offender and who the other people are and how they relate to the main offender. They can have confidence that their understanding is underpinned with analytical proof, based on the completed task of reading/investigating other people of interest. This activity can also serve to justify why criminal intelligence analysts are investigating specific individuals (reality/policy loop). In AB2.1 the criminal intelligence analyst found additional people of interest whilst reading through the intelligence reports. In AB2.2, the criminal intelligence analyst used intelligence reports to analyse who the main offender is socialising with, which could lead to the apprehension of the main offender.

Table 12 - Chapter 4: Study 1: NVivo coding of interview snippets for: Foreground Information Seeking –> Intelligence or Information Gathering –> Intelligence Reports

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to read through intelligence reports to find additional people of interest	Additional people of interest can shed light on the main offender	Increased confidence in anchoring point that identified people of interest are worth investigating further	- Are you sure that you understand the role of other people of interest in relation to the main offender? - Poof is the additional analysis from the new information from intelligence reports	- [1] Broadening - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 5 – Read and Extract - [2] Step 6 – how are they related? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[AB.2.1]:** (P4:26-29) …they [detectives] think he's done this one [crime] and he's done these two [crimes] as well, and has he potentially done more [crimes], or his friend, afterwards looking into him is when I found intelligence on him which linked him to another person. **[AB2.2]:** (P4:332-333) …there's actually intelligence stating he's offending within this area…intel log it then states a second name of someone who hangs around with Offender A, so immediately I'm thinking Offender B, let's have a look who he is.

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you understand the role of other people of interest in relation to the main offender]?' to determine how confident they are that they have sufficient understanding of the people who are associated with the main offender.

Figure 50 - Chapter 4: Study 1: Linked diagram depicting the rationale on how intelligence reports yield additional people of interest to investigate



Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can use the outcomes of the intelligence report searches, as justifications for suggesting that specific individuals are worth being investigated.

Figure 50 depicts a linked-diagram indicating that the public search permits further investigation into specific individuals. The solid connector lines between the node indicate a high level of confidence that the individuals are of interest.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Most offenders are sociable
Premise 2: Sociable people have relationships
Therefore,
Conclusion: An offender is likely to have relationships
Premise 3: People that appear in intelligence reports along with the offender, probably have some relationship to that offender
Therefore,
Conclusion: The people that appear in the intelligence reports have some relationship to main offender and is worth investigating further

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Hypothesis generation and testing - Diagnostic Reasoning (evaluate a single item of evidence in multiple hypotheses)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)

Possible critical questions for Analytical Rationale:

- Is there reason to believe that the identified name should be investigated further?
- Does the intelligence rating (5x5x5) suggest trustworthy information?

Possible critical questions for Implicit Argument:

- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [identified name] and [main offender]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, [that is not of criminal intent], that is causing both [identified name] and [relationship with offender]?

(AC) Self-Study

(AC1) Prior Cases

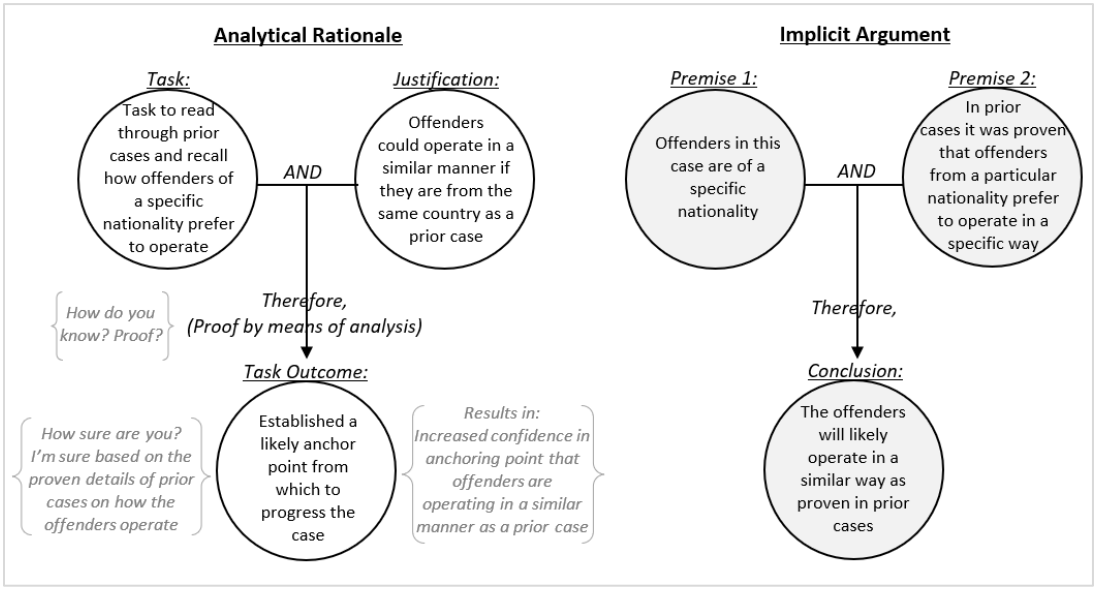
Criminal intelligence analysts can have the task of searching through and recalling details of prior cases (broadening) that are similar to the current criminal case. Engagement with this type of task is justified with the reasoning that knowledge from prior cases could yield similar offender details and behaviour (anchors) that could be applicable to the current case (laddering). Once criminal intelligence analysts establish prior details of interest, then they have more understanding of the current case and can explore those hypotheses with more confidence as they are being applied to the current case (narrowing).

In AC1.1 the criminal intelligence analyst recalled from past work experience how offenders from a specific nationality operate and could therefore apply the same logic to the current set of data to progress the case.

Table 13 - Chapter 4: Study 1: NVivo coding of interview snippets for: Foreground Information Seeking –> Intelligence or Information Gathering –> Prior Cases

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to read through prior cases and recall how offenders of a specific nationality prefer to operate	Offenders could operate in a similar manner if they are from the same country as a prior case	Increased confidence in their likely anchoring point for further analysis	- Are you sure about the preferred way the offenders operate in? - Proof is the prior cases that the analyst worked on	- [1] Broadening, Narrowing - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[AC1.1]:** (P9:17-18) ...This is his phone at this moment... I keep saying this as he is nationality] ... (Interviewer) what does this tell you?... (Interviewee)…From knowledge, they change teams quite a lot. They drop all phones on a table and say each one [offender] to pick one [phone]...

Figure 51 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the details from prior cases leads to likely anchors that would further the investigation



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [about the preferred way the offenders operate in]?' to determine how confident they are their analytical approach to the data set.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to previous cases as justification for suggesting that specific offenders prefer to operate in a specific way.

Figure 51 depicts a linked-diagram indicating that details from a prior case are needed to progress the current investigation. The solid connector lines between the nodes indicate a high level of confidence the prior case is applicable to the current case.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Offenders in this case is of a specific nationality
Premise 2: In prior cases it was proven that offenders from a particular nationality prefer to operate in a specific way
Therefore,
Conclusion: The offenders will likely operate in a similar way as proven in prior cases

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Hypothesis generation and testing – Hypothesis Generation
- Hypothesis generation and testing – Deception Detection (consider possibility that offenders are attempting to mislead or hide important information)
- Assessment of cause and effect – Role Playing (see problem from offender's perspective)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)

Possible critical questions for Analytical Rationale:

- Have you considered that the offenders may not operate in the same way as the previous cases?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [current case] and [prior cases] that would tend to undermine the force of the [pattern] cited?
    - Is there some other case that is also similar to [pattern], but is different to not be [pattern]?

(AC2) Profiling

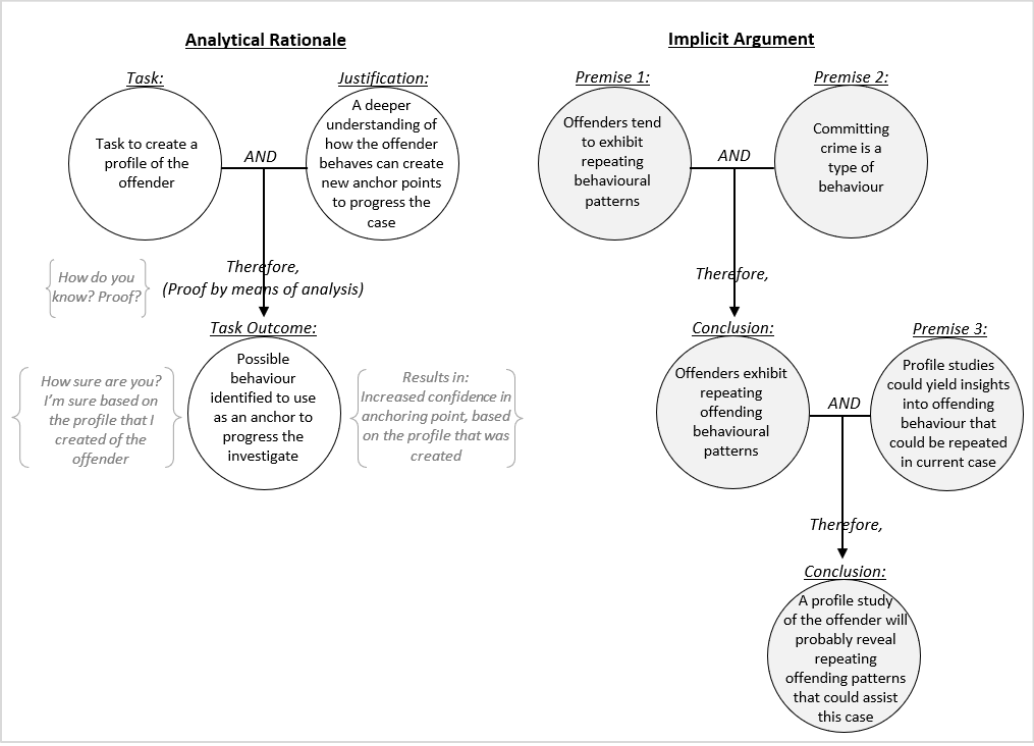
Criminal intelligence analysts can have the task of delving deeper into an offender's history in order to get a better understanding of who the offender is and how the offender is likely to offend (broadening). Engagement with this type of task is justified with the reasoning that a better understanding of the offender (anchor) could assist with the next steps in their analytical approach (laddering). Once criminal intelligence analysts created a profile, then they have a better understanding of the current case and can engage with new hypotheses in a more confident manner.

In AC2.1 the criminal intelligence analyst created a profile of the offender in order to understand their offending behaviour and thus gained new ideas on how to progress the case.

Table 14 - Chapter 4: Study 1: NVivo coding of interview snippets for: Foreground Information Seeking –> Intelligence or Information Gathering –> Profiling

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to create a profile of the offender	A deeper understanding of how the offender behaves can create new anchor points to progress the case	Increased confidence in the possible behaviour identified, to use as an anchor to progress the investigation	- Are you sure that you have sufficient understanding of the offender's offending history? - Proof is the profile that was created	- [1] Broadening - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchor, Laddering	**[AC2.1]:** (P4) …I wanted to know who it [the offender] was…could he have done others [crimes] …what [crimes] has he done previously... that kind of thing.

Figure 52 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the profiling of an offender leads to new insights about the offender's behaviour that could further the investigation



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you have sufficient understanding of the offender's offending history]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the profile they created that were based on the offender's offending history.

Figure 52 depicts a linked-diagram indicating that details from a profile study are needed to progress the investigation. The solid connector lines between the nodes indicate a high level of confidence that details from the profile study could yield new insights that could progress the case.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Offenders tend to exhibit repeating behavioural patterns
Premise 2: Committing crime is a type of behaviour
Therefore,
Conclusion: Offenders exhibit repeating offending behavioural patterns
Premise 3: Profile studies could yield insights into repeating offender behaviour that could be repeated in the current case
Therefore,
Conclusion: A profile study of the offender will probably reveal repeating offending patterns that could assist the case

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Idea generation - Starbursting (generating questions - Who? What? How? Where? and Why?)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Oversensitivity to Consistency bias (Placing too much emphasis on patterns within small sample information without reflecting on the reason for the patterns)
- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Representativeness bias (Tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data.)

Possible critical questions for Analytical Rationale:

- Are the observed behaviours, really behavioural patterns that can be applied to this case?
- How many other offenders fit this type of behaviour?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)

    - Are there differences between [profile behaviour pattern] and [current case behaviour pattern] that would tend to undermine the force of the [pattern] cited?
    - Is there some other case that is also similar to [current offender behaviour pattern], but is different to not be [identified offender]?
- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [profile behaviour pattern] and [current case behaviour pattern]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, C, that is causing both [current observed behavioural pattern] and [profile behavioural pattern]?

(AC3) Phenomenon Studies

Similar to profiling, criminal intelligence analysts can have the task of studying topics related to behaviour or practices from a particular discipline or group of people (broadening). Engagement with this type of task is justified with the reasoning that a better understanding of the discipline or practice (anchor) could assist with the next steps in their analytical approach (laddering). Once criminal intelligence analysts carried out the phenomenon study, then they have a better understanding of the current case and can engage with new hypotheses in a more confident manner.

In AC3.1 the criminal intelligence analyst conducted a phenomenon study in order to understand how a particular ritual is usually carried out and thus gained new ideas on how to progress the case.

Figure 53 - Chapter 4: Study 1: NVivo coding of interview snippets for: Foreground Information Seeking –> Intelligence or Information Gathering –> Phenomenon Studies

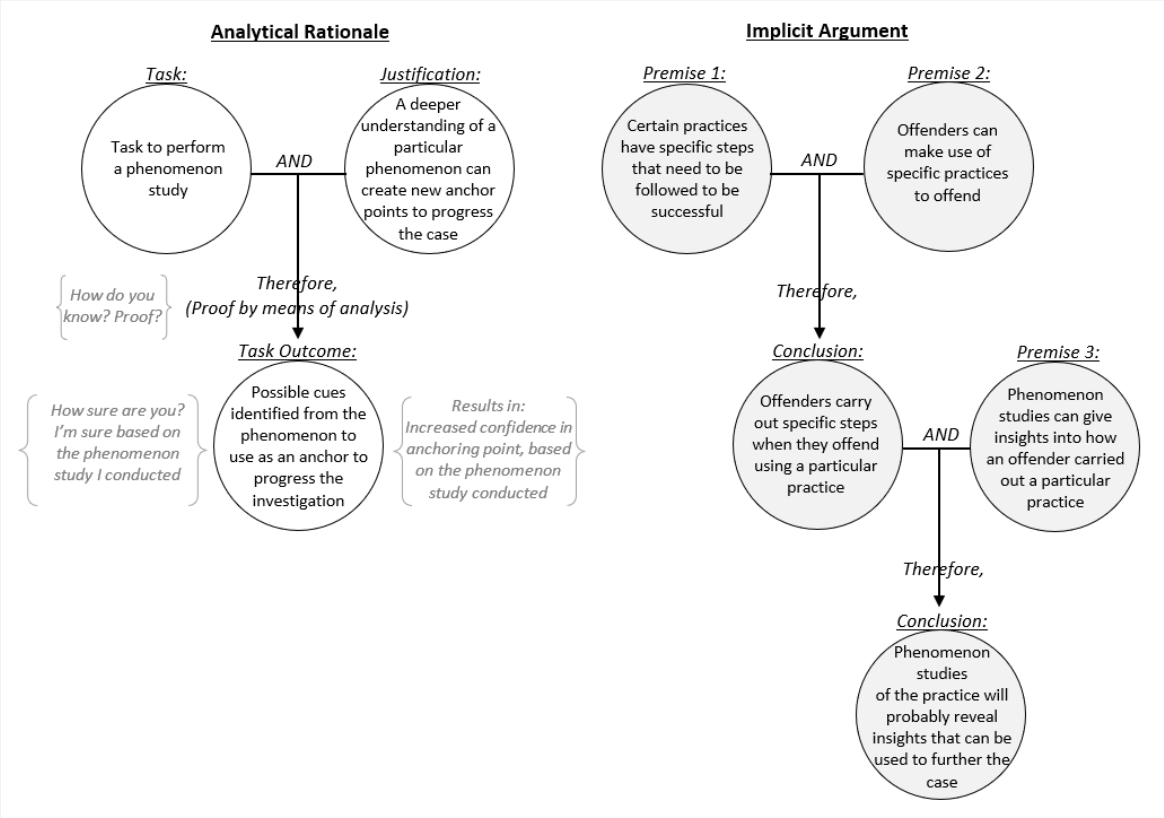
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to perform a phenomenon study	A deeper understanding of a particular phenomenon can create new anchor points to progress the case	Increased confidence in possible cues identified from the phenomenon to use as an anchor to progress the investigation	- Are you sure that you have sufficient understanding of the phenomenon? - Proof is the new understanding from the phenomenon study	- [1] Broadening - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[AC3.1]:** (P1.349-353) …I looked up [the phenomenon], because I don't know the community…what I saw was it doesn't take one time [to perform phenomenon]."

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you have sufficient understanding of the phenomenon]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the phenomenon study that they conducted.

Figure 54 depicts a linked-diagram indicating that details from a phenomenon study are needed to progress the investigation. The solid connector lines between the tasks indicate a high level of confidence that details from the phenomenon study could yield new insights that could progress the case.

Figure 54 - Chapter 4: Study 1: Linked diagram depicting the rationale on how a phenomenon study leads to new insights to progress the case



The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Certain practices have specific steps that need to be followed to be successful
Premise 2: Offenders can make use of specific practices to offend
Therefore,
Conclusion: Offenders carry out specific steps when they offend using a particular practice
Premise 3: This offender used a specific practice to offend
Therefore,
Conclusion: This offender carried out specific steps when they offended using a specific practice
Premise 4: Phenomenon studies could outline the steps involved in a specific practice
Therefore,
Conclusion: A phenomenon study of the practice could probably reveal new insights that could further the case

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Assessment of cause and effect - Outside-In Thinking (reach beyond specialist's area)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Oversensitivity to Consistency bias (Placing too much emphasis on patterns within small sample information without reflecting on the reason for the patterns)
- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Representativeness bias (Tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data.)

Possible critical questions for Analytical Rationale:

- Are the observed qualities of the phenomenon, really applicable to this case?
- How much are you stretching the case data to fit this phenomenon?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [qualities of phenomenon] and [qualities of case] that would tend to undermine the force of the [phenomenon] cited?
    - Is there some other phenomenon that is also similar to [qualities of the identified phenomenon], but is different to not be [the identified phenomenon]?
- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [qualities of identified phenomenon] and [qualities that appear in case]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, C, that is causing both [qualities of phenomenon] and [qualities of case]?

(AC4) Field Studies

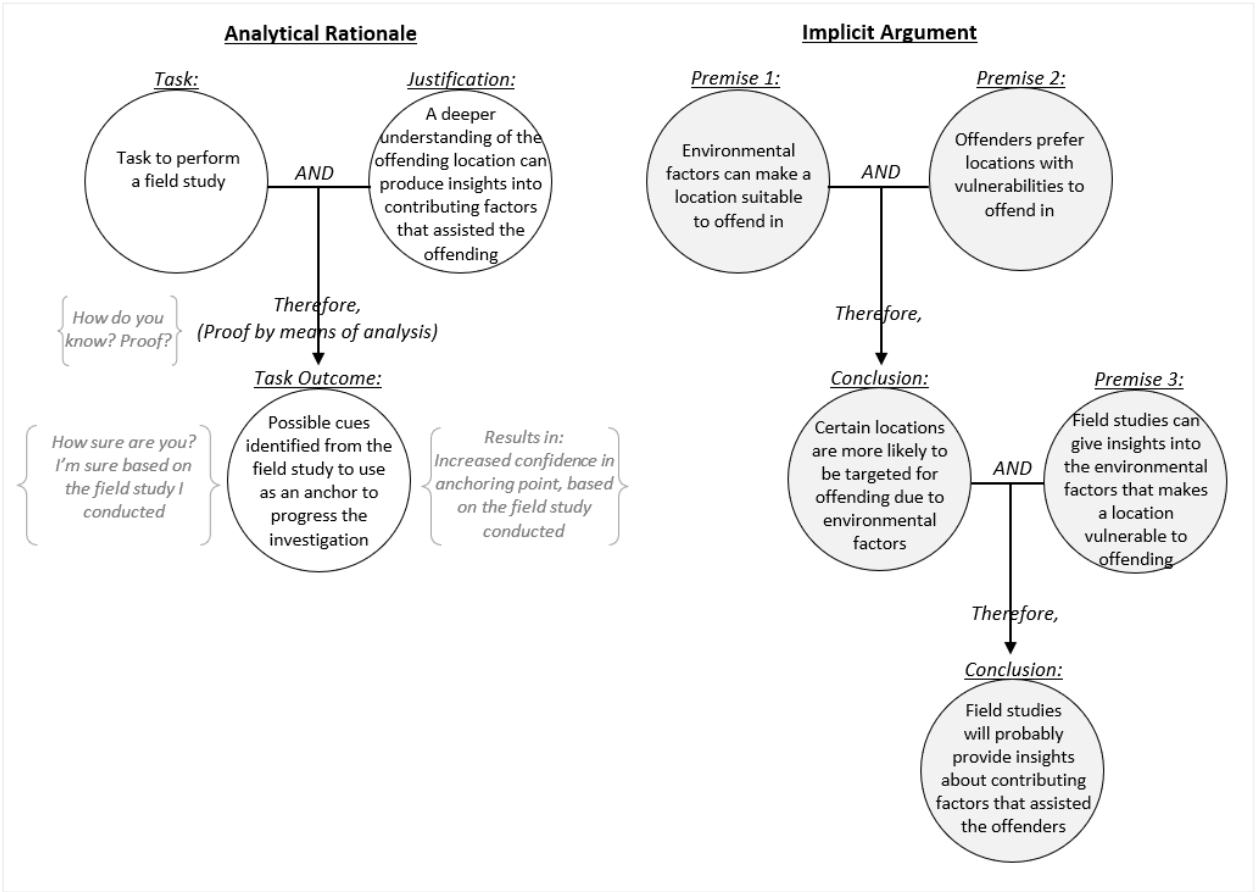
Similar to profiling and phenomenon studies, criminal intelligence analysts can have the task of conducting a field study (broadening) to get a sense of the environment where the offence took place. Engagement with this type of task is justified with the reasoning that a better understanding the environment could yield possible contributing factors (anchor) that facilitated the offender during the offence. An understanding of the contributing factors could assist with the next steps in their analytical approach (laddering). Once criminal intelligence analysts carried out the field study, then they have a better understanding of the current case and can engage with new hypotheses in a more confident manner.

In AC4.1 the criminal intelligence analyst conducted a field study in order to gain a better understanding of the offending environment and the contributing factors that could assist the type of offending. Field studies can lead to new ideas on how to progress the case.

Figure 55 - Chapter 4: Study 1: NVivo coding of interview snippets for: Foreground Information Seeking –> Intelligence or Information Gathering –> Field Studies

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to perform a field study	A deeper understanding of the offending location can produce insights into contributing factors that assisted the offending	Increased confidence in possible cues identified from the field study to use as an anchor to progress the investigation	- Are you sure that you have sufficient understanding of the factors that lead to the offence? - Poof is their observations from visiting the offending area	- [1] Broadening - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[AC4.1]:** (P4:184) ...we do go out and see what the areas are like where the offending is happening.

Figure 56 - Chapter 4: Study 1: Linked diagram depicting the rationale on how a field study leads to new insights to progress the case



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you have sufficient understanding of the factors that lead to the offence]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to their observations during the field study that they conducted.

Figure 56 depicts a linked-diagram indicating that details from a field study are needed to progress the investigation. The solid connector lines between the nodes indicate a high level of confidence that details from the field study could yield new insights that could progress the case.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Environmental factors can make a location suitable to offend in
Premise 2: Offenders prefer locations with vulnerabilities to offend in
Therefore,
Conclusion: Certain locations are more likely to be targeted for offending due to environmental factors
Premise: Field studies can give insights into the environmental factors that makes a location vulnerable to offending
Conclusion: Field studies will probably provide insights about contributing factors that assisted the offenders.

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Assessment of cause and effect – Red Hat Analysis (perceive threats and opportunities as others see them)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Oversensitivity to Consistency bias (Placing too much emphasis on patterns within small sample information without reflecting on the reason for the patterns)
- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Representativeness bias (Tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data.)

Possible critical questions for Analytical Rationale:

- Are the observed factors from the field study, really applicable to this case?
- How much are you stretching the case data to fit the observed factors from the field study?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)

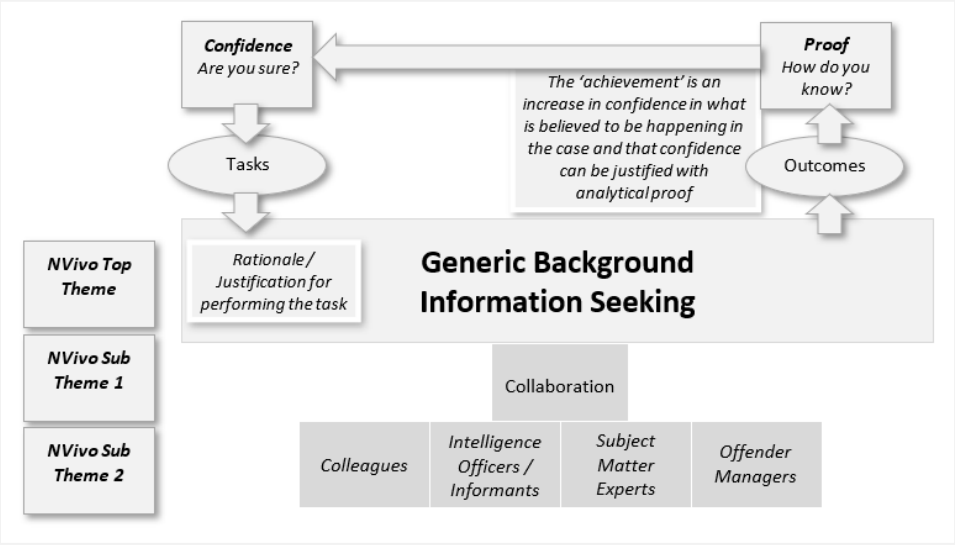
- Are there differences between [observed factors from field study] and [qualities of case] that would tend to undermine the force of the [observed factors from the field study] cited?
- Is there some other phenomenon that is also similar to [the observed factors from the field study], but is different to not be [applicable to the current qualities of the case]?

- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
  - Is there really a correlation between [observed factors of the field study] and [qualities that appear in case]?
  - Is there any reason to think that the correlation is any more than a coincidence?
  - Could there be some third factor, C, that is causing both [observed factors of the field study] and [qualities of case]?

(B) Generic Background Information Seeking

Generic Background Information Seeking refers to those activities where criminal intelligence analysts consult other people when the information in front of them are lacking in content or meaning. During these activities, criminal intelligence analysts are not able to progress their understanding on their own as seen within the previous section covering foreground information seeking. This NVivo emerging theme would equate to the foraging loop within Pirolli and Card's (2005) Notional Model of Sensemaking, where information comes from external sources. It also touches on the sensemaking loop in situations where criminal intelligence analysts already have adequate information but need to corroborate with colleagues on the meaning of the information.

Figure 57 - Chapter 4: Study 1: Generic Background Information Seeking



The results listed in each NVivo theme outlines the play between Elm et al.'s (2005) Broadening and Wong and Kodagoda's (2015) anchoring, laddering and associative questioning concepts.

(BA) Collaboration

(BA1) Colleagues

Criminal intelligence analysts can have a task to corroborate with colleagues on their analytical findings (broadening). Engagement with this type of task is justified with the reasoning that their analytical findings (anchors) are correct, and that understanding is sufficient to proceed with further analysis (laddering). Once criminal intelligence analysts establish that their colleagues have derived the same outcomes as they did, then they have confidence in their own understanding and analytical process. They can have confidence that their understanding is underpinned with proof, based on the completed task of corroborating with colleagues. This activity can also serve as proof for due diligence (reality/policy loop) as colleagues derived the same set of outcomes.

In BA1.1, the criminal intelligence analysts corroborated with a colleague to find out if their colleague same the same patterns in the data as they did. This served as reassurance to the criminal intelligence analyst that their analysis and understanding was on the right track.

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that your findings and reasoning are correct]?' to determine next steps in the analytical approach.

Table 15 - Chapter 4: Study 1: NVivo coding of interview snippets for: Generic Background Information Seeking –> Collaboration –> Colleagues

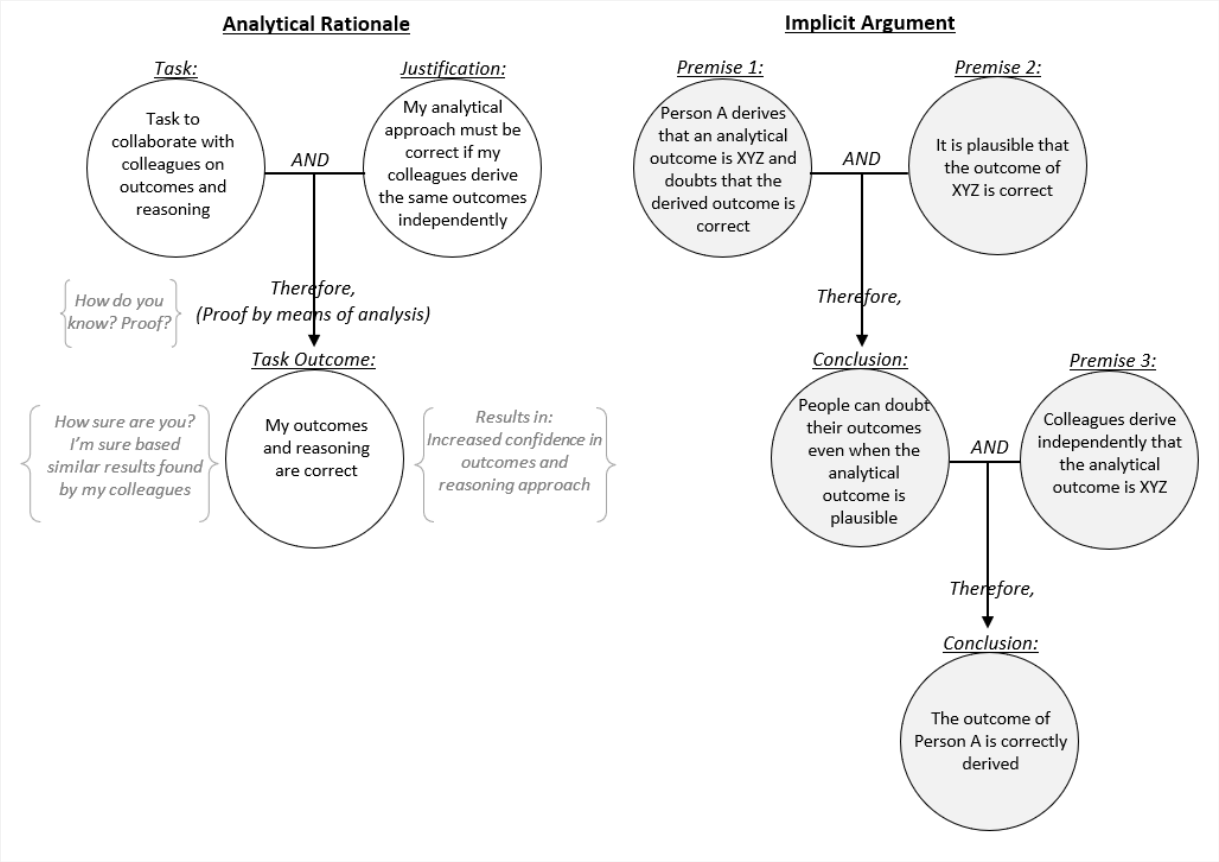
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to collaborate with colleagues on outcomes and reasoning	My analytical approach must be correct if my colleagues derive the same outcomes independently	Increased confidence that the analytical approach and outcomes are correct	- Are you sure that your findings and reasoning are correct? - Poof is confirmation and information from colleagues	- [1] Broadening - [2] Reality/Policy loop - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Laddering	**[BA1.1]** (P3:488-490) ...whether [colleague] could see anything different to me or just what I can see, reassurance that checking that [colleague] agrees, seeing if there is anything... different that [colleague] would look at…

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to their collaboration with their colleagues and that their colleagues derived the same outcomes as they did.

Figure 58 depicts a linked-diagram indicating how the collaboration with colleagues can result in the same analytical outcomes and understanding. The solid connector lines between the nodes

indicate a high level of confidence that the criminal intelligence analyst's outcomes and findings are correct.

Figure 58 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the collaboration with colleagues can assure criminal intelligence analysts that their analytical outcomes and reasoning are correct



The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Person A derives that an analytical outcome is XYZ and doubts that the derived outcome is correct
Premise 2: It is plausible that the outcome of XYZ is correct
Therefore,
Conclusion: People can doubt their outcomes even when the analytical outcome is plausible
Premise 3 (implicit): Colleagues derive independently that the analytical outcome is XYZ
Therefore,
Conclusion: The outcome of Person A is correctly derived

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Challenge Analysis - Structured Self-Critique (identify weaknesses in own analysis)
- Challenge Analysis - Delphi Method (different analysts use different techniques to arrive at same conclusion)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Persistence of Impressions Based on Discredited Evidence bias (When an impression is formed, it will likely persist even if other information or evidence disproves the initial impression)
- Blind Spot Bias (Tendency to see the errors in another analyst's collection and interpretation work while not seeing mistakes in their own research work)

Possible critical questions for Analytical Rationale:

- If arriving at same conclusions:
    - Did you influence your colleague's thought process to get the outcome you wanted?
    - Is the chosen colleague the best person to confirm your outcomes?
    - Do you need a third opinion?
- If arriving at different conclusions:
    - Are you blindly accepting your colleague's conclusions and adapting your analysis accordingly?
    - Are you being stubborn to see their point of view?
    - Do you need a third opinion?

Possible critical questions for Implicit Argument:

- Argument from Position of Know (Adapted from Walton et al., 2008:p309)
    - Is [colleague] in position to know/determine whether [outcomes] are correct/incorrect?
    - Did [colleague] assert that [outcomes] are correct/incorrect?
- Argument from Expert Opinion (Adapted from Walton et al., 2008:p310)
    - What did [colleague] assert that implied [outcomes to be correct/incorrect]?
    - Is [colleague]'s assertion based on [analytical process that can be reproduced]?

(BA2) Intelligence Officers / Informants

Criminal intelligence analysts can have a task to liaise with Intelligence Officers to increase their understanding of a criminal case (broadening). Intelligence Officers are people who are responsible for "researching, gathering, evaluating, developing, analysing and disseminating intelligence for a range of objectives" (NCA, 2022). Intelligence Officers can obtain the intelligence themselves or by working closely with covert human intelligence source (informants) (NCA, 2022; MI5, 2022).

Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that their analysis and understanding (anchors) would benefit more when they collaborate with Intelligence Officers, rather than just performing the analysis on their own. Once criminal

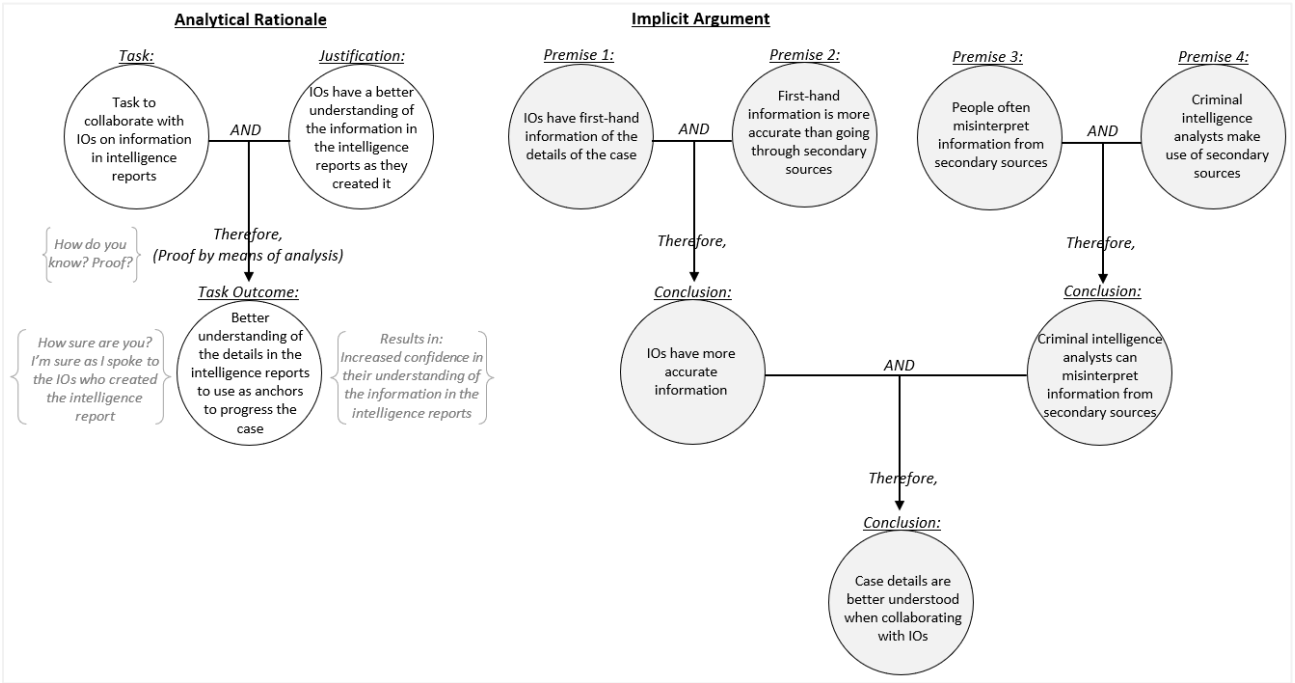
intelligence analysts establish or verify the details of the case that they are working on, then then they have confidence in their own understanding and analytical process to continue with the analysis process (laddering). They can have confidence that their understanding is underpinned with proof, based on the completed task of collaborating with the Information Officers to obtain and clarify the case details. This activity can also serve as proof of due diligence (reality/policy loop) when they can show that they have collaborated with the Information Officers.

In BA2.1, the criminal intelligence analysts collaborate with the Intelligence Officer in order to get the Intelligence Officer's perspective on the details of the case and possibly where else to look for information.

Table 16 - Chapter 4: Study 1: NVivo coding of interview snippets for: Generic Background Information Seeking –> Collaboration –> Intelligence Officers/Informants

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to collaborate with IOs on information in intelligence reports	IOs have a better understanding of the information in the intelligence reports as they created it	Increased confidence on their understanding of the details in the intelligence reports to use as anchors to progress the case	- Are you sure that your understanding of the details of the case is correct? - Poof is the confirmation and information from the Information Officers	- [1] Broadening - [2] Reality/Policy loop - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[BA2.1]** (P3) ...I think a lot of our job is talk to people see what's going on and normally we'd have Intel Officers with us and they'd be able to talk to us about what Intel they've seem to see, rather than me looking through all of that Word document they'd be able to say 'Oh so and so was here and so and so was there, that might be something worth looking at or whether you'd talk to different Departments.

Figure 59 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the collaboration with colleagues can result in better understanding of the case details



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that your understanding of the case details is correct]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to their collaboration with the Intelligence Officers and the details the Intelligence Officers provided.

Figure 59 depicts a linked-diagram indicating how the collaboration with Information Officers can result in a better understanding of the case details. The solid connector lines between the nodes indicate a high level of confidence that criminal intelligence analyst have when obtaining case details from Intelligence Officers directly.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Argument 1:
Premise 1: Intelligence Officers have first-hand information of the details of the case
Premise 2: First-hand information is more accurate than going through a secondary source
Therefore,
Conclusion: Intelligence Officers have more accurate information

Argument 2:
Premise 3: People often misinterpret information from secondary sources
Premise 4: Criminal intelligence analysts make use of secondary sources
Therefore,
Conclusion: Criminal intelligence can misinterpret information from secondary sources

Therefore (based on Argument 1 and 2),
Conclusion: Case details are better understood when collaborating with Intelligence Officers

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Assessment of cause and effect - Outside-In Thinking (reach beyond specialist's area)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Vividness Criterion Bias (Remember and use information experienced first-hand more easily than reports)
- Anchoring Bias (Use a known starting point from which to make judgements)

Possible critical questions for Analytical Rationale:

- Are you relying solely on the account from the IO, whilst ignoring the intelligence reports?
- Did you cross-check the information from the IO and what is actually written in the intelligence reports, for consistency?
- Is the intelligence report still up to date?

Possible critical questions for Implicit Argument:

- Argument from Position of Know (Adapted from Walton et al., 2008:p309)
    - Is [IO] in position to know whether [account of intelligence] is accurate?
    - Did [IO] assert that [intelligence] is accurate/up-to-date?
- Argument from Expert Opinion (Adapted from Walton et al., 2008:p310)
    - What did [IO] assert that implied [account of intelligence]?
    - Is [IO]'s assertion based on [intelligence that is up to date]?

(BA3) Subject Matter Experts (SMEs)

Criminal intelligence analysts can have a task to liaise with SMEs to increase their understanding of a subject (broadening) that requires specialised knowledge. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that their analysis and understanding (anchors) would benefit more when they have a better understanding of a particular subject that forms part of the offender's offending patterns. Once criminal intelligence analysts establish or verify the details of the subject that appeared in the case, then then they have confidence in their own understanding of the subject and renewed analytical approaches to continue with the analysis process (laddering). They can have confidence that their understanding is underpinned with proof, based on the completed task of liaising with the SMEs to obtain and clarify the details pertinent to the subject that they are investigating. This activity can also serve as proof of due diligence (reality/policy loop) when they can show that they have collaborated with the SME's.

In BA3.1, the criminal intelligence analysts liaised with the SME who has knowledge of a particular community, their language and their customs. This provided the criminal intelligence analyst with a better understanding of the community with new anchor points to investigate.

Table 17 - Chapter 4: Study 1: NVivo coding of interview snippets for: Generic Background Information Seeking –> Collaboration –> SMEs

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to collaborate with SMEs on subject that they know very well	SMEs have in-depth knowledge of particular subjects that can enhance my knowledge and create new anchors	Increased confidence in their understanding of the details of a subject that can be used as anchors to progress the case	- Are you sure that you have sufficient knowledge of the details of the subject to progress the case? - Poof is the confirmation and information from SME's	- [1] Broadening - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[BA3.1]** (P1: 343-349) ... But then you see something and I cannot make a hypothesis at this moment. I see something strange so then I have to go back to the first thing - any analyst [can] do the phenomenon study; What is a [practice]? What does a [practitioner] do? What do we know about the [victim]? What do we know about the [victim's parent]? What do we know? And then I talked with friend, the other analyst. At that time, he has more experience than me and he follows [name is omitted] language. He follows. He follows at that time [name of a second langue] so he knows more of that community."

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you have sufficient knowledge of the details of the subject to progress the case]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to their collaboration with the SME's and the details that the SME's provided.

Figure 60 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the collaboration with SMEs can result in better understanding of the case details

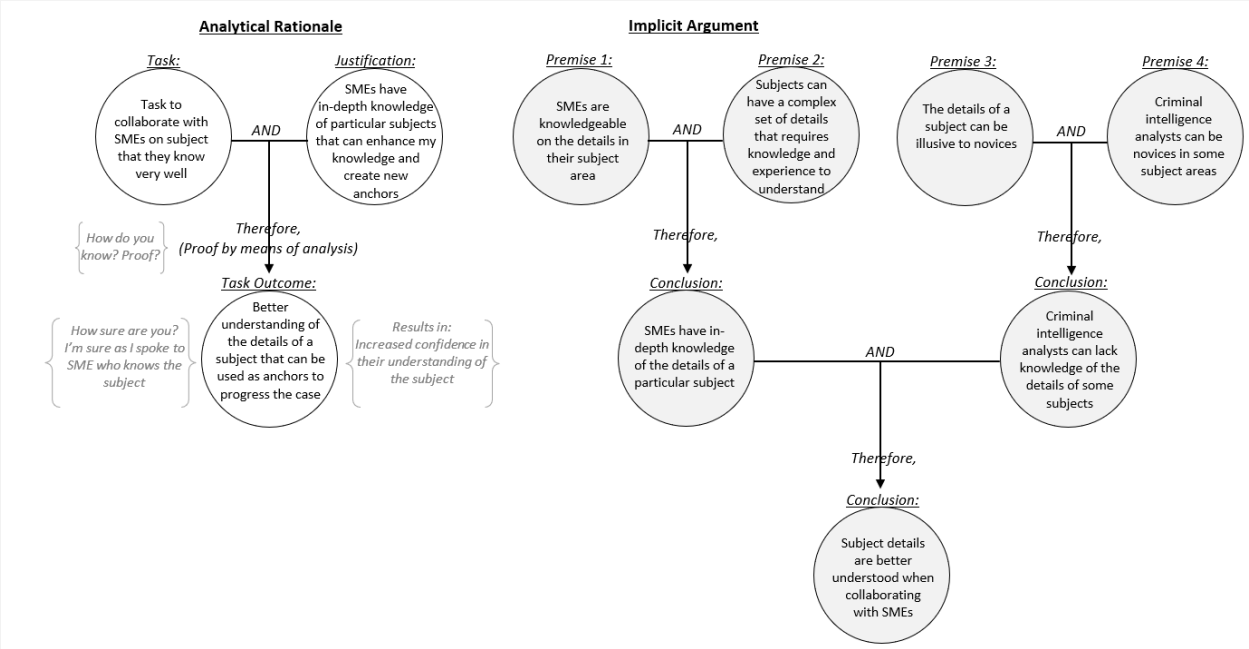


Figure 60 depicts a linked-diagram indicating how the collaboration with SME's can result in a better understanding of a particular subject within the case details. The solid connector lines between the nodes indicate a high level of confidence that criminal intelligence analyst have when obtaining subject details from SME's.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Argument 1:
Premise 1: SMEs are knowledgeable on the details in their subject areas
Premise 2: Subjects can have a complex set of details that requires knowledge and experience to understand
Therefore,
Conclusion: SMEs have in-depth knowledge of the details of a particular subject

Argument 2:
Premise 3: The details of subjects can be illusive to novices
Premise 4: Criminal intelligence analysts can be a novice in some subject areas

Therefore,
Conclusion: Criminal intelligence can lack knowledge of the details of some subjects

Therefore (based on Argument 1 and 2),
Conclusion: Subject details are better understood when collaborating with SMEs

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Assessment of cause and effect - Outside-In Thinking (reach beyond specialist's area)
- Idea generation - Starbursting (generating questions - Who? What? How? Where? and Why?)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Use a known starting point from which to make judgements)

Possible critical questions for Analytical Rationale:

- Are you relying solely on the information from the SME whilst ignoring other details of the case?
- How biased is the SME with the details they share?

Possible critical questions for Implicit Argument:

- Argument from Position of Know (Adapted from Walton et al., 2008:p309)
    - Is [SME the best candidate] to know about [subject details]?
    - Did [SME] assert that [subject details] is accurate/current?
- Argument from Expert Opinion (Adapted from Walton et al., 2008:p310)
    - What did [SME] assert that implied [account of subject details]?
    - Is [SME]'s assertion based on [subject details that is current]?

(BA4) Offender Managers

Criminal intelligence analysts can have a task to liaise with Offender Managers to increase their understanding of offenders (broadening) that operate within a Local Policing Area (LPA). Offender managers are people who work "for the National Probation Service (NPS) or Community Rehabilitation Company (CRC). They are usually based in an office in the local area and are responsible for overseeing someone who has a conviction, whether they are serving a sentence in the community, in custody (prison) or a mixture of both" (prisonersfamilies.org, 2022).

Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that their analysis and understanding (anchors) would benefit more when they have a better understanding of who the offenders in the LPA are or which offenders might have recently been released from prison. Once criminal intelligence analysts establish or verify the details of possible

offenders of interest, then then they have confidence in their understanding of who is operating in their LPA (laddering). They can have confidence that their understanding is underpinned with proof, based on the completed task of liaising with the Offender Manager to obtain and clarify the details pertinent to the case that they are investigating. This activity can also serve as proof of due diligence (reality/policy loop) when they can show that they have collaborated with the Offender Managers.

In BA4.1, the criminal intelligence analysts liaised with the Offender Manager who is familiar with the offenders in the LPA and how those offenders prefer to offend. This provided the criminal intelligence analyst with a better understanding of the offenders in the LPA which afforded new anchor points to investigate further.

Table 18 - Chapter 4: Study 1: NVivo coding of interview snippets for: Generic Background Information Seeking –> Collaboration –> Offender Managers

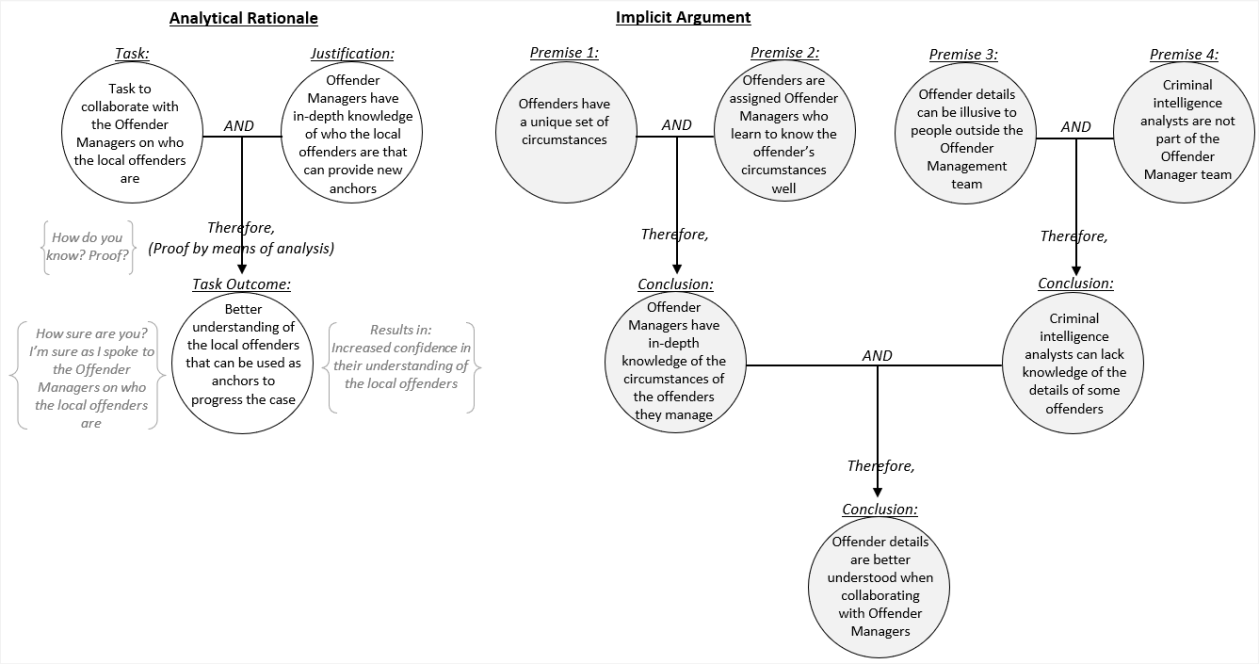
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to collaborate with the Offender Managers on who the local offenders are	Offender Managers have in-depth knowledge of who the local offenders are that can provide new anchors	Increased confidence in their understanding of the local offenders that can be used as anchors to progress the case	- Are you sure that you know who the local offenders are and their current circumstances? - Poof is the confirmation and information from the Offender Managers	- [1] Broadening - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[BA4.1]** (P3: 172-174) ... you'd speak to Offender Managers and see if they're aware of anyone that's been released in that area and see if there's anything else that they're aware of that might be contributing to the increase in offences in [area]

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you know who the local offenders are and their current circumstances]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to their collaboration with the Offender Managers and the details that the Offender Managers provided about the circumstances of the local offenders.

Figure 61 depicts a linked-diagram indicating how the collaboration with SME's can result in a better understanding of a particular offender within the case details. The solid connector lines between the nodes indicate a high level of confidence that criminal intelligence analyst have when obtaining subject details from SME's.

Figure 61 – Chapter 4: Study 1: Linked diagram depicting the rationale on how collaboration with the Offender Managers can result in better understanding of the case details



The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Argument 1:
Premise 1: Offenders have a unique set of circumstances
Premise 2: Offenders are assigned Offender Managers who learn to know the offender's circumstances well
Therefore,
Conclusion: Offender Managers have in-depth knowledge of the circumstances of the offenders they manage

Argument 2:
Premise 3: Offender details can be illusive to people outside the Offender Management team
Premise 4: Criminal intelligence analysts are not part of the Offender Management team
Therefore,
Conclusion: Criminal intelligence can lack knowledge of the details of some offenders

Therefore (based on Argument 1 and 2),
Conclusion: Offender details are better understood when collaborating with Offender Managers

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Assessment of cause and effect - Outside-In Thinking (reach beyond specialist's area)
- Idea generation - Starbursting (generating questions - Who? What? How? Where? and Why?)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Use a known starting point from which to make judgements)

Possible critical questions for Analytical Rationale:

- Are you relying solely on the information from the Offender Manager whilst ignoring other details of the case?
- How biased is the Offender Manager with the details they share?

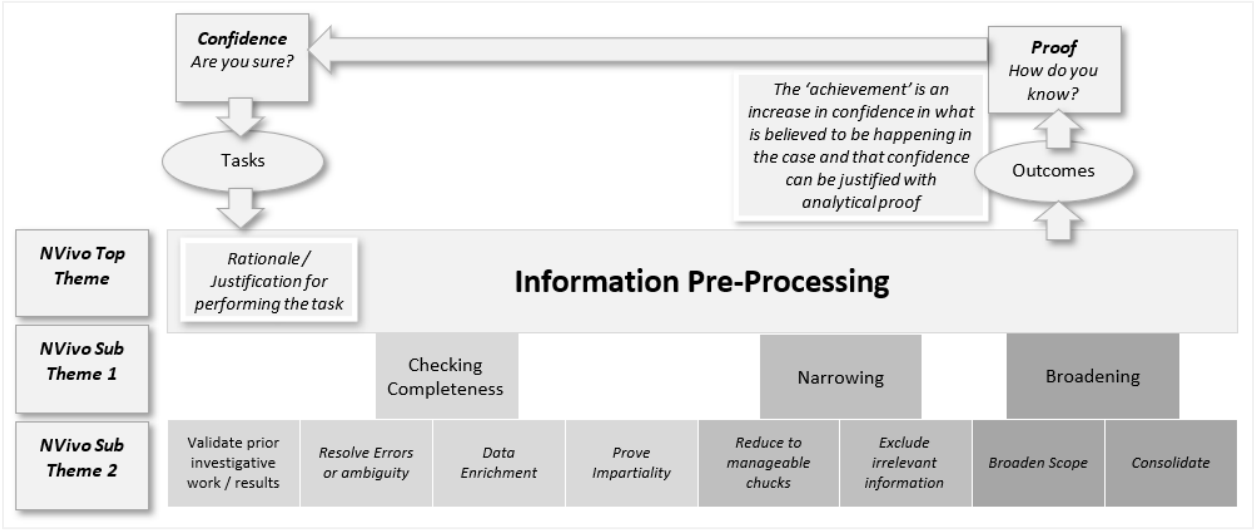
Possible critical questions for Implicit Argument:

- Argument from Position of Know (Adapted from Walton et al., 2008:p309)
    - Is [Offender Manager the best candidate] to know about [offender details]?
    - Did [Offender Manager] assert that [offender details] is accurate/current?
- Argument from Expert Opinion (Adapted from Walton et al., 2008:p310)
    - What did [Offender Manager] assert that implied [account of offender details]?
    - Is [Offender Manager]'s assertion based on [offender details that is current]?

(C) Information Pre-Processing

Information pre-processing refers to those activities where criminal intelligence analysts prepare information for analysis or where they verify completeness of the analysis process. This consists out of activities such resolving errors in the information or broadening/narrowing activities. This NVivo emerging theme would equate to the foraging loop within Pirolli and Card's (2005) Notional Model of Sensemaking, where information from external sources needs to be transformed into a more meaningful format to derive meaning.

Figure 62 – Chapter 4: Study 1: Information Pre-Processing



It also touches on the sensemaking loop in situations where criminal intelligence analysts are unable to make sense of the information in its raw, unaltered format. The activity of verifying the completeness of the analysis is part of Pirolli and Card's (2005) top-down approach.

The results listed in this NVivo category outlines the play between Elm et al.'s (2005) Broadening and Narrowing concepts and Wong and Kodagoda's (2015) anchoring, laddering and associative questioning concepts.

(CA) Checking completeness

(CA1) Validating prior investigative work/results

Criminal intelligence analysts can have a task to reconsider information (broadening, associative questioning) and analytical results to ensure that the analysis has been done correctly and that their understanding is correct. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that their analysis and understanding (anchors) are correct, thus increase their confidence in the results (proof) that underpin their theories. This activity can also serve as proof of due diligence (reality/policy loop) when they can show that they have double checked (narrowing) their analysis or another person's analysis (laddering).

In CA1.1, the criminal intelligence analyst reported that she reconsidered information to gain a better understanding on the proceedings of the arrest. This provided the criminal intelligence analyst with a better understanding of the MO details of her case and could thus eliminate the offender as a suspect, based on the additional information (stolen goods) that was stipulated in the arresting officer's notes. The suspect was prolifically stealing certain goods that were not the same as what was reported as stolen in her case, hence unlikely to be the offender responsible for the activity in her case. The criminal intelligence analyst therefore completed her due-diligence by reconsidering additional information pertaining to the suspect.

In CA1.2, the criminal intelligence analysts reconsidered the analysis of the original investigator, as he found a phone number that was not investigated and could thus not be eliminated as being involved in the crime. The criminal intelligence analyst therefore completed his due-diligence by completing the analysis pertaining to that phone number.

Table 19 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Pre-Processing –> Checking Completeness –> Validating Prior Investigative Work

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to reconsider prior analysis and understanding	Verified results proves that analysis is correct and complete	Increased confidence in results as possible proof or anchoring points for further investigation	- Are you sure that the analysis is complete and thoroughly explored? - Proof is the additional analysis performed and the same results or new results produced, that either confirm or deny theories	- [1] Broadening and Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Laddering, Associative Questioning	**[CA1.1]** (P4:159-175) … Well for this one specifically I was looking for a name, so I just wanted to know who was arrested – but then when I found who was arrested said right, I wanted to put these in, added records now, I want to know what the Officer's done already, if he's, you've looked at the pattern and if you've done exactly what it's found to do then you can do it again, or if I don't believe you've done it thoroughly enough I'll do it again. I need to know what you've done, so I went

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
					through, checking to see have they, [System Searched] him, have they found, because I mean looking, it was looking through these notes that I found out that they hadn't got the property from him – so I didn't know that before, it didn't state that in the MO, it was reading the investigation that's actually like, okay, they actually ended up doing a Section 18 search of his premises and found a lot more stolen items. Well right, okay, so he's prolific doing whatever he's doing, let's, and then it gave me a list of all the property that was stolen, gone brilliant, I don't need to cross off into that with anything that's been stolen in my hotspot see, haven't got him linked by property to any of the other offences… **[CA1.2]** (P9: 31-32) ...What the other investigator didn't do... There was another number in the time frame of the shooting.... Is this an important number?

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that the analysis is complete and thoroughly explored]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to their additional analysis that they have performed. The additional analysis will either support or negate the initial analytical effort.

Figure 63 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the reconsideration of the analysis can lead to the verification that the analysis is correct and complete

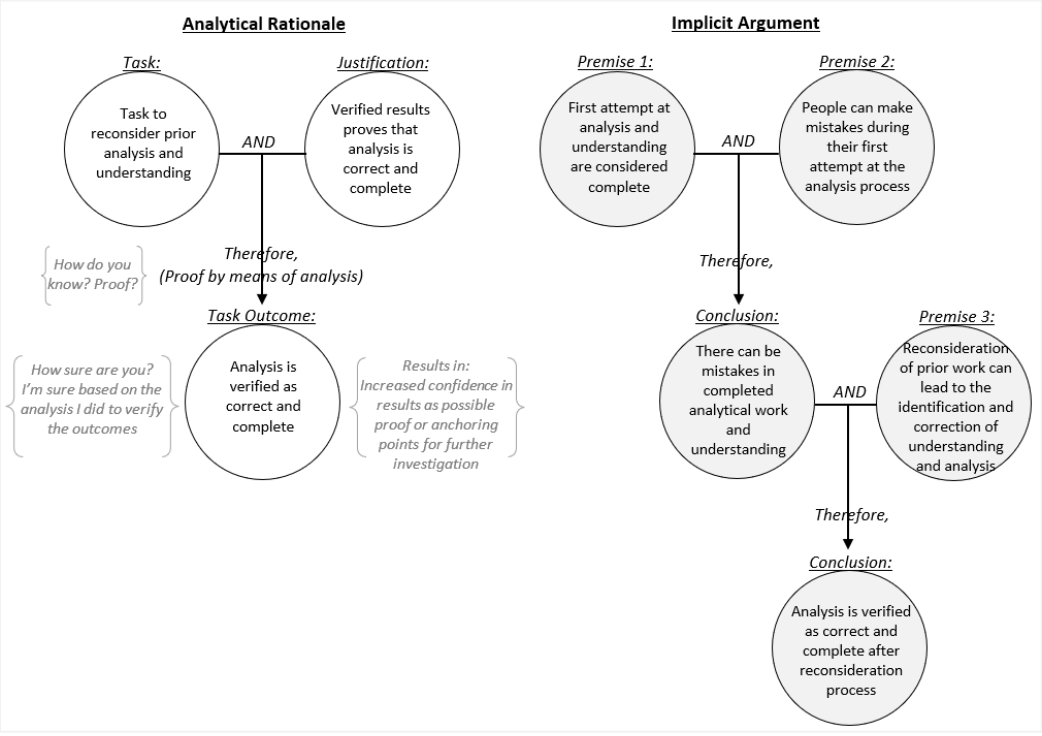


Figure 63 depicts a linked-diagram indicating how the reconsideration of prior analysis and understanding can lead to verified results and understanding.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: First attempt at analysis and understanding are considered complete
Premise 2: People can make mistakes during their first attempt of the analysis process
Therefore,
Conclusion: There can be mistakes in completed analytical work and understanding
Premise 3: Reconsideration of prior work can lead to the identification and correction of understanding ana analysis
Therefore,
Conclusion: Analysis is verified as correct and complete after reconsideration process

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Challenge analysis - Structured Self-Critique (identify weaknesses in own analysis)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Persistence of Impressions Based on Discredited Evidence bias (When an impression is formed, it will likely persist even if other information or evidence disproves the initial impression)
- Absence of Information Bias (Forget to factor in missing information)
- Coping with Evidence of Uncertain Accuracy Bias (Place too much validity on all the information, based on some valid information)
- Representativeness Bias (Tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data)
- Blind Spot Bias (Tendency to see the errors in another analyst's collection and interpretation work while not seeing the mistakes in their own research work)

Possible critical questions for Analytical Rationale:

- Are you accepting/dismissing the outcomes of the new analysis blindly?
- Did you factor in any missing information when you re-analysed?
- How sure are you of the outcomes after re-analysing?
- Are you forcing the information to fit a specific structure during the re-analysis process?
- Did you get the point of view from the person who did the analysis before you, on why they did what they did?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [new outcomes] and [old outcomes] that would tend to undermine the force of the [old outcomes] cited?

(CA2) Resolve errors or ambiguity

Criminal intelligence analysts can have a task to resolve errors or ambiguity in the data set before being able to continue with the analysis. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that their analysis and understanding (anchors) will be of a better quality after they have corrected the errors or ambiguity. This activity leads to an increase their confidence that their results (proof) stem from accurate and un-ambiguous data (anchors).

In CA2.1, the criminal intelligence analyst reported that she was unable to progress the analysis until the ambiguity regarding the anagram that appeared in the case details were resolved. This was done by tasking the officers (broadening) to go to the neighbourhoods and enquiring about the meaning of the anagram. Feedback from the officers would resolve the meaning (laddering) of the anagram and the criminal intelligence analyst can progress her case with confidence that she understood the meaning of the anagram (anchoring).

In CA2.2, the criminal intelligence analyst reported that she had to resolve the ambiguity on which offender was arrested (anchor, narrowing) in order to establish if two cases were linked or not (laddering). By resolving the ambiguity around which offender was arrested would allow the criminal intelligence analysts to have greater confidence in their anchor point for further analysis.

In CA2.3, the criminal intelligence analyst reported that she had to resolve the ambiguity in the visualisations (anchor) in order to understand what she was looking at. She was able to do so by looking at what the underlying data consisted of (laddering, narrowing) to understand what the visualisation was representing. By doing so, she was able to have higher confidence in what the visualisation was presenting as high-volume crime location.

In CA2.4 the criminal intelligence analyst reported that she had to resolve the errors in the intelligence reports which had the same personal details for two different offenders. These errors caused ambiguity as she did not know which offender (anchor) the intelligence was referring to. She was to resolve the errors by analysing various databases (laddering, broadening) in order to differentiate the offenders (narrowing), which she was able to do by referencing their custody records (broadening). By doing so, she was able to have higher confidence in which offender (anchor, narrowing) the intelligence was referring to in order to continue her analysis (laddering).

Table 20 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Pre-Processing –> Checking Completeness –> Resolve Errors or Ambiguity

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to resolve errors and ambiguity (Clarify the meaning of the anagram)	Clear information creates stronger anchors for further analysis	Increased confidence in results as possible proof or anchoring points for further analysis	- Are you sure that you understand the meaning of the information? - Proof is the additional analysis that clarifies ambiguity or incorrect data	- [1] Broadening - [2] Step 3 – who & what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring & Laddering	**[CA2.1]** (P2:267-275) … I couldn't do anything because we had nothing to go on further, only a car and a figurative name... could be an anagram…The phone… they can see where they are living and then can go and look in the neighbourhood if a name occurs over there."

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to resolve errors and ambiguity (Clarify that two crime reports are for the same person)	Clear information creates stronger anchors for further analysis	Increased confidence in results as possible proof or anchoring points for further analysis	- Are you sure that you understand the meaning of the information? - Proof is the additional analysis that clarifies ambiguity or incorrect data	- [1] Narrowing - [2] Step 6 – how are they related? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring & Laddering	**[CA2.2]** (P4:6-10) …the Officer has found, offender arrested for this offence, or arrest made for this offence, didn't state who it was, but basically I got there's an arrest there, then the next one below [crime report], stated that there was an arrest for a very similar offence and these two appear to be linked."
Task to resolve errors and ambiguity (Understand why the graphs are showing particular patterns)	Clear information creates stronger anchors for further analysis	Increased confidence in results as possible proof or anchoring points for further analysis	- Are you sure that you understand the meaning of the information? - Proof is the additional analysis that clarifies ambiguity or incorrect data	- [1] Narrowing - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring & Laddering	**[CA2.3]** (P3:325-327) ... If you had all crime on there [graph] it tends to be shopping centres and things like that will show higher [number of occurrences] than the things that you actually want [to show as high]..."
Task to resolve errors and ambiguity (Clarify misconceptions or resolve errors in the information)	Clear information creates stronger anchors for further analysis	Increased confidence in results as possible proof or anchoring points for further analysis	- Are you sure that you understand the meaning of the information? - Proof is the additional analysis that clarifies ambiguity or incorrect data	- [1] Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[CA2.4]** (P4:441-467)… - I ha-, yes, the only, the issue I had with Offender B was there were two, there was multiple files created for him so he'd got, all of his information was split over different links, which is a pain 'cause you want it all to be in one place, on top of, there was another offender who we'd had come through our system who had the same name and the same dates of birth – which confused me because I wasn't sure who was who, 'cause I don't know what they look like, so I got very confused on, well that's, they don't match any offending patterns that I'm looking at, and then found that there was another guy that does, which caused me issues – it slowed me down quite a lot, 'cause I spent half an hour in the afternoon interrogating that system trying to figure out who he was and who the other guy was and apparently it was the same person, it was a mistake, it's that, two different people. Turned out to be two different people, and then they had to be in exactly the same notch because they reckoned, but the intel, they were all split (inaudible), and I had no pictures so I had to then think well who's that one linked to, they're both the same name and the same date of birth, I can't tell. So that was, that was a pain, that cause, that slowed me down, that was a process which I could've done without. (Interviewer) How do you, how do you tell? (P4) Well the custody, I managed to tell from the intel, how recently they'd been in custody, so the one had said

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
					he hadn't been arrested since two thousand and eight – I was thinking that's odd, why, why have we written intelligence on someone who's not been arrested for six years and has, and has not got previous for vehicle crime, that's, it seemed out of – I then checked another one for the one below, who'd been arrested in December for vehicle crime and I'm thinking right, that's the guy that they're talking about..."

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you understand the meaning of the information]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the additional analysis that they have performed. The additional analysis will resolve any ambiguity or errors.

Figure 64 - Chapter 4: Study 1: Linked diagram depicting the rationale on how clear and error-free information increases the understanding of the case details

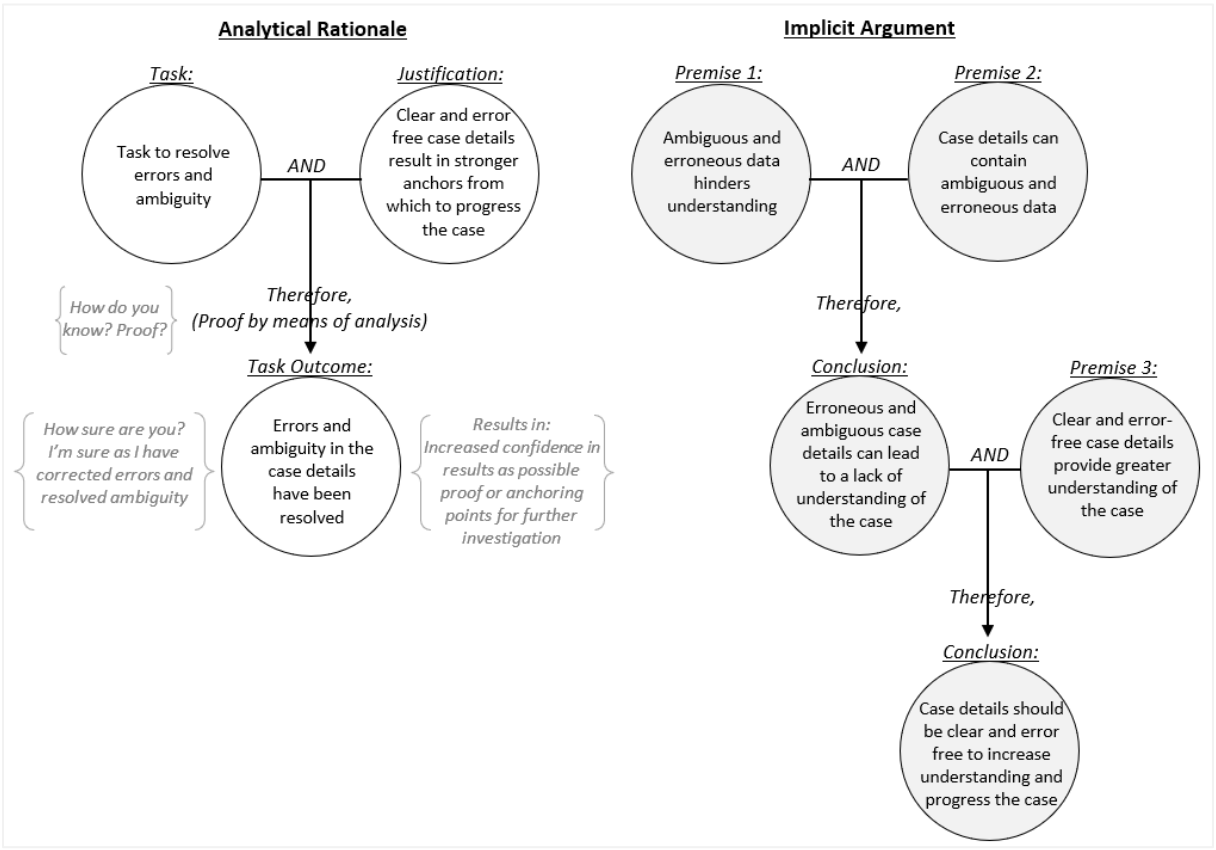


Figure 64 depicts a linked-diagram indicating how resolving errors and ambiguity in the case details can lead to better understanding and thus the progression of the case with stronger anchors.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Ambiguous and erroneous data hinders understanding
Premise 2: Case details can contain ambiguous and erroneous data
Therefore,
Conclusion: Erroneous and ambiguous case details can lead to a lack of understanding of the case
Premise 4: Clear and error-free case details provide greater understanding of the case
Therefore,
Conclusion: Case details should be clear and error free to increase understanding and to the progress of the case

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Assessment of cause and effect - Key Assumption Checks (make assumptions explicit)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Perceptual Biases - Ambiguities (Initial exposure to ambiguous information causes the initial blurred understanding to persist, even with subsequent clear information)
- Coping with Evidence of Uncertain Accuracy Bias (Place too much validity on all the information, based on some valid information)

Possible critical questions for Analytical Rationale:

- Have you reconsidered other information/theories based on the newly corrected/clarified information?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [details from old understanding] and [details from new understanding] that would tend to undermine the force of the [details from the understanding] cited?

(CA3) Data Enrichment

Criminal intelligence analysts can have a task to enrich data with codes (broadening) that convey a specific meaning. An example of such a code is to use red highlighting. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that their codes (anchors) serve as reminders for further actioning (laddering). Enriching the data with codes thus increase their confidence that they have not forgotten something and that they have delivered

the best set of outcomes (proof). This activity can also serve as proof of due diligence (reality/policy loop) when they can show that they have double checked their analysis.

In CA3.1, the criminal intelligence analyst reported that she made notes with red highlighting, as a reminder to come back to information for correction. The note with red highlighting served as a classification and as a visual reminder that another colleague had to update the case details. The criminal intelligence analyst therefore also completed her due-diligence by finding erroneous data and passing it on to the colleagues who could correct the data.

Table 21 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Pre-Processing –> Checking Completeness –> Data Enrichment

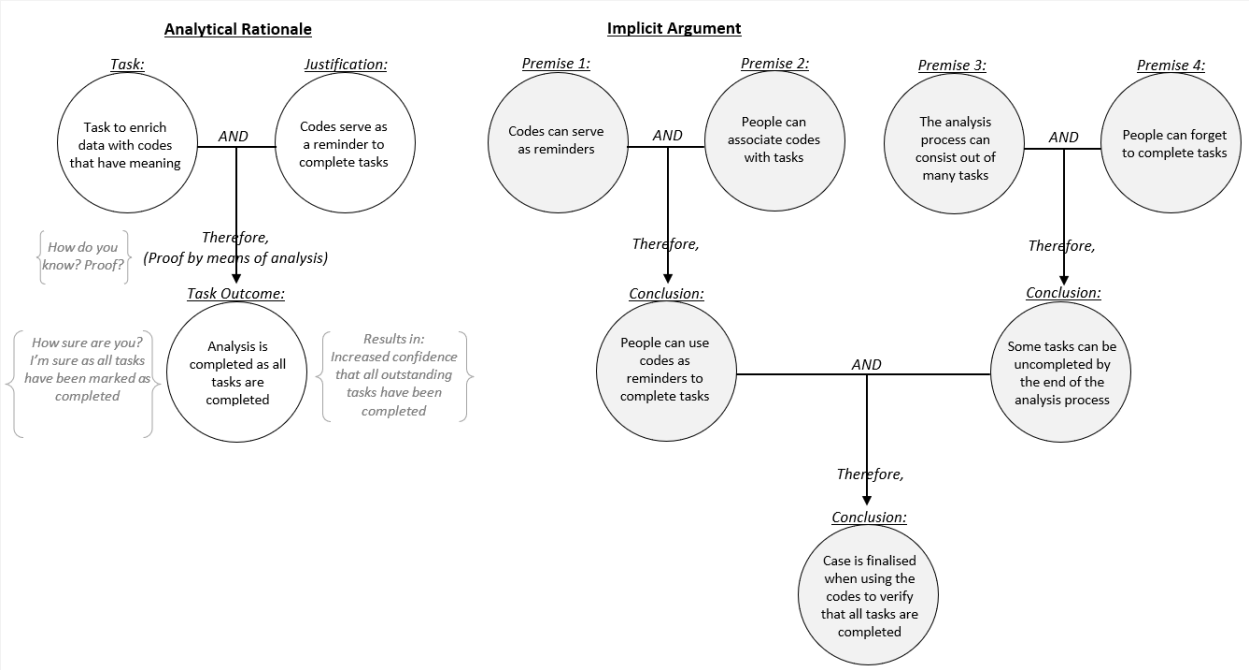
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to enrich data with codes that have meaning	Codes serve as a reminder to complete tasks	Increased confidence that all outstanding tasks have been completed	- Are you sure that you have completed all tasks? - Proof is ticking off the boxes	- [1] Broadening, Narrowing - [2] Reality/Policy loop - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring	[CA3.1] (P4:13-16) …so I highlighted that in red basically to say right, I need to come back to that, that's an avenue (inaudible). (Interviewer) - so that's a memory note for you to – (P4) - yes, to come back to… that was just a note to myself saying that's noted as a theft from and yet there's been nothing stolen, so there's no, that not a theft, that was an attempt, so that was just more, classification of the crime… (P4:33-40) … yes, the other half, yeah. This was before I merged them, I don't remember why I made that red – oh, classification, that was basically, that was just a note to myself saying that's noted as a theft from and yet there's been nothing stolen, so there's no, that not a theft, that was an attempt, so that was just more, erm, classification of the crime, not, mm, that made no bearing on my analysis, it just, it was something to note that we need to change whilst highlighting that I'd passed that on to the man who needs to change."

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you have completed all of the tasks]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the details of the enrichment activities and that confirm that all tasks have been ticked off as completed.

Figure 65 depicts a linked-diagram indicating how the enrichment activities can assist with the confirmation that all tasks were completed.

Figure 65 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the enrichment activities can assist with the confirmation that all tasks were completed.



The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Argument 1:
Premise 1: Codes can serve as reminders
Premise 2: People can associate codes with tasks
Therefore,
Conclusion: People can use codes as reminders to complete tasks

Argument 2:
Premise 3: The analysis process can consist out of many tasks
Premise 4: People can forget to complete tasks
Therefore,
Conclusion: Some tasks can be uncompleted by the end of the analysis process

Therefore (based on Argument 1 and 2),
Conclusion: Case is finalised when using the codes to verify that all tasks are completed

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Checklists

Based on the identified analytical rationale, the following cognitive biases are possible:

- Hindsight biases in evaluation of intelligence reporting (Overconfident in past performances)

Possible critical questions for Analytical Rationale:

- Have you reviewed your work to ensure that you have not forgotten/left-out something?

Possible critical questions for Implicit Argument:

- Argument from Composition (Adapted from Walton et al., 2008:p316)
    - When [analysis as a whole] has property [code of completed], then every [task/subtask] that composes [analysis as a whole] has [code of completed]?

(CA4) Prove impartiality

Criminal intelligence analysts can have a task to prove that their analysis process was conducted with an impartial mindset. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that the analytical steps taken was done in such a manner that they did not superimpose their beliefs on the analysis. This activity serves as proof of due diligence (reality/policy loop) when they can show that they have done the analysis in an appropriate manner.

In CA4.1, the criminal intelligence analyst reported that she takes a consistent analytical approach to all the offenders that she analyses. Even when she has background information on a particular offender, she still completes the full set of analytical steps.

Table 22 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Pre-Processing –> Checking Completeness –> Prove impartiality

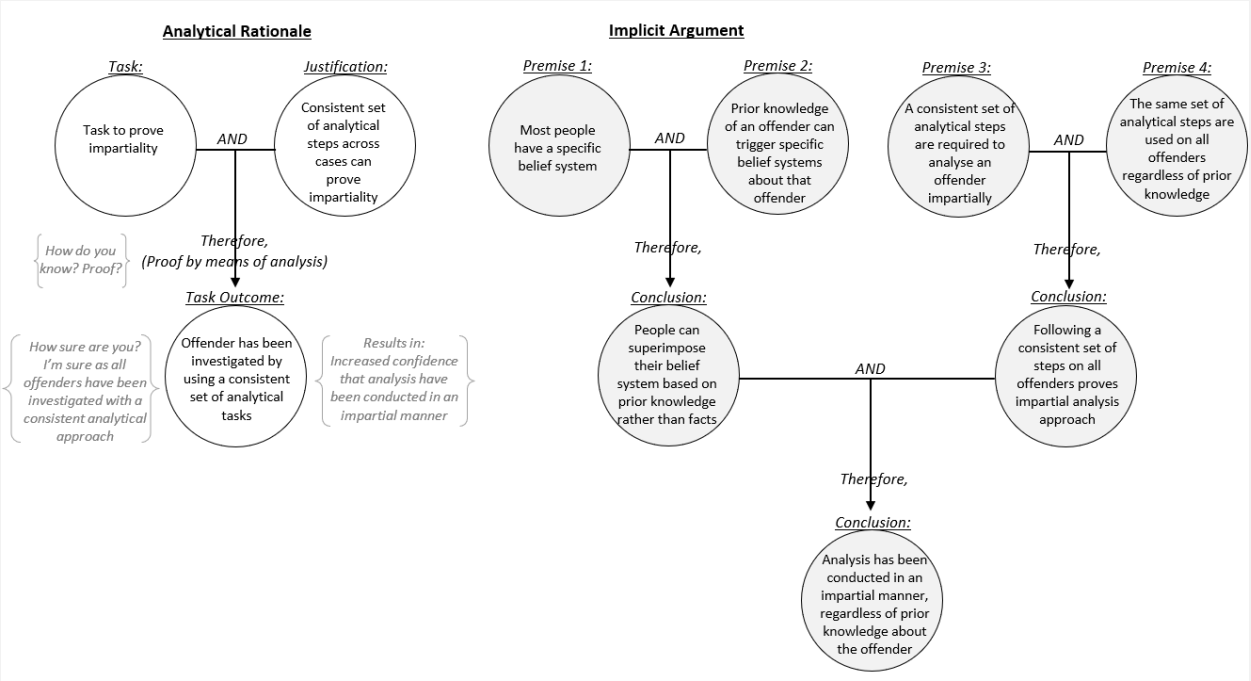
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to prove impartiality	Consistent set of analytical steps across cases can prove impartiality	Increased confidence that analysis have been conducted in an impartial manner	- Are you sure that your personal beliefs are not super-imposed on the analysis? - Proof is the entire analytical approach	- [2] Reality/Policy loop - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence)	[CA4.1] (P6:266-280) ...stereotyping ... I mean they [offenders] are innocent until proven guilty, so we can't just start looking – 'well, you always do it so it's your fault, so I'm just going put everything on you or find stuff to prove that it's you'. I need to come from an unbiased point of view... previous offending can't count at all – it does in terms of my thought process but it doesn't in terms of my analysis, I'm still going take the exact same analysis regardless of – this offender I've never heard of, but even if I had, I'd be doing exactly the same things [analysis steps] in a way to make sure I've not superimposed [the offender] in that position as opposed to [the offender] actually being there...

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that your personal beliefs are not super-imposed on the analysis]?' to determine their level of impartiality during the analysis process or at the end of the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to all the analytical tasks completed and that a consistent set of analytical steps are followed across the analytical approach and other cases.

Figure 66 depicts a linked-diagram indicating how the enrichment activities can assist with the confirmation that all tasks were completed.

Figure 66 - Chapter 4: Study 1: Linked diagram depicting the rationale on how a consistent analytical approach can be used as a basis to show impartiality



The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Argument 1:
Premise 1: Most people have a specific belief system
Premise 2: Prior knowledge of an offender can trigger specific beliefs about that offender
Therefore,
Conclusion: People can superimpose their belief system based on prior knowledge rather than facts

Argument 2:
Premise 3: A consistent set of analytical steps are required to analyse an offender impartially

Premise 4: The same set of analytical steps are used on all offenders regardless of prior knowledge

Therefore,

Conclusion: Following a consistent set of steps on all offenders proves an impartial analytical approach

Therefore (based on Argument 1 and 2),

Conclusion: Analysis has been conducted in an impartial manner, regardless of prior knowledge of the offender

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Assessment of Cause and Effect - Structured Self-Critique (identify weaknesses in own analysis)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Biases in evaluating evidence – Perceptual Biases – Expectations (Perceiving what one expects to see)
- Availability Bias (Imaginability or retrievability from memory)

Possible critical questions for Analytical Rationale:

- How much is your prior knowledge about this offender affecting your analytical approach?

Possible critical questions for Implicit Argument:

- Argument from Example (Adapted from Walton et al., 2008:p314)
    - Is the [offence] claimed in the [Offender] in fact true?
    - Does the [knowledge of prior offences] support the [generalisation that Offender always offends this way], it is supposed to be an instance of [current case]?

(CB) Narrowing

(CB1) Reduce to manageable chunks

Criminal intelligence analysts can have a task to reduce the data set into manageable chunks (narrowing) of data to assist with their sensemaking process. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that some chunks of the data (anchors) are more applicable than other chunks. This increases their confidence that they are working with the most appropriate information concerning the case that the results (proof) that underpin their theories, are the most pertinent concerning the case. This activity can also serve as proof of due diligence (reality/policy loop) when they can show their reasoning on why some chunks of information (narrowing) was deemed as unsuitable to the analysis (laddering).

In CB1.1, the criminal intelligence analyst reported that she had issues with the size of the hotspot as it did not reveal any meaningful insights into when the offending was likely to occur. She therefore divided the hotspot into smaller hotspots (narrowing) which allowed her to derive a likely pattern (anchor) of when the offending was occurring and could therefore instruct the officers to a more applicable time frame to patrol that area and report back on their findings (laddering). This activity can also serve as proof of due diligence (reality/policy loop) when she can show that the department's resources (officers) were used in an appropriate (cost-effective) manner. In CB1.2, the criminal intelligence analyst read through the crime reports and broke the reports into manageable chunks (narrowing) that she could refer to at a later date and compare (associative questioning) with other crime reports. This narrowing activity assisted her with her sensemaking process across time (laddering).

In CB1.3, the criminal intelligence analyst reported that she divided the data set into crime types by neighbourhood (narrowing). By doing so, she was able to prioritise her analysis to crimes and areas that were the most affected. This activity can also serve as proof of due diligence (reality/policy loop) when she can show her reasoning on why some neighbourhoods were deemed a higher priority than others.

Table 23 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Pre-Processing –> Narrowing –> Reduce to manageable chunks

Task	**Task Rationale / Justification**	**Task Outcome / Achievement**	**Argumentation**	**Literature link**	**Interview snippets**
Task to reduce the data set into smaller chunks	Some chunks of information are more pertinent than others and should be analysed first	The selected chunk of information is the most pertinent to analyse	- Are you sure that you are looking at the most pertinent information? - Proof is different chunks of information and evaluation that some chunks are most pertinent	- [1] Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering, Associative Questioning	**[CB1.1]** (P4:138-144) … for this I wanted to see when is best for us to police in those, these locations where there was (inaudible), obviously we can't be there all the time, I want the key times and dates to put us there at those times so we can cost effective be there when it's meant to be happening – if not to catch them to prevent it altogether, erm, which I was struggling to do treating it as one hotspot, 'cause it was quite sporadic in terms of days and times to a certain extent, trying to split it into two.." **[CB1.2]** (P4: 195-202) I think we still need to have an understanding of what is happening so you still need that knowledge, looking through things to try and understand it. I think yesterday (Inaudible) to try to speed it up a little bit I wouldn't normally try to remember each one but (Inaudible) reading through it and breaking it down a little bit does help it for me, it helps me remember things and oh that happened last week then I can go back to the Spreadsheet and find where it was because if it's just presented to you and then I wouldn't remember if I just read something I'd have to break it down a little bit so that it's stick in my mind." **[CB1.3]** (P3:232-257) … yeah so, we have the previously Set up Searches that are saved in the Database, so at the morning if I was back on the LPU I would search for all the offences that have happened in the last 24 hours to get a snapshot of what's happened, put that on the map and then we can Import and Save. (Interviewer) OK... yesterday was from the last 3 weeks? (P3) ...yes so on a daily basis we use it says here 4 weeks but we can do it over any time period up until the database was cleared so (Interviewer) so does that ring a bell? (P3) yeah so that's all the crimes exported into Excel and then I've pivoted the (inaudible) data is which column type have had the most offences. (Interviewer) So what are these columns? (P3) They're the Neighbourhood Beats. (Interviewer) OK so this is Crime Type by Neighbourhood and how does that help you? (P3) just says whether which

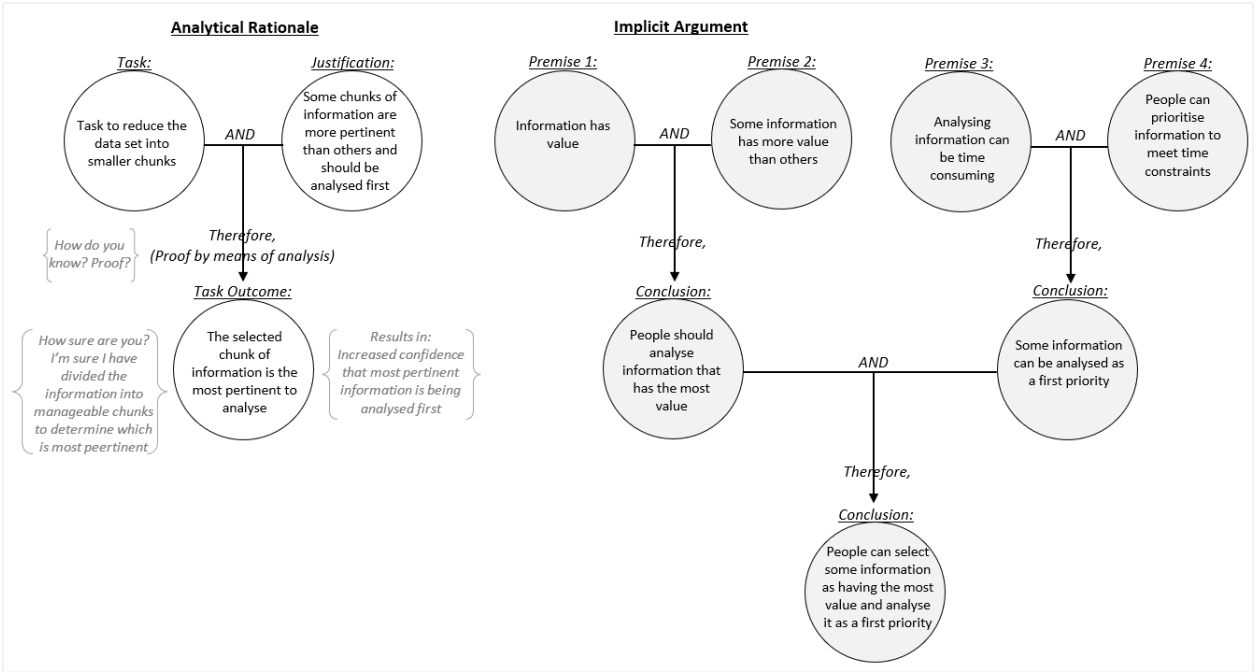
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
					neighbourhoods had the most offences in total and also in each crime type as well. (Interviewer) Right and how is that helpful? (P3) So if we know we're looking at Theft from Motor Vehicle, because it's the highest volume we can then look at it and then before we plot it on a map we've already got an idea of which neighbourhoods have the most offending. (Interviewer) Ah, so it's an initial view before you go to the map it provides you with a sort of this area is going to be important to look at from the point of view of the and that's a Summary produced in the Spreadsheet? (P3) yeah."

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you are looking at the most pertinent information]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the different chunks of information and their reasoning on why some chunks of information were deemed as more pertinent than others.

Figure 67 depicts a linked-diagram indicating how reducing the data set into smaller chunks can lead to the analysis of the most pertinent information.

Figure 67 - Chapter 4: Study 1: Linked diagram depicting the rationale that reducing the data set into smaller chunks can lead to the analysis of the most pertinent information first



The implicit premises and conclusions (Govier) would look as follow:

Argument 1:
Premise 1: Information has value
Premise 2: Some information has more value than others
Therefore,
Conclusion: People should analyse information that has the most value

Argument 2:
Premise 3: Analysing information can be time consuming
Premise 4: People can prioritise information to meet time constraints
Therefore,
Conclusion: Some information can be analysed as a first priority

Therefore (based on Argument 1 and 2),
Conclusion (explicit): People can select some information as having the most value and analyse it as a first priority

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Sorting & Ranking

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgements)

Possible critical questions for Analytical Rationale:

- Why is the chosen data the most pertinent information to analyse first?

Possible critical questions for Implicit Argument:

- Value-Based Practical Reasoning (Adapted from Walton et al., 2008:p324)
    - What other [considerations] do I have that might conflict with [my understanding that this information is the most pertinent to analyse]?
    - What alternative [analytical actions] to my bringing about [my understanding that this information is the most pertinent to analyse] that would also bring about [different focus that] should be considered?

(CB2) Exclude irrelevant information

Criminal intelligence analysts can have a task to exclude irrelevant information (narrowing) to assist their sensemaking process. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that some information (anchors) is more applicable to the case than others. This increases their confidence that they are working with the most appropriate

information concerning the case, which has a cascading effect on the results (proof). This activity can also serve as proof of due diligence (reality/policy loop) when criminal intelligence analysts can show their reasoning on why some information were deemed as unsuitable to the analysis process (laddering).

In CB2.1, the criminal intelligence analyst reported that she excluded the robbery data from her analysis as it was deemed irrelevant, because the quantity of crimes committed were not significant enough to indicate a problem area (anchor).

In CB2.2, the criminal intelligence analyst reported that the traffic camara data (anchor) could be excluded from the investigation, as the offender did not drive and would therefore add no real value to the investigation (laddering).

In CB2.3, the criminal intelligence analyst reported that he did not yet know which data he needed for the investigation, so obtaining the telephone data (anchor) of all employees at the company as well as the security footage (anchor) of the harbour, would add no real value to the investigation at that point in time.

Table 24 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Pre-Processing –> Narrowing –> Exclude irrelevant information

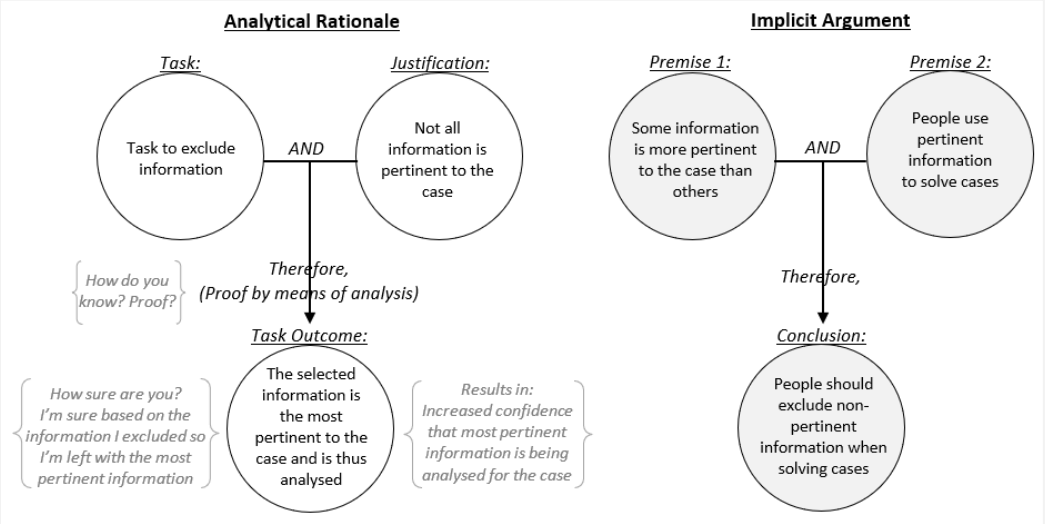
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to exclude information	Not all information is pertinent to the case	Increased confidence that most pertinent information is being analysed for the case	- How sure are you are that the information that you're looking at is the most pertinent? - Proof is the chosen set of information and evaluation that it is most pertinent	- [1] Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[CB2.1]** (Interviewer) It looks like you're filtering (P3) yeah I think because we looked into the robberies and it wasn't an issue and so we might have been getting rid of the Robbery Data from the Excel spreadsheet that I had at that point. (Interviewer) What do you mean it wasn't an issue (P3) [Person] looked at (Inaudible) and the level of offending was quite consistent week on week and it was also below the average. **[CB2.2]** (P1:154-155) …We don't have to go to the traffic cameras…he doesn't drive. **[CB2.3]** (P5: 137-140) No it [police statements of 50 people] wasn't good enough. I also had the telephone records. Even film records of the harbour. I said to the judge, shouldn't do it [to obtain phone and harbour records], because, at this moment, we can't do anything with it. You gonna have 1 million records to search in, and you don't know what you are looking for. So, at this moment, it is a waste of money.

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you are looking at the most pertinent information]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to their reasons for the information that they have kept and the information that they have discarded.

Figure 68 depicts a linked-diagram indicating how the reconsideration of prior analysis and understanding can lead to verified results and understanding.

Figure 68 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the exclusion of information results in only the most pertinent information for analysis and thus, assists with solving the case



The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Some information is more pertinent to the case than other information
Premise 2: People use pertinent information to solve cases
Therefore,
Conclusion: People should exclude non-pertinent information when solving cases

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Sorting & Ranking

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgements)

Possible critical questions for Analytical Rationale:

- Why is the chosen data considered to be non-pertinent to the case?

Possible critical questions for Implicit Argument:

- Value-Based Practical Reasoning (Adapted from Walton et al., 2008:p324)

- What other [considerations] do I have that might conflict with [my understanding that this information is not pertinent to the case]?
- What alternative [analytical actions] to my bringing about [my understanding that this information is not pertinent to the case] that would also bring about [different viewpoint that] should be considered?

(CC) Broadening

(CC1) Broaden Scope

Criminal intelligence analysts can have a task to broaden the scope of the data they need for the analysis process. They can do so by requesting all the possible information upfront or by requesting additional information as they move through the analysis process. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that more information could lead to new findings (anchors) that could progress their understanding (laddering) of the crime scenario. Criminal intelligence analysts can increase their confidence that they have sufficient information to reach an appropriate set of results (proof) that underpin their theories. This activity can also serve as proof of due diligence (reality/policy loop) when they can show why they have broadened their scope of information.

In CC1.1, the criminal intelligence analyst reported that he reached out to a foreign country (broaden) to obtain the offender details (anchors) he needed to progress his case. He pointed out that it could be a time-consuming task to get the information back from a foreign country, so in CC1.2 the criminal intelligence analyst reported that he broadened his request by also asking for the offenders' bank records. In CC1.3, the criminal intelligence analyst reported that he broadened his understanding of the crime details by analysing additional aspects of the information, such as who the owner of a car was (laddering), as it assists with forming a greater picture of the MO (anchor) used in the crime.

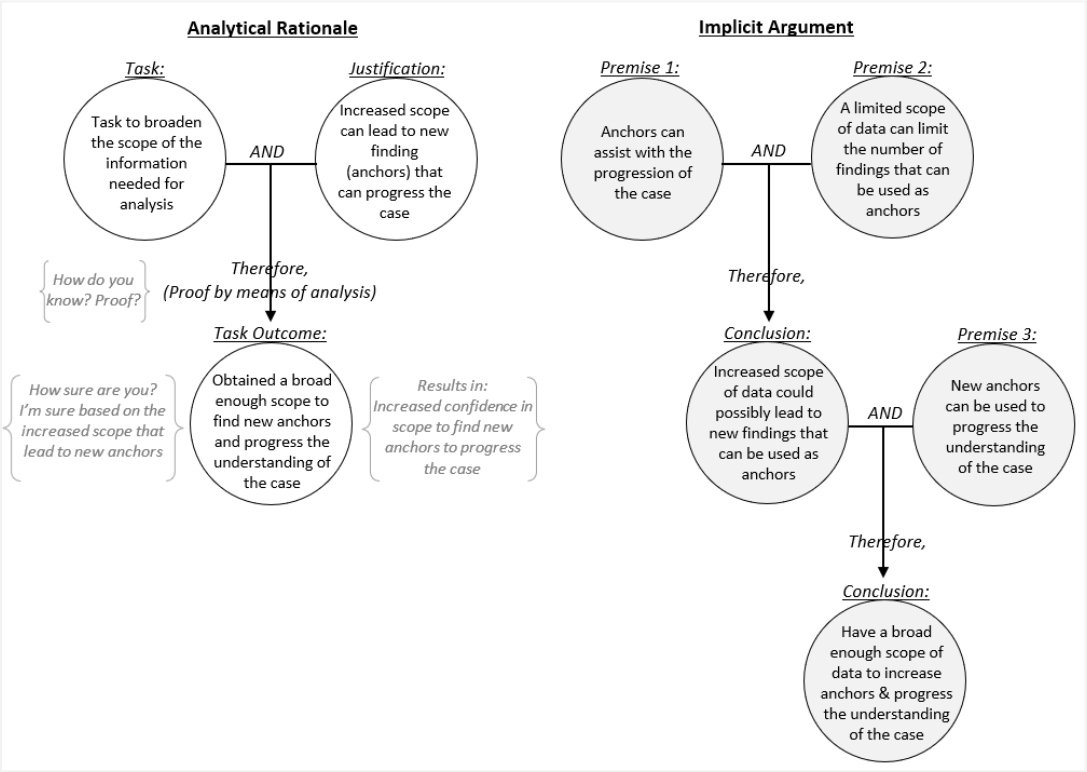
In CC1.4, the criminal intelligence analyst reported that he broadened the scope of information after he determined the movements (anchors) of the victim by requesting a broad spectrum of telephone data between two cities, so that he could further his understanding (laddering) of the victim's movements.

Table 25 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Pre-Processing –> Broadening –> Broaden Scope

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to broaden the scope of the information needed for analysis	Increased scope can lead to new finding (anchors) that can progress the case	Increased confidence in scope to find new anchors to progress the case	- How sure are you are that you have enough information to progress your analysis? - Proof is increased scope of data and new anchors found	- [1] Broadening - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[CC1.1]** (P9: 20) …Go to police in foreign country and ask them to look the [telephone] numbers up for you...some cases it is quick .. others you need to wait weeks, months... **[CC1.2]** (P9: 21) … we also ask his bank records...if I don't have it then I will ask for it...why?...every information

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
					we get on that person is very important...you don't know in this moment in time what you are going to need...I ask for everything... **[CC1.3]** (P9:22) ..I want to know the owner [of the car]...it is of the uttermost importance, because it is part of the MO... **[CC1.4]** (P5: 253-257) ... So, we knew the guy [victim] lived in [city A], and came to [city B] that afternoon and died in [city B] at about [timestamp]. So, you got two location - [city A] and [city B]. We know the street and the number, we asked the [phone] providers, give us all the calls between our x and y in [city A], before the incident in [city B], and all the telecommunications in the incidents till the morning after.

Figure 69 - Chapter 4: Study 1: Linked diagram depicting the rationale on how broadening the scope of data could lead to new findings (anchors) that could progress the understanding of the case



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you have enough information to progress the case]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to their broadening activities and their reasons for requesting the additional information.

Figure 69 depicts a linked-diagram indicating how the reconsideration of prior analysis and understanding can lead to verified results and understanding.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Anchors can assist with the progression of a case
Premise 2: A limited scope of data can limit the number of findings that can be used as anchors
Therefore,
Conclusion: Increased scope of data could possibly lead to new findings that can be used as anchors
Premise 3: New anchors can be used to progress the understanding of the case
Therefore,
Conclusion: Have a broad enough scope of data to increase anchors and progress the understanding of a case

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Starter Checklist

Based on the identified analytical rationale, the following cognitive biases are possible:

- Perceptual Biases – Ambiguities (Initial exposure to ambiguous information causes the initial blurred understanding to persist, even with subsequent clear information)
- Representativeness bias (Tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data)

Possible critical questions for Analytical Rationale:

- Do you have enough information to formulate your rationale?
- What value would more information add to your understanding?
- Are you dismissing subsequent information as it conflicts with your current understanding?

Possible critical questions for Implicit Argument:

- Value-Based Practical Reasoning (Adapted from Walton et al., 2008:p324)
    - What other [analytical approaches] do I have that might [resolve] [my need for more information]?

    - What alternative [analytical approaches] to my bringing about [need for more information] that would also bring about [new anchors] should be considered?
- Argument from need for Help (Adapted from Walton et al., 2008:p334)
    - Would the proposed action [need for more information] help [finding new anchors]?
    - Would there be negative side effects of carrying out [need for more information] that would be too great?

(CC2) Consolidate

Criminal intelligence analysts can have a task to consolidate different data sections or analytical results (broaden) to create an additional view of the data. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that a consolidated data set could lead to new findings (anchors) that could assist with the progression of the case (laddering). This leads to an increase in their confidence in the results (proof) that underpin their theories. This activity can also serve as proof of due diligence (reality/policy loop) when they can show how the consolidated data led to the creation of new anchors.

In CC2.1, the criminal intelligence analyst reported that different sections (anchors) of the analysis all pointed to a telephone number belonging to a particular offender (laddering). The criminal intelligence analyst therefore consolidated (broadened) the results and continued his analysis with the new understanding regarding offender and the telephone number. The criminal intelligence analyst could also use the broadened view of the results as proof of due diligence (reality/policy loop) that sufficient analysis has been conducted to link the offender with the telephone number.

In CC2.2, the criminal intelligence analyst reported that she consolidated findings from crime data reports into a separate spreadsheet/database over time (broaden). By doing so, she could use the consolidated data as a separate analysis tool and therefore find new anchors.

Table 26 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Pre-Processing –> Broadening –> Consolidate

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Consolidate different data sections or analytical results in order to create an additional view of the data	The consolidated data set could lead to new findings (anchors) that could assist with the progression of the case	Increased confidence that the consolidated view of the data is the 'best' basis from which to increase understanding	- How sure are you are you have the most appropriate view of the data? - Proof is the combined information over time	- [1] Broadening - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, laddering	**[CC2.1]** (P9:33) When I have two or three confirmations that the [telephone] number is [belongs to] (Person A), then I'll merge them... placed (Person A) in many [offences] with the same MO... **[CC2.2]** (P4:242-248) well what we do – now this is what takes up a lot of time – is, on a daily basis what I do (inaudible) on a daily basis, I'll look at all of the vehicle crime that's taken place on that twenty four hour period, I will look in detail at all of those offences – have we had any

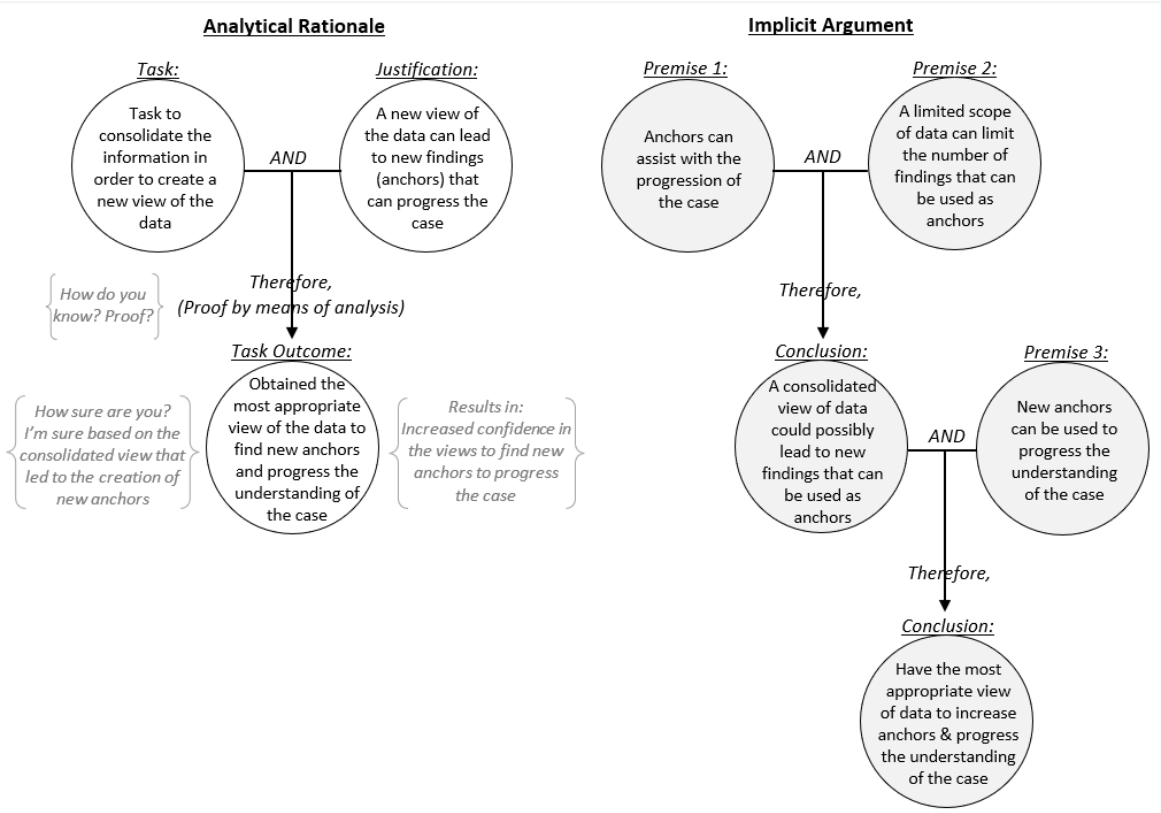
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
					arrests, have we had this happen, any other for MOs, I'll then put that into my own spreadsheet database and I will put in the offenders so that I've sort of created my own database that I can search for my offence types and my offenders that tend to offend.

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you have the most appropriate view of the data]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the consolidated view of the data and the reasons for why they consolidated the data or results.

Figure 70 depicts a linked-diagram indicating how the consolidated view of data can lead to new findings.

Figure 70 - Chapter 4: Study 1: Linked diagram depicting the rationale on how the consolidation of information could lead to new views of the data and thus lead to new anchors to progress the case



The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Anchors can assist with the progression of a case
Premise 2: A limited view of the data can limit the number of findings that can be used as anchors
Therefore,
Conclusion: A consolidated view of the data could possibly lead to new findings that can be used as anchors
Premise 3: Anchors can be used to assist with the understanding of case details
Therefore,
Conclusion: Have the most appropriate view of the data to increase anchors and progress the understanding of a case

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Starter Checklist

Based on the identified analytical rationale, the following cognitive biases are possible:

- Perceptual Biases – Ambiguities (Initial exposure to ambiguous information causes the initial blurred understanding to persist, even with subsequent clear information)
- Representativeness bias (Tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data)

Possible critical questions for Analytical Rationale:

- Do you have enough understanding of what the information represents to consolidate into one?
- What value would the consolidation of information/views/perspectives bring to your understanding?
- Are you dismissing subsequent anchors from the consolidated information as it conflicts with your current understanding?
- Are you dismissing new information as it conflicts with your understanding from the consolidated information?

Possible critical questions for Implicit Argument:

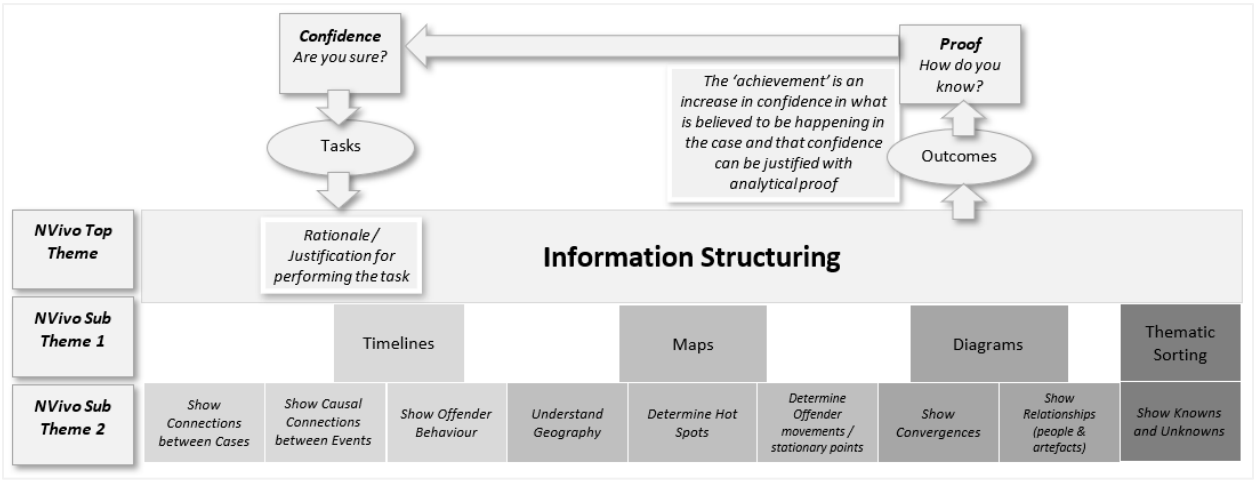
- Value-Based Practical Reasoning (Adapted from Walton et al., 2008:p324)
    - What other [interpretations could exist] that might conflict with [interpretations form consolidated information/views/perspectives]
- Argument from need for Help (Adapted from Walton et al., 2008:p334)
    - Would the proposed action [consolidating information/views/perspectives] help [finding new anchors]?
    - Would there be negative side effects of carrying out [consolidating information/views/perspectives] that would be too great?

(D) Information Structuring

Information Structuring refers to those activities where criminal intelligence analysts transform the information into a structured format that would allow them to derive further meaning. This consists out of activities such as creating timelines, maps, pivot tables and other structured formats. This NVivo emerging theme would equate to the Schematise process and the Schema information flow within Pirolli and Card's (2005) Notional Model of Sensemaking.

The results listed in this NVivo category outlines the play between Elm et al.'s (2005) Broadening and Narrowing concepts and Wong and Kodagoda's (2015) anchoring, laddering and associative questioning concepts.

Figure 71 – Chapter 4: Study 1: Information Structuring



(DA) Timelines

(DA1) Show connections between cases

Criminal intelligence analysts can have a task to determine connections between cases using a timeline. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that a timeline is a suitable visual medium to reveal the connections (anchors, narrowing) between cases once the information is arranged on it (broadening). Once they understand (laddering) the connections between the cases, then they can determine the next set of analytical approaches to drive the investigation forward. A timeline increases their confidence in the validity of the results (proof) that underpin their theories. This activity can also serve as proof of due diligence (reality/policy loop) when they can show how the plotted information revealed the connections.

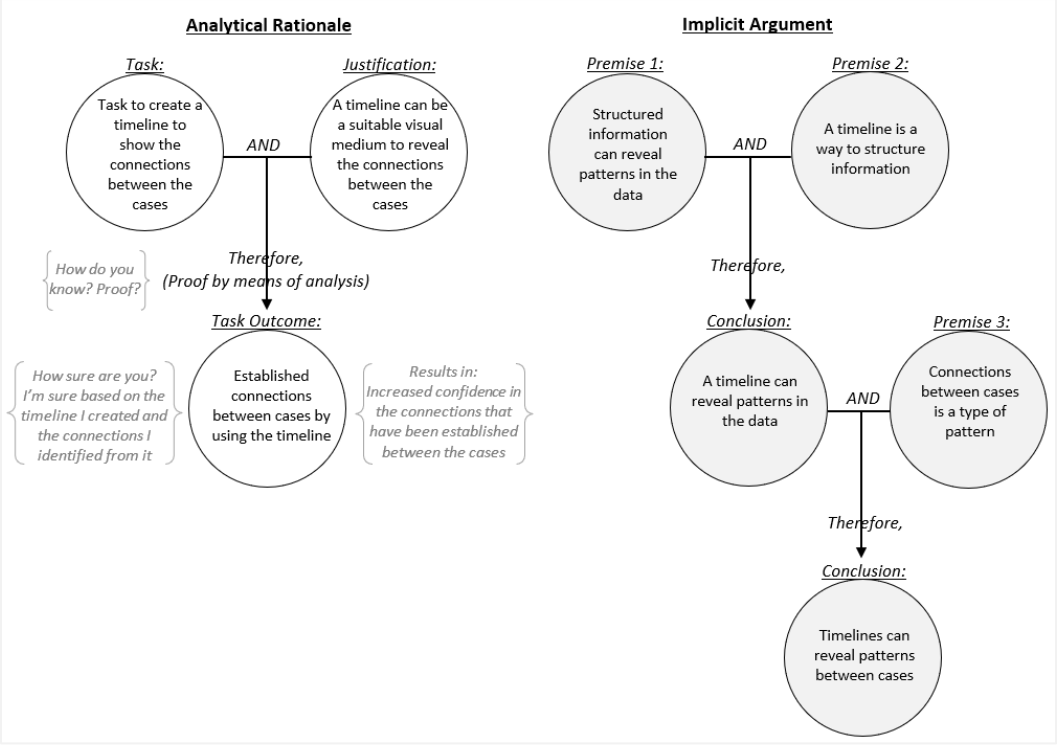
In DA1.1, the criminal intelligence analyst reported how she plotted different case details onto a timeline. This allowed her to compare (broadening) the different cases and in doing so, it revealed that the same offender (anchor, narrowing) was responsible for all the plotted cases. This increased understanding (laddering) allowed her to progress the case.

In DA1.2, the criminal intelligence analyst reported how a timeline serves as a suitable medium to communicate the case details to the decision-makers (reality/policy loop).

Table 27 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Structuring –> Timelines –> Show connections between cases

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to create a timeline to show the connections between cases	A timeline can be a suitable visual medium to reveal the connections between cases	Increased confidence in the connections that have been established between the cases	- How sure are you that cases are connected? - Proof is by means of a timeline	- [1] Broadening, Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[DA1.1]** (P2:291-301) ... yes, I put them [case details] on a timeline so I could ...compare them with each other and ...lead the same person always to the different cases. **[DA1.2]** (P3) Because you can see, if you visualise ...that's very important for all the, pictures and the Judges because they can see it at once what happened, and who is involved and what's going on...

Figure 72 - Chapter 4: Study 1: Linked diagram depicting the rationale on how timelines can be used to show connections between cases



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that the cases are connected]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the timeline that they have created and how that activity revealed the connections between the cases.

Figure 72 depicts a linked-diagram indicating how a timeline can reveal the connections between the cases.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Structured information can reveal patterns in the data
Premise 2: A timeline is way to structure information
Therefore,
Conclusion: A timeline can reveal patterns in the data
Premise 3: Connections between cases is a type of pattern
Therefore,
Conclusion: A timeline can reveal the connections between the cases

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Timelines
- Making sense of complex data - Comparative Case Analysis (identifies similarities between incidents)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Oversensitivity to Consistency bias (Placing too much emphasis on patterns within small sample information without reflecting on the reason for the patterns)
- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Representativeness bias (Tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data.)

Possible critical questions for Analytical Rationale:

- Are the observed connections, really connections?
- Are other factors contributing to the connections?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [item-1 on timeline], [item-2 on timeline]…[item-x on timeline] that would tend to undermine the force of the [connection] cited?
    - Is there some other case that is also similar to [connection], but is different to not be [connection]?
- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)

- Is there really a correlation between [observed connection] and [number of connection occurrences]?
- Is there any reason to think that the correlation is any more than a coincidence?
- Could there be some third factor, C, that is causing both [observed connection] and [number of connection occurrences]?

(DA2) Show causal connections between events

Criminal intelligence analysts can have a task to determine the different causal connections between the events within a case. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that a timeline is a suitable visual medium to reveal and explain the causal connections (anchors, narrowing) between the different events of a case, once the information is arranged on a timeline (broadening). Once they understand (laddering) how the events are connected, then they can explain how the crime likely unfolded and decide on further analytical steps or conclude the case. A timeline increases their confidence in the likelihood of causal connections between events and the analytical results (proof) that underpin each causal connection or event. This activity can also serve as proof of due diligence (reality/policy loop) when they can show how the plotted information revealed the connections.

In DA2.1, the criminal intelligence analyst reported that he used a timeline to plot telephone details (anchors, narrowing). He then used the timeline along with the analytical results for each crime event (broadening, laddering), to determine and explain the likely causal connections that linked each of the events (before, during and after the shooting).

Table 28 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Structuring –> Timelines –> Show causal connections

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to create a timeline to show the causal connections between events	A timeline can be a suitable visual medium to reveal the causal connections between events	Increased confidence the likelihood of causal connections between case events	- Are you sure of the likelihood of the explanation of the causal connections between the events? - Proof is by means of a timeline	- [1] Broadening, Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[DA2.1]** (P9:13)...I have all the [phone] records.. This victim has this phone and this number to it… at this time I try to identify what happened here [referring to the shooting event] … if I have the phone billing, I draw a timeline… (T-1) [referring to the time the shooting happened and the hours before] … at one point in time [referring to the overview of the timeline] I see the morning the afternoon and the evening..."

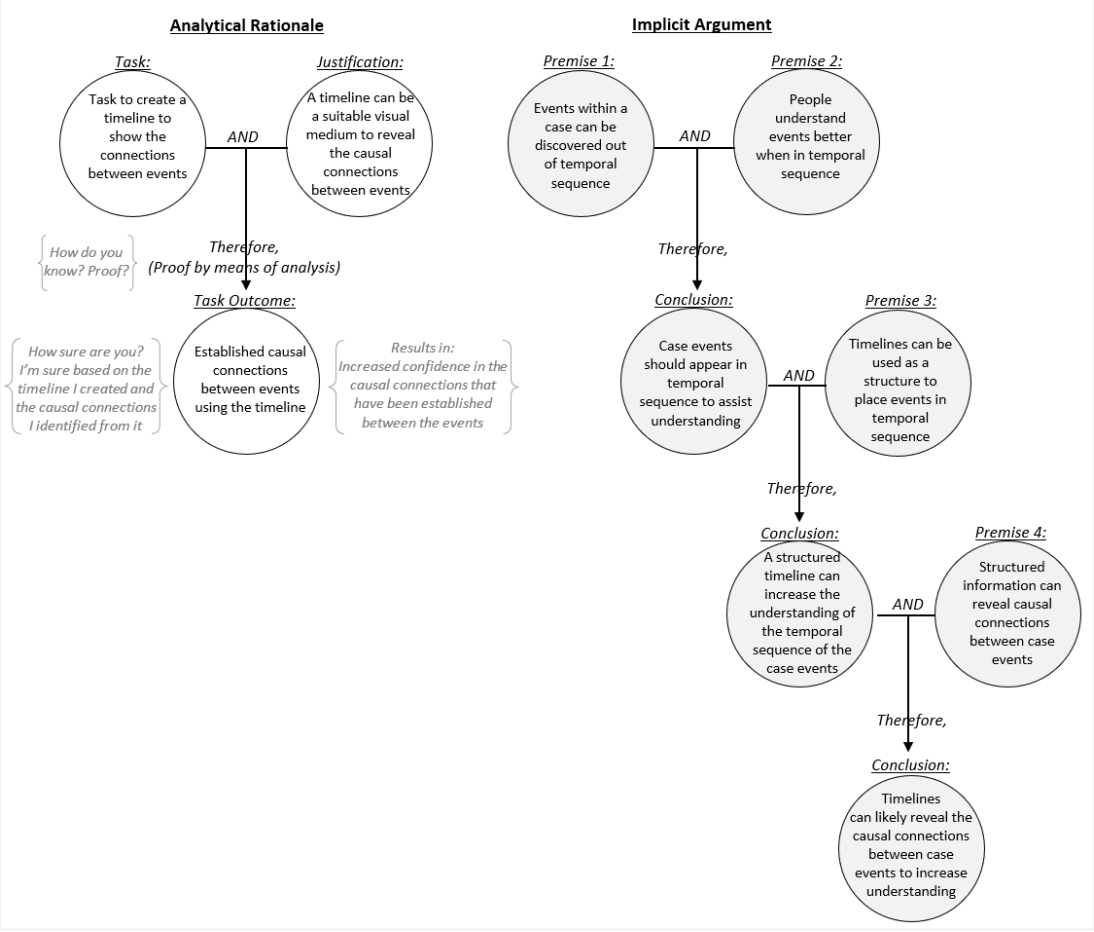
Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [of the likelihood of the explanation of the causal connections between the events]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the constructed timeline and how it reveals and explains the causal connections between cases. Figure 73 depicts a linked-diagram indicating how a timeline can be used to reveal likely causal connections between events.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Events within a case can be discovered out of temporal sequence
Premise 2: People understand events better when in temporal sequence
Therefore,
Conclusion: Case events should appear in temporal sequence to assist understanding
Premise 3: Timelines can be used to place events in temporal sequence
Therefore,
Conclusion: A timeline can increase the understanding of the temporal sequence of case events
Premise 4: Structured information can reveal causal connections between cases
Therefore,
Conclusion: Timelines can likely reveal the causal connections between case events to increase understanding

Figure 73 - Chapter 4: Study 1: Linked diagram depicting the rationale on how a timeline can be used to reveal likely causal connections between events



Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Timelines
- Other - Crime Script Analysis (breaks down information into logical steps in an organised sequence. There are four stages to a crime: preparation, pre-activity, activity and post-activity)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Oversensitivity to Consistency bias (Placing too much emphasis on patterns within small sample information without reflecting on the reason for the patterns)
- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Representativeness bias (Tendency for people to judge the probability or frequency of a hypothesis by considering how much the hypothesis resembles available data.)
- Bias in favour of causal explanations (Random events are regarded as having meaning and order, when they are in fact just random)

Possible critical questions for Analytical Rationale:

- Are the observed connections, really connections?
- Are other factors contributing to the connections?
- Are the events random enough to not be connected?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [item-1 on timeline], [item-2 on timeline]…[item-x on timeline] that would tend to undermine the force of the [connection] cited?
    - Is there some other case that is also similar to [connection], but is different to not be [connection]?
- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [observed connection] and [number of connection occurrences]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, C, that is causing both [observed connection] and [number of connection occurrences]?

(DA3) Show offender behaviour

Criminal intelligence analysts can have a task to plot different case details (broadening) onto a timeline to determine the likely offending behaviour of the offender (narrowing). The way offenders prefer to offend is referred to as the Modus Operandi (MO) and the timeline can shed light on the details of the MO. Criminal Intelligence Analysts' engagement with this type of task

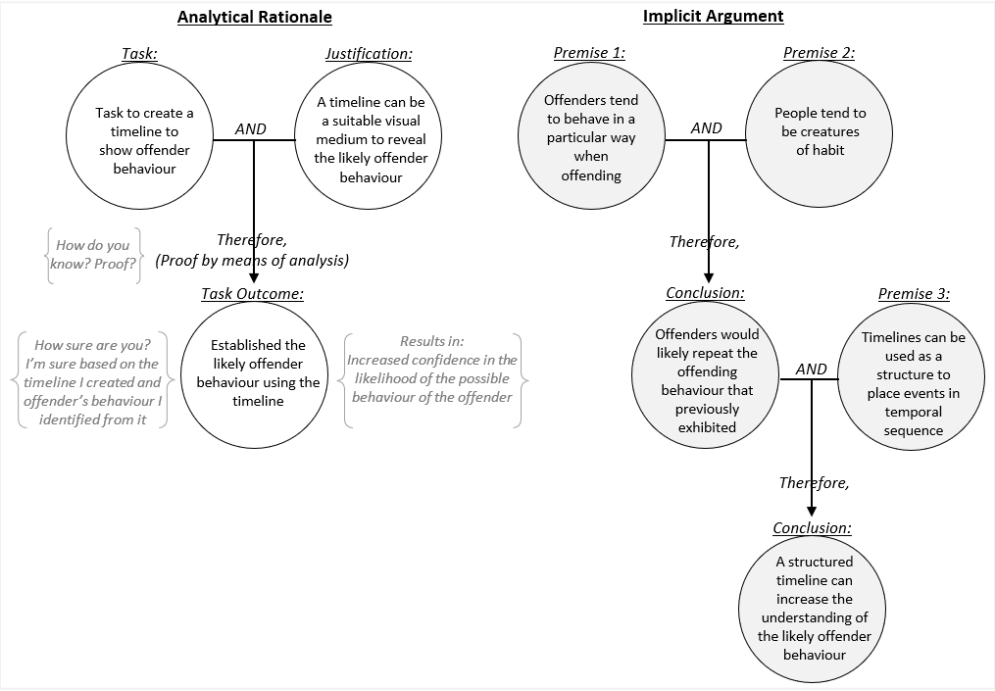
is justified with the reasoning that a timeline is a suitable visual medium to reveal the MO details (anchors, narrowing) on how the offenders prefer to offend. Once they understand (laddering) how the offenders are behaving, then they can decide on further analytical steps or conclude the case. A timeline increases their confidence in the likelihood of the MO being correctly determined (proof). This activity can also serve as proof of due diligence (reality/policy loop) when they can show how the plotted information revealed the MO.

In DA3.1, the criminal intelligence analyst reported that she plotted the details of multiple cases onto a timeline (broadening). By doing so, she could determine how much time the offenders needed to regroup before they offended again. This increased her understanding on the likely way the offenders preferred to offend (as the MO for offender behaviour) (laddering).

Table 29 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Structuring –> Timelines –> Show offender behaviour

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Create a timeline to determine the offending behaviour of offenders	A timeline can be a suitable visual medium to determine the likely offending behaviour	Increased confidence in the likelihood on how the offenders behave	- Are you sure that you understand the likely offender behaviour? - Proof is by means of a timeline	- [1] Broadening, Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	[DA3.1] (P2:562-565) …You can see very fast all the links between all the cases and then you can put it on a timeline and so you can see how much time is between all the facts and how much time they need [referring to cool off period of offenders] to go for another victim [referring to committing another offence] …

Figure 74 - Chapter 4: Study 1: Linked diagram depicting the rationale on how a timeline can be used to determine the offending behaviour



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you understand the likely offender behaviour]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the constructed timeline and how it reveals and explains the likely behaviour of the offenders.

Figure 74 depicts a linked-diagram indicating a timeline can be used to reveal the offender behaviour.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Offenders tend to behave in a particular way when offending
Premise 2: People tend to be creatures of habit
Therefore,
Conclusion: Offenders would likely repeat the offending behaviour that they previously exhibited
Premise 3: Timelines can be used as a structure to place events in a temporal sequence
Therefore,
Conclusion: A timeline can increase the understanding of the likely offending behaviour

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Timelines
- Making sense of complex data – Crime pattern analysis (identify emerging and current trends, linked crimes or incidents, hotspots of activity and common characteristics of offending behaviour.)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Bias in favour of causal explanations (Random events are regarded as having meaning and order, when they are in fact just random)
- Bias Favouring Perception of Centralized Direction (Actions are seen as planned actions when they are in fact unintended consequences or coincidences)

Possible critical questions for Analytical Rationale:

- Is the observed behaviour really what is going on?
- Are other factors contributing to the appearance of being a particular observed behaviour?
- Are the observed behaviours actually a coincidence and not the particular observed behaviour?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [observed behaviour] that would tend to undermine the force of the [actual behaviour] cited?
    - Is there some other case that is also similar to [observed behaviour], but is different to not be [observed behaviour]?
- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [observed behaviour] and [actual behaviour]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, C, that is causing both [observed behaviour] and [actual behaviour]?

(DB) Maps

(DB1) Understand geography

Criminal intelligence analysts can have a task to use maps to understand the geography of the offending area. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that a map a suitable visual medium to reveal the MO details (anchors, narrowing) on where the offenders prefer to offend. Once they understand (laddering) the geography of an offending area, then they can decide on further analytical steps or conclude the case. A map increases their confidence in the likelihood of the MO correctly being determined (proof). This activity can also serve as proof of due diligence (reality/policy loop) when they can show how the plotted information on the map revealed the MO.

In DB1.1, the criminal intelligence analyst reported that he used a map (broadening) to try and understand the geography (laddering) of where the offender lived (anchor) and where the victim's body was found (anchor). This could provide insights on how the offender travelled (anchor, narrowing) to the victim's location, which could assist the criminal intelligence analyst with the next steps in his analytical approach.

In DB1.2, the criminal intelligence analyst reported that she plotted several connected cases onto a map (broadening) to try and understand (laddering) how the offenders travelled through the offending area (anchor) or why they chose that area in the first place (anchor). By doing so, she could use the map to determine the next steps in her analytical approach.

Table 30 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Structuring –> Maps –> Understand Geography

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Use a map to understand the geography of the offending area	Using a map can increase the understanding of how and where offenders offend to	Increased confidence in the understanding of the area in which the offending happens and the anchors that can be created from	- Are you sure that you understand the geography of where the offenders offend? - Proof is by means of a map and the observations from it	- [1] Broadening, Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[DB1.1]** (P1:1.86) ...Where does he live, where this has happened ... (P1.116-119) A map, map point was… to visualize where he lives and where the location of the body.

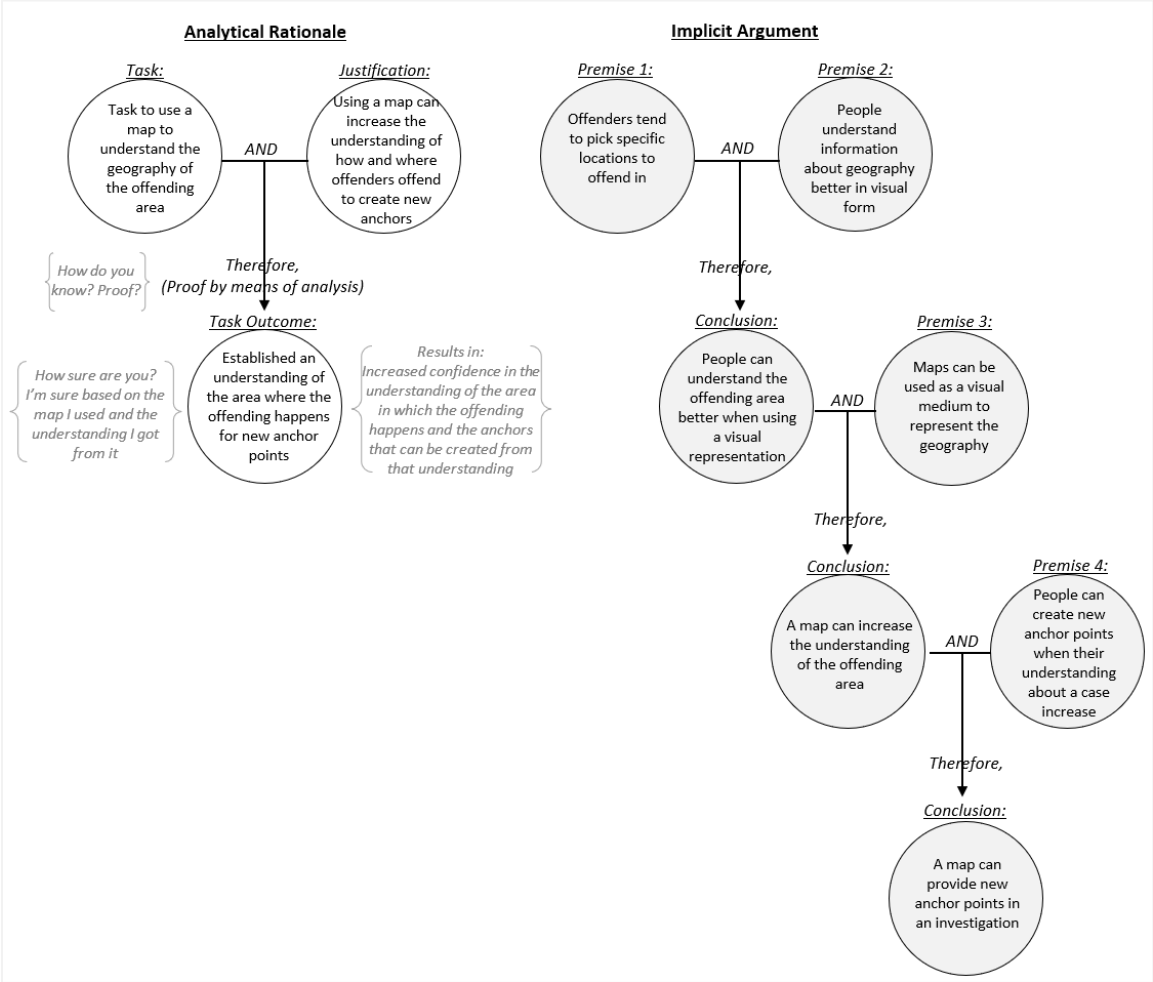
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
	create new anchors	that understanding			**[DB1.2]** (P3) …plotted that out to a mapping to see the geography of where the offending is happening."

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you understand the geography of where the offenders offend]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the map and how that led to new insights.

Figure 74 depicts a linked-diagram indicating the rationale of how a map could increase the criminal intelligence analyst's understanding and how that could lead to new anchor points to further the investigation.

Figure 75 - Chapter 4: Study 1: Linked diagram depicting the rationale of how a map could increase understanding and provide new anchor points



The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Offenders tend to pick specific locations to offend in
Premise 2: People understand information about geography better in visual form
Therefore,
Conclusion: People understand the offending area better when using a visual representation
Premise 3: Maps can be used as a visual medium to represent the geography
Therefore,
Conclusion: A map can increase the understanding of the offending area
Premise 4: People can create new anchor points when their understanding about a case increase
Therefore,
Conclusion: A map can provide new anchor points in an investigation

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Maps
- Assessment of cause and effect – Red Hat Analysis (perceive threats and opportunities as others see them)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Bias in favour of causal explanations (Random events are regarded as having meaning and order, when they are in fact just random)
- Bias Favouring Perception of Centralized Direction (Actions are seen as planned actions when they are in fact unintended consequences or coincidences)

Possible critical questions for Analytical Rationale:

- Is the observed activity, really the activity that is taking place?
- Are other factors contributing to the appearance of being a particular observed activity?
- Are the observed activities actually a coincidence and not the actual activity?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [observed activity] that would tend to undermine the force of the [actual activity] cited?
    - Is there some other case that is also similar to [observed activity], but is different to not be [observed activity]?
- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [observed activity] and [actual activity]?
    - Is there any reason to think that the correlation is any more than a coincidence?

- Could there be some third factor, C, that is causing both [observed activity] and [actual activity]?

(DB2) Determine Hot Spots

Criminal intelligence analysts can have a task to determine which locations are a priority to investigate (Narrowing). They can do so by reviewing hotspots as they appear on a map. Hotspots are visual colour representations of the number of crimes that occurred within a given location. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that if they understand where the greatest number of offences are within an area (anchor), then they can focus the next steps in their analysis on those areas (laddering). This activity increases their confidence in which areas they should prioritise for their analysis. This activity can also serve as proof of due diligence (reality/policy loop) when they can show why they chose to prioritise those cases within those areas.

In DB2.1, the criminal intelligence analyst reported that she structured the underlying crime data into hotspots to see if it revealed anything worth to investigate.

Table 31 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Structuring –> Maps –> Determine Hot Spots

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to determine where the hot spot areas are	Hotspots can be used to determine where the analytical priority lies and use it to create new anchor points	Increased confidence in the understanding of the priority areas and the anchors created from it.	- Are you sure that you have prioritised your analysis appropriately? - Proof is by means of hotspots on a map	- [1] Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[DB2.1]** (P3) …I used Hot Spot on top of data to see if there was anything… just to see if it showed anything [for analysis].

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you have prioritised your analysis appropriately]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the hotspots on the map and why they chose to investigate those crimes.

Figure 74 depicts a linked-diagram indicating the rationale on how a hotspot can direct analytical priority.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Each offence occurs within a specific location
Premise 2: The volume of offences determines the analytical priority
Therefore,
Conclusion: Areas with the greatest number of offences takes analytical priority
Premise 3: Hotspots can be used as a visual medium to represent the volume of crime

Therefore,

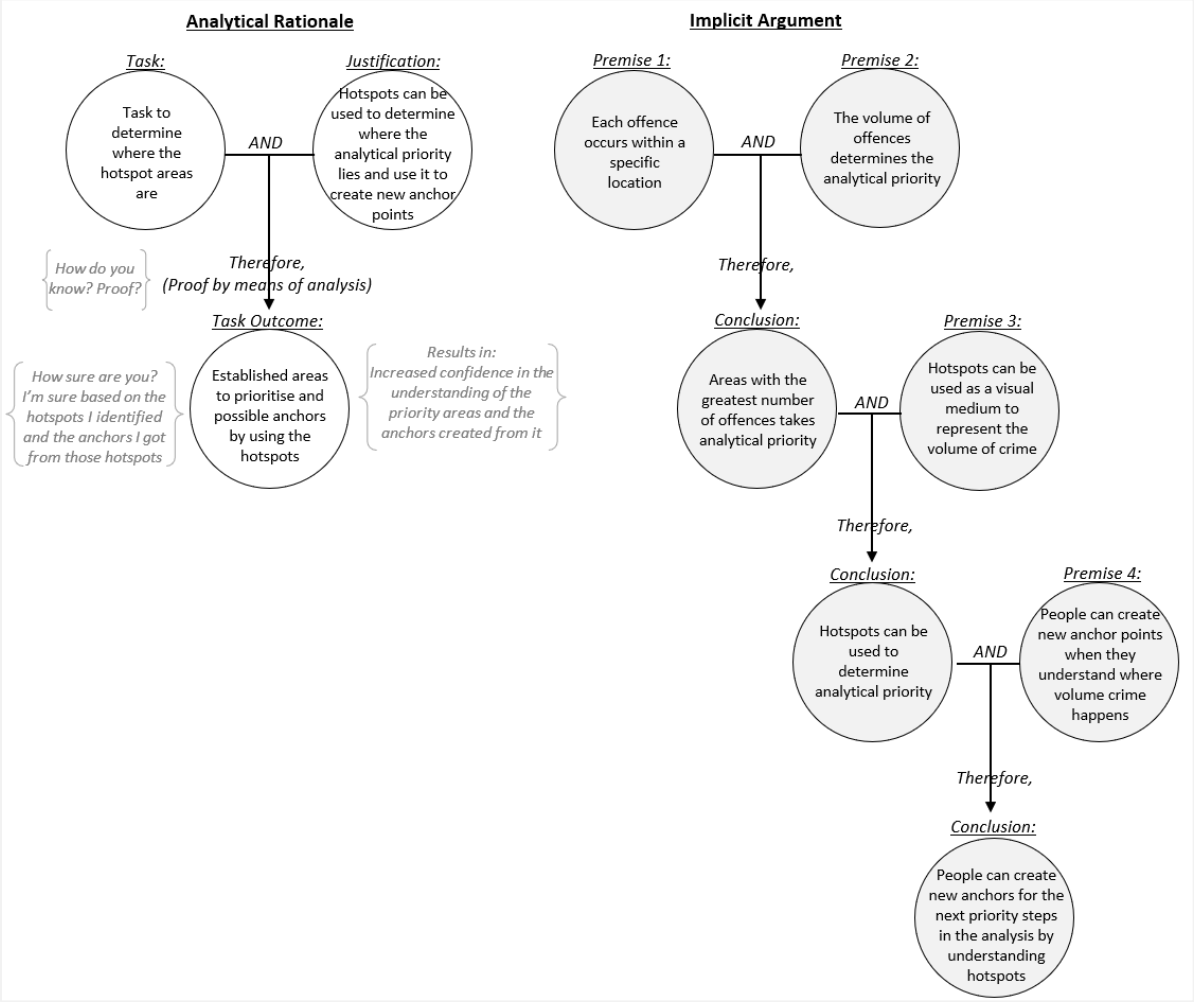
Conclusion: Hotspots can be used to determine analytical priority

Premise 4: People can create new anchor points when they understand where volume crime happens

Therefore,

Conclusion: People can create new anchors for the next priority steps in the analysis by understanding hotpots

Figure 76 - Chapter 4: Study 1: Linked diagram depicting the rationale on how a hotspot can direct analytical priority.



Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Maps & Ranking
- Making sense of complex data – Crime pattern analysis (identify emerging and current trends, linked crimes or incidents, hotspots of activity and common characteristics of offending behaviour. Uses maps, graphs, charts and tables.)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)

Possible critical questions for Analytical Rationale:

- Is the observed hotspot, really an issue?
- Are other factors contributing to the appearance of being a hotspot?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [observed hotspot] that would tend to undermine the force of the [actual underlying crime data type priority] cited?
    - Is there some other case that is also similar to [trigger hotspot], but is different to not be [actual underlying crime data type priority]?
- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [observed hotspot] and [actual underlying crime data type priority]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, C, that is causing both [observed hotspot] and [actual underlying crime data type priority]?

(DB3) Determine offender movements / stationary points

Criminal intelligence analysts can have a task to determine the movements of offenders as well as their stationary points. Stationary points would refer to places where offenders meet up or sleep. They can determine how offenders move or where they stay by using maps and also sometimes by combining maps with timelines. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that if they understand how the offenders move through an area or where they are stationary, then they are in a better position to determine what the next set of analytical steps should be. This activity increases their confidence in their anchor points. This activity can also serve as proof of due diligence (reality/policy loop) when they can show how the map influenced their understanding of the offenders' movements or stationary points.

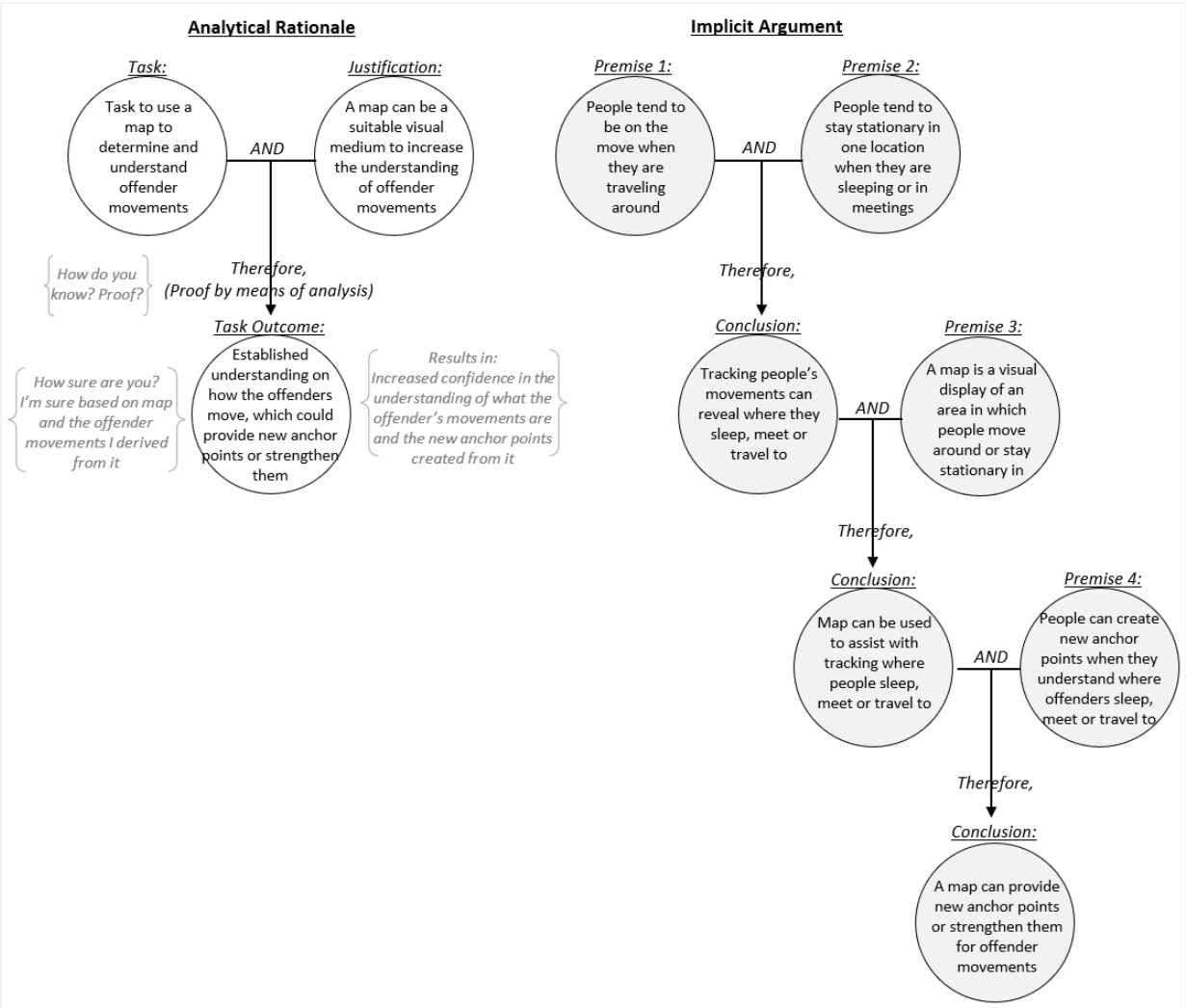
In DB3.1, the criminal intelligence analyst reported that he had combined a map with a timeline so that he could determine how the offender moved through an area. This informed him of his next set of analytical tasks to progress the case.

In DB3.2, the criminal intelligence analyst reported that he plotted the telephone numbers onto a map to determine where the offenders lived. This informed him of his next set of analytical tasks to progress the case.

Table 32 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Structuring –> Maps –> Determine Offender Movements / Stationary Points

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Use a map to determine / understand offender movements	A map can be a suitable visual medium to increase the understanding of offender movements	Increased confidence in the understanding of what the offender's movements are and the new anchor points created from it	- Are you sure that you understand the offender's movement? - Proof is by means of a map	- [1] Broadening, Narrowing - [2] Reality/Policy loop - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[DB3.1]** (P1.166-170) …I took his cell phone and saw communications for the day… I have put [phone tower] mast one, mast two, mast three, mast four [to create a timeline] …and I put them here [on the map] so that I can see movement." **[DB3.2**] (P2) …No, it was a different number [used to contact] for every victim… if you compared with the places where they wake up and everything (inaudible) so you can find them."

Figure 77 - Chapter 4: Study 1: Linked diagram depicting indicating the rationale on how the use of a map can lead to the understanding of an offender's movements



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you understand the offender's movements]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the map and how that contributed to figuring out the offender's movements.

Figure 77 depicts a linked-diagram indicating the rationale on how the use of a map can lead to the understanding of an offender's movements.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: People tend to be on the move when they are traveling around
Premise 2: People tend to stay stationary in one location when they are sleeping or meeting
Therefore,
Conclusion: Tracking people's movements can reveal where they sleep, meet or travel to
Premise 3: A map is a visual display of an area
Therefore,
Conclusion: A map can be used to assist with determining tracking where people sleep, meet or travel to
Premise 4: People can create new anchor points (or strengthen them) when they understand where offenders sleep, meet or travel to.
Therefore,
Conclusion: A map can provide new anchor points or strengthen them for offender movements or stationary points

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Maps
- Making sense of complex data – Crime pattern analysis (identify emerging and current trends, linked crimes or incidents, hotspots of activity and common characteristics of offending behaviour.)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Bias in favour of causal explanations (Random events are regarded as having meaning and order, when they are in fact just random)
- Bias Favouring Perception of Centralized Direction (Actions are seen as planned actions when they are in fact unintended consequences or coincidences)

Possible critical questions for Analytical Rationale:

- Is the observed activity, really the activity that is taking place?

- Are other factors contributing to the appearance of being a particular observed activity?
- Are the observed activities actually a coincidence and not the actual activity?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [observed activity] that would tend to undermine the force of the [actual activity] cited?
    - Is there some other case that is also similar to [observed activity], but is different to not be [observed activity]?
- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [observed activity] and [actual activity]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, C, that is causing both [observed activity] and [actual activity]?

(DC) Diagrams

(DC1) Show Convergences

Criminal intelligence analysts can have a task to determine where different offenders converge by using network diagrams. Convergence happens when offenders are together in a single location. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that if they understand where offenders' convergence points are, then they are in a better position to determine what the next set of analytical steps should be. This activity increases their confidence in their anchor points and the offenders' whereabouts at a given time. This activity can also serve as proof of due diligence (reality/policy loop) when they can show how the network diagram influenced their understanding of convergence points and how that new understanding influenced their next set of analytical steps.

In DC1.1, the criminal intelligence analyst reported that he used the telephone records to create a network diagram of the telephone masts and the related telephone numbers. He used it to determine where telephone numbers converged together in the same location.

Table 33 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Structuring –> Diagrams –> Show Convergences

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to use a diagram to understand offenders' convergence points	A diagram can be a suitable visual medium to reveal convergence points of offenders, which reveal their whereabouts	Increased confidence in the understanding of offenders' conversion points (whereabouts) and the new anchor points created from it as a result	- Are you sure you understand offenders' conversion points? - Proof is by means of diagram produced	- [1] Narrowing - [2] Step 3 – who and what? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[DC1.1]** (P9:19)…we take all phone billings...put it in the database...produce [application] diagram... Find where they all are under the same mast."

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you understand offenders' conversion points]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the diagram that they produced and how the convergence points influenced further analysis.

Figure 78 - Chapter 4: Study 1: Linked diagram depicting the rationale on how diagrams can be used to determine convergence points.

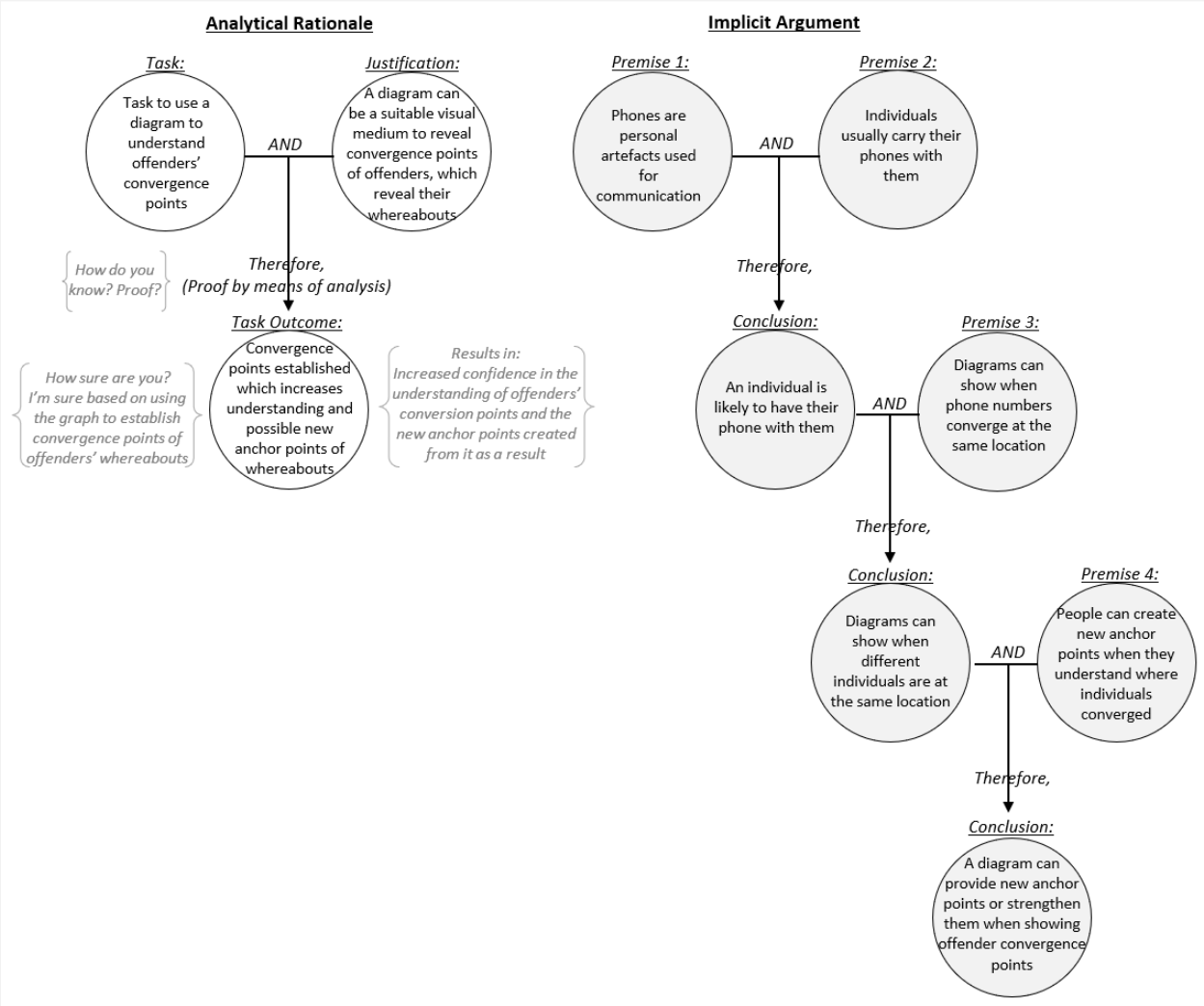


Figure 74 depicts a linked-diagram indicating the rationale on how diagrams can be used to determine convergence points.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Phones are personal artefacts used for communication
Premise 2: Individuals usually carry their phones with them
Therefore,
Conclusion: An individual is likely to have their phone with them
Premise 3: Diagrams can show when phone numbers converge at the same location
Therefore,
Conclusion: Diagrams can show when individuals are at the same location
Premise 4: People can create new anchor points when they understand where individuals converge
Conclusion: A diagram can provide new anchor points or strengthen them when showing offender convergence points

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Diagrams
- Making sense of complex data – Crime pattern analysis (identify emerging and current trends, linked crimes or incidents, hotspots of activity and common characteristics of offending behaviour.)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Bias in favour of causal explanations (Random events are regarded as having meaning and order, when they are in fact just random)
- Bias Favouring Perception of Centralized Direction (Actions are seen as planned actions when they are in fact unintended consequences or coincidences)
- Fundamental Attribution Error (Tendency to over-emphasize personality-based explanations for behaviours observed in others, while underestimating the role of situational influences on the same behaviour)

Possible critical questions for Analytical Rationale:

- Is the observed activity, really the activity that is taking place?
- Are other factors contributing to the appearance of being a particular observed activity?
- Are the observed activities actually a coincidence and not the actual activity?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [observed activity] that would tend to undermine the force of the [actual activity] cited?
    - Is there some other case that is also similar to [observed activity], but is different to not be [observed activity]?

- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [observed activity] and [actual activity]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, C, that is causing both [observed activity] and [actual activity]?

(DC2) Show relationships (people & artefacts)

Criminal intelligence analysts can have a task to determine the possible relationship between offenders. One way to accomplish this is to determine who is calling who. A relationship diagram can also be used to determine the relationship between artefacts and people. An artefact can refer to different objects that an offender has been in contact with for example a licence plate number from a shared car or shared phone number. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that if they understand who (or with what) the offenders are in contact with (laddering, broadening), then they will have a better understanding of who to investigate further (anchors, narrowing). This activity increases their confidence in their anchor points and their understanding of the social network of offenders. This activity can also serve as proof of due diligence (reality/policy loop) when they can show how the relationship diagram influenced their understanding and how that understanding influenced their next set of analytical steps.

In DC2.1, the criminal intelligence analyst reported that after he constructed the relationship diagram, he found an additional telephone number who was in contact with the offender. This provided him with a new anchor point to further his investigation.

In DC2.2, the criminal intelligence analyst reported that he used a relationship diagram to determine how artefacts relate to different people. He would then be able to track how the artefact (for example a shared phone) exchange hands. This can provide him with new anchor points to investigate further.

Table 34 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Structuring –> Diagrams –> Show Relationships (people & artefacts)

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to use a diagram to understand the relationship between offenders / artefacts	A diagram can be a suitable visual medium to increase understanding of offenders / artefact relationships, that can be used as new anchoring points	Increased confidence in the understanding of relationships between offenders / artefacts and the new anchors created from it as a result	- Are you sure that you understand the relationships between offenders / artefacts? - Proof is by means of diagram produced	- [1] Narrowing - [2] Step 6 – how are they related? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[DC2.1]** (P1.292-303) …to visualize relationships… See there was communications, but there was also [communication] between this [number] and this [number], and this is interesting also. **[DC2.2]** (P9:3) …what I always do first… Take each person...Make a relational diagram... between the known nodes [offenders] of each…and the artefacts.

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you understand the relationship between offenders / artefacts]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the relationship diagram that they produced and how that influenced further investigation.

Figure 79 - Chapter 4: Study 1: Linked diagram depicting the rationale on how a relationship diagram can create new anchors

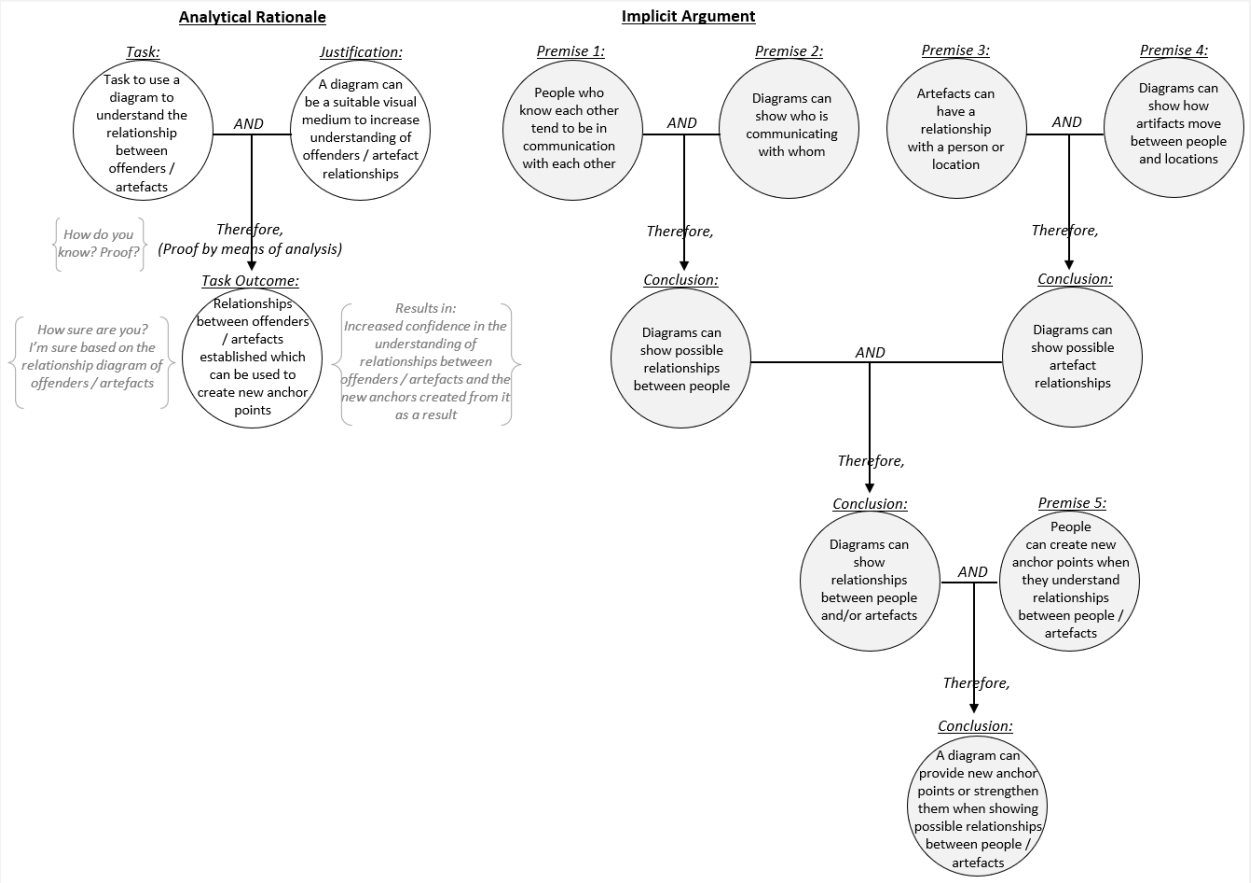


Figure 79 depicts a linked-diagram indicating the rationale on how a people / artefact relationship diagram can lead to the increase in understanding and the creation of new anchor points as a result from the enhanced understanding.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Argument 1:
Premise 1: People who know each other tend to be in communication with each other
Premise 2: Diagrams can show who is communicating with whom
Therefore,
Conclusion: Diagrams can show possible relationships between people

Argument 2:
Premise 3: Artefacts can have a relationship with a person or a location
Premise 4: Diagrams can show how artefact move between people and locations
Therefore,
Conclusion: Diagrams can show possible artefact relationships

Therefore (based on argument 1 and 2),
Conclusion: Diagrams can show relationships between people and/or artefacts
Premise 5: People can create new anchor points when they understand relationships between people/artefacts
Conclusion: A diagram can provide new anchor points or strengthen them for possible relationships between people / artefacts

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Diagrams
- Making sense of complex data – Network Analysis (uses association charts to link relationships between people, locations, objects etc.)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Bias in favour of causal explanations (Random events are regarded as having meaning and order, when they are in fact just random)
- Bias Favouring Perception of Centralized Direction (Actions are seen as planned actions when they are in fact unintended consequences or coincidences)
- Fundamental Attribution Error (Tendency to over-emphasize personality-based explanations for behaviours observed in others, while underestimating the role of situational influences on the same behaviour)

Possible critical questions for Analytical Rationale:

- Is the observed activity, really the activity that is taking place?
- Are other factors contributing to the appearance of being a particular observed activity?
- Are the observed activities actually a coincidence and not the actual activity?

Possible critical questions for Implicit Argument:

- Argument from Analogy (Adapted from Walton et al., 2008:p315)
    - Are there differences between [observed activity] that would tend to undermine the force of the [actual activity] cited?
    - Is there some other case that is also similar to [observed activity], but is different to not be [observed activity]?

- Argument from Correlation to Cause (Adapted from Walton et al., 2008:p328)
    - Is there really a correlation between [observed activity] and [actual activity]?
    - Is there any reason to think that the correlation is any more than a coincidence?
    - Could there be some third factor, C, that is causing both [observed activity] and [actual activity]?

(DD) Thematic Sorting

(DD1) Show Knowns and Unknowns

Criminal intelligence analysts can have a task to determine what they currently know about the investigation, as per their findings, and also what they do not know. They can do so by thematically sorting their findings into 'knowns' and 'unknowns'. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that by taking stock of what they know and what they do not know, they can then determine the next steps in their analytical approach. This increases their confidence in the results (proof) that they have thus far determined and also the areas where they lack confidence.

In DD1.1, the criminal intelligence analyst reported that he sorted all the details about the investigation based on what he knew as probable (weak anchors) as well as what he did not know.

Table 35 - Chapter 4: Study 1: NVivo coding of interview snippets for: Information Structuring –> Thematic Sorting –> Show known and unknowns

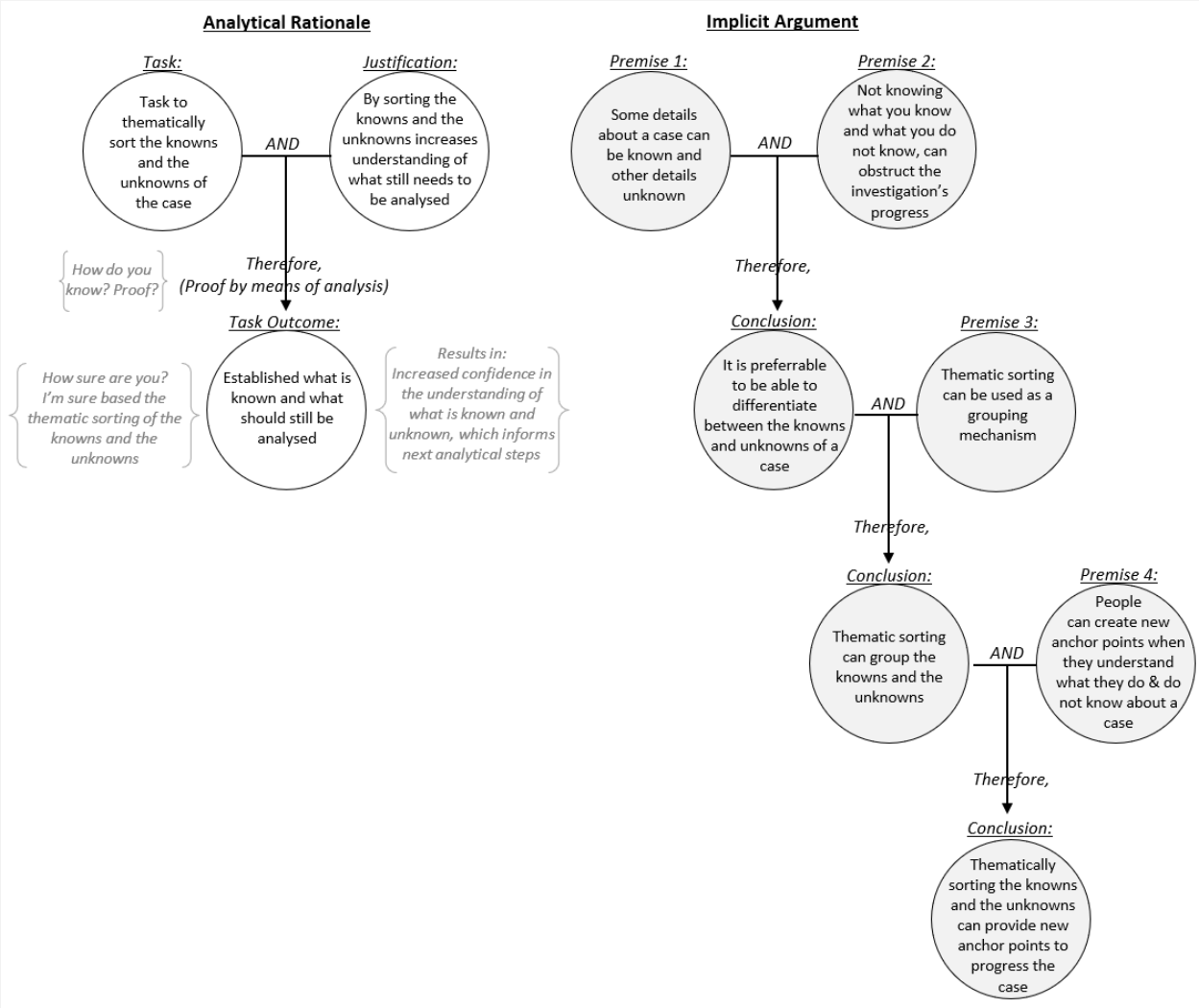
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to thematically sort the knowns and the unknowns of the case	By sorting the knowns and the unknowns increases understanding of what still needs to be analysed	Increased confidence in the understanding of what is known and unknown, which informs next analytical steps	- Are you sure that you have an understanding of what is known and unknown in the case? - Proof is by means of thematically sorting the case details based on the analysis conducted thus far	- [1] Narrowing - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[DD1.1]** (P9:2) …What I also have is the event… then I know that all these things are related… (09:05) …What do we know about this one [event]? We are checking everything…police reports … everything…this [event] we don't know… this [event] is a probability… this [event] is unknown… and now we know exactly what is what…at that time we set it all out [in groups]…"

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you have an understanding of what is known and unknown in the case]?' to determine next steps in the analytical approach.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the thematic groups of the case details based on the analysis they have conducted thus far.

Figure 80 depicts a linked-diagram indicating the rationale of how the thematic groups can guide the next steps in the investigation.

Figure 80 - Chapter 4: Study 1: Linked diagram depicting indicating the rationale of how the thematic groups can guide the next steps in the investigation



The implicit premises and conclusions (Govier) would look as follow:

Premise 1: Some details about a case can be known and other details can be unknown
Premise 2: Not knowing what you know and do not know can obstruct the investigation's progress
Therefore,
Conclusion: It is preferrable to differentiate between the knowns and unknowns of a case
Premise 3: Thematic sorting can be used as a grouping mechanism
Therefore,
Conclusion: Thematic sorting can group the knowns and the unknowns of a case

Premise 4: People can create new anchor points when they understand what they do and do not know about a case
Conclusion: Thematically sorting knowns and unknowns can provide new anchor points to progress the case

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Decomposition and Visualisation – Sorting

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Tendency to rely too heavily or overly restrict one's attention to one trait or piece of information when making judgments)
- Absence of information bias (Difficulties in judging the impact of missing information)
- Coping with Evidence of Uncertain Accuracy bias (Place too much validity on all the information, based on some valid information)

Possible critical questions for Analytical Rationale:

- What do you really know about the knowns?
- How does the unknowns affect the knowns?

Possible critical questions for Implicit Argument:

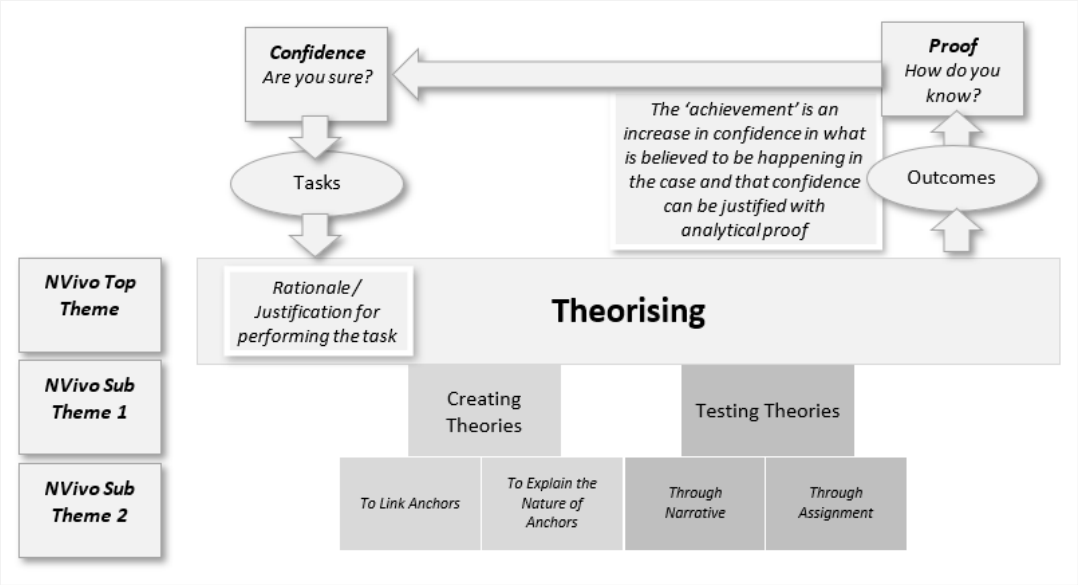
- Argument from Verbal Classification (Adapted from Walton et al., 2008:p319)
    - What evidence is there that [member of thematic group] has property [known/unknown], as opposed to evidence indicating room for doubt whether it should be so classified?

(E) Theorising

Theorising refers to those activities where criminal intelligence analysts attempt to temporarily link anchors together to progress the investigation. They can also create theories to temporarily explain the nature of anchors to progress the investigation. Criminal intelligence analysts can test their theories by using narrative to test cogency or by assigning colleagues to report back on specific assignments. This NVivo emerging theme would equate to the sensemaking loop within Pirolli and Card's (2005) Notional Model of Sensemaking, where hypothesis generation takes place.

The results listed in this NVivo category outlines the play between Elm et al.'s (2005) Broadening and Narrowing concepts and Wong and Kodagoda's (2015) anchoring, laddering and associative questioning concepts.

Figure 81 – Chapter 4: Study 1: Theorising



(EA) Creating Theories

(EA1) To Link Anchors

Criminal intelligence analysts can have a task to theorise about the links between the 'knowns' and 'unknowns' (anchors) within the crime data. This type of theorising is associated with the concepts of what Gerber et al., (2015) referred to as "leaps-of-faith". Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that leaps-of-faith can temporarily connect anchor points which could inform the next steps of the analytical approach (broadening). This task does not increase criminal intelligence analysts' confidence immediately from the onset of the task, but once an outcome has been reached to either prove or disprove the theory, then they have increased their understanding on how to close the gaps between the anchor points. The new understanding could lead to new anchor points being created (laddering).

In EA1.1, the criminal intelligence analyst reported that they theorised that the offenders could have travelled between different areas (leap-of-faith, anchor), thus could be responsible for more offences (laddering). Based on this theory, the criminal intelligence analyst attempted to find a connection between the offenders (anchor) and other locations (anchor).

In EA1.2, the criminal intelligence analyst reported that the witness statements (anchor) did not contain descriptions of the people that the witness referenced in their statement. The criminal intelligence analyst therefore had to theorise who the witnesses were referring to in each report (leap-of-faith) and then go and find evidence (laddering) to support his theory (anchor).

In EA1.3, the criminal intelligence analyst reported that he theorised about why the telephone of the offender did not receive any calls (leap-of-faith, anchor) after the shooting that resulted in

the victim's death. By theorising that the offender was on the run and has thus 'gone silent' (anchor), informed the next steps in his analytical approach (laddering).

In EA1.4, the criminal intelligence analyst reported that he theorised about the communication behaviour between two offenders. He theorised the two offenders were in communication with one another to make arrangements and then the communication stopped, because one offender picked up the other offender in is car (leap-of-faith, anchor) and then drove to the victim's house. By theorising that the one offender was picking up the other explained the role of each offender (anchor), which informed the next steps in his analytical approach (laddering).

Table 36 - Chapter 4: Study 1: NVivo coding of interview snippets for: Theorising –> New Theories –> As a Result of Incomplete Data

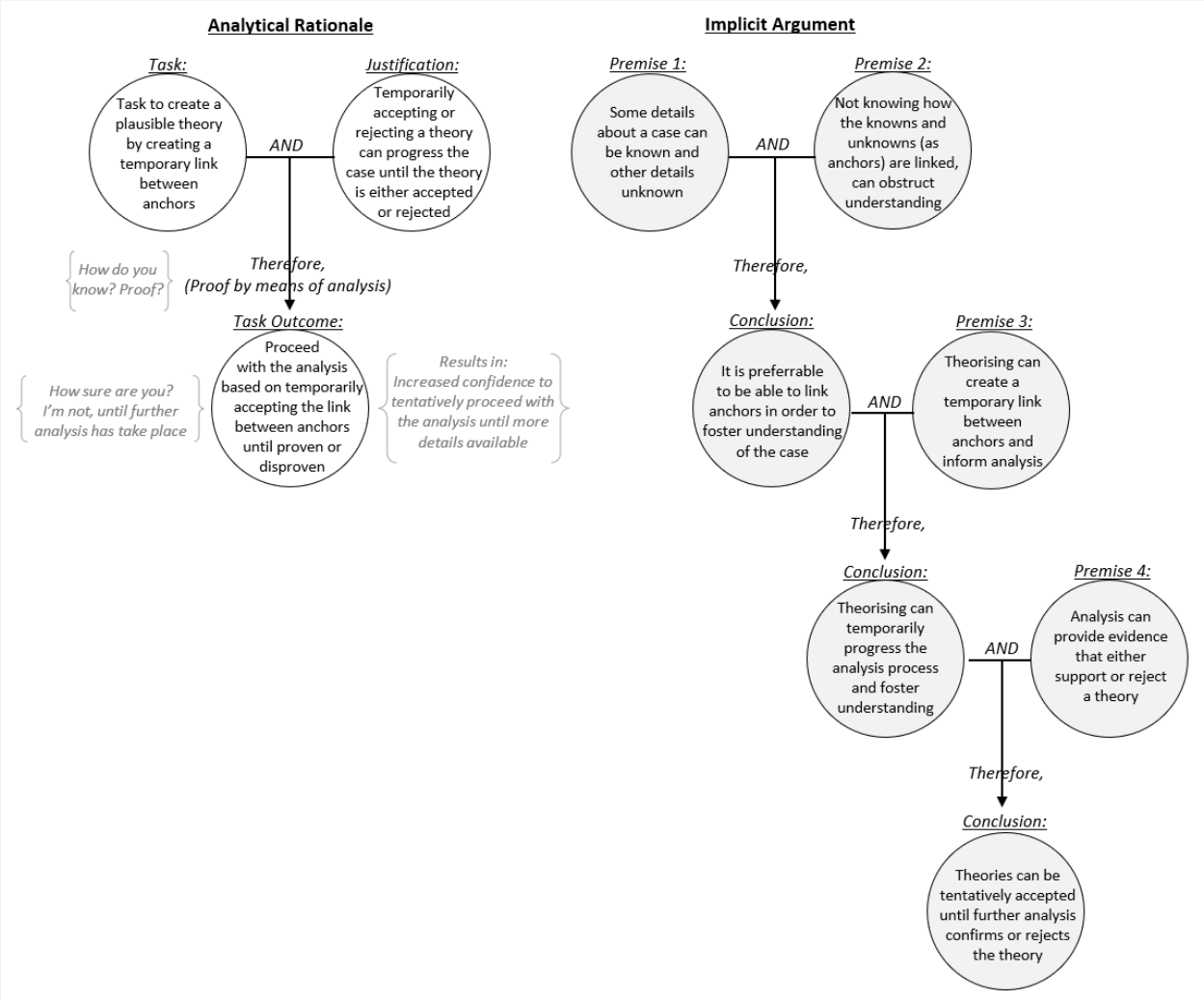
Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to create a plausible theory by creating a temporary link between anchors	Temporarily accepting or rejecting a theory can progress the case until the theory is either accepted or rejected	Increased confidence to tentatively proceed with the analysis until more details available	- Are you sure that the links between anchors are cogent? - Proof is by means of showing which theories were temporarily accepted and the results that either prove or disprove the theory.	- [1] Broadening - [2] Step 3 – who and what? - [2] Step 6 – how are they related? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering	**[EA1.1]** (P6:381-386) …I looked at what crime they'd been arrested for and then looked at what, where that crime took place, if any took place within the location or – 'cause there was only one within, near my hotspot, I then think oh, maybe it's not too difficult for them to go here to there…or were any of these crimes a very similar MO for a specific MO that I was looking at... **[EA1.2]** (P2:171) …There are also reports where there is no description of the person, so I have to guess." **[EA1.3]** (P9:28) …No information is also information...the phone had many calls to the [person] and after the shooting it stopped ... (Interviewer) what do you infer from that?... (Participant)… he is running...can't say for sure...it is not normal. **[EA1.4]** (P:25) ...I see him [driver] communicating with this [offender telephone] number... driving to this [telephone] phone mast [where the offender is located] ...the communication stops [between the offender and the driver] ...gap...so hypothesis... He [the driver] is calling him [the offender] to say that I am going to fetch you or not...

Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that the links between anchors are cogent]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to which theories were temporarily accepted and then refer to the analytical results that either prove of disproved their theory.

Figure 82 depicts a linked-diagram indicating the rationale on how theorising about links between the 'knowns' and 'unknowns' (as anchors) can temporarily progress the case.

Figure 82 - Chapter 4: Study 1: Linked diagram depicting the rationale on how theorising about links between the 'knowns' and 'unknowns' (as anchors) can progress the case



The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Some details about a case can be known and other details can be unknown
Premise 2: Not knowing how the knowns and unknowns (as anchors) are linked, can obstruct understanding
Therefore,
Conclusion: It is preferrable to be able to link anchors in order to foster understanding of a case
Premise 3: Theorising can create a temporary link between anchors and inform analysis

Therefore,
Conclusion: Theorising can temporarily progress the analysis process and foster understanding
Premise 4: Analysis can provide evidence that either support or reject a theory
Therefore,
Conclusion: Theories can be tentatively accepted until further analysis confirms or rejects the theory

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Hypothesis Generation and Testing - Hypothesis Generation
- Assessment of cause and effect – Role Playing (see problem from offender's perspective)
- Scenarios and Indicators - Scenario Analysis (Identify multiple ways a situation might develop)
- Assessment of cause and effect – Red Hat Analysis (perceive threats and opportunities as others see them)
- Assessment of cause and effect - Key Assumption Checks (make assumptions explicit)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Biases in perceiving causality – Attribution (Judge situations based on one's own experiences and understanding rather from the other person's perspective)
- Bias in favour of causal explanations (Random events are regarded as having meaning and order, when they are in fact just random)
- Bias Favouring Perception of Centralized Direction (Actions are seen as planned actions when they are in fact unintended consequences or coincidences)
- Illusory Correlation bias (Assumes that one event caused a second event, when there is in fact no real evidence to support that)

Possible critical questions for Analytical Rationale:

- Are you keeping track of the degree of leap-of-faiths? In other words, the bigger the leap to connect the anchors, the less cogent the rationale and greater the need for analysis to make it cogent.
- Are you looking at the situation from the offender's perspective?
- Are you looking at the environmental factors that could impact the situation?
- Are you seeing too much into this situation?

Possible critical questions for Implicit Argument:

- Argument from Cause to Effect
    - How strong is the [causal or any other] connection?
    - Is the evidence cited (if there is any) strong enough to warrant the [causal or any other] generalisation?
    - Are there other [causal or any other] factors that could interfere with the production of the effect in the given case?

(EA2) To Explain the Nature of Anchors

Criminal intelligence analysts can have a task to theorise about the nature of the existing anchors that they have created. This type of theorising is what Wong and Kodagoda (2015) referred to as "associative questioning". Associative questioning is when criminal intelligence analysts are "*asking questions that would help them make associations with concepts that may be totally un-related or not usually known to be related. Such associations can present new understandings that can lead to insight."* (Wong and Kodagoda, 2015). Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that associative questioning can temporarily explain the nature of anchor points which could inform the next steps of the analytical approach (broadening). This task does not increase their confidence immediately from the onset of the task, but once an outcome has been reached to either prove or disprove the theory, then they have increased their understanding (laddering) on what the anchor point actually resembles. The new understanding could lead to new anchor points being created.

In EA2.1, the criminal intelligence analyst reported that although he had knowledge of an individual (anchor) related to the criminal activity, the criminal intelligence analyst did not know the reason why this individual was involved. The criminal intelligence analyst theorised about the nature of the involvement of the individual (broadening), by temporarily providing an answer to the question 'why him?' (Associative questioning). This allowed the investigation to move forward (laddering) with a temporary explanation of the nature of the anchor.

In EA2.2, the criminal intelligence analyst reported that he found one unknown telephone number (anchor) which was in communication with the offenders, but the criminal intelligence analyst did not know who or what that phone number belonged to. The criminal intelligence analyst theorised about the nature of the phone number (broadening) by providing an answer to the question 'Is it another guy carrying the phone?'. This allowed the investigation to move forward (laddering) with a temporary explanation of the nature of the anchor.

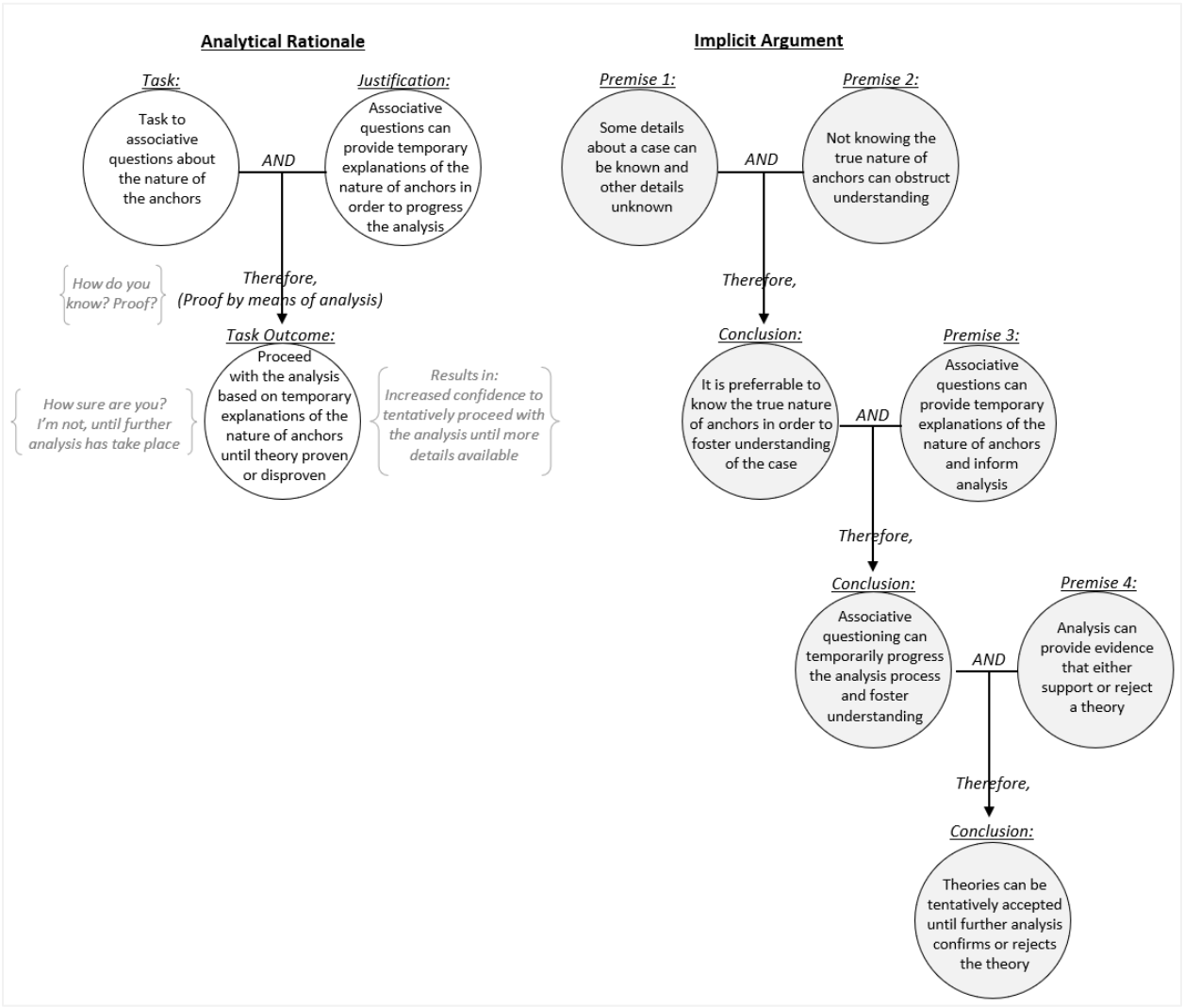
In EA2.3, the criminal intelligence analyst reported that she found no specific pattern to how the offenders offended and then resolved to theorise about the aesthetic nature (associative questioning, anchors) of the MO details in order to derive a plausible pattern. The associative questions were about what the nature of the stolen money was (i.e. big money) and what the nature of the meeting places were (i.e. chic). This allowed the investigation to move forward (laddering) with a temporary explanation of the nature of the anchors.

Table 37 - Chapter 4: Study 1: NVivo coding of interview snippets for: Theorising –> New Theories –> As a Result of Questioning

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to associative questions about the nature of the anchors	Associative questions can provide temporary explanations of the nature of anchors in order to progress	Proceed with the analysis based on temporary explanations of the nature of anchors until theory proven or disproven	- Are you sure that you understand the nature of your anchors? - Proof is by means of proving or disproving a theory	- [1] Broadening - [2] Step 3 – who and what? - [2] Step 6 – how are they related? - [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence) - [3] Anchoring, Laddering, Associative Questioning	**[EA2.1]** (P1:396-397) ... Every move he made… Every communication… Why him? **[EA2.2]** (P9:35) Different cases… Same MO... Same telephone numbers coming up in each... One unknown number...why is it different... Number calling him in past 6

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
	the analysis				months? ... Is it another guy carrying the phone? **[EA2.3]** (P2:617)…It was always big money. (P2:680)…In this case it's all hotels and it's very chic.

Figure 83 - Chapter 4: Study 1: Linked diagram depicting the rationale on how theorising about the nature of anchors can progress the case



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that you understand the nature of your anchors]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to which theories were temporarily accepted and then refer to the analytical results that either prove of disproved their theory.

Figure 83 depicts a linked-diagram indicating the rationale on how theorising about the nature of anchors can progress the case.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: The nature of details about a case can be known and other details can be unknown (as anchors)
Premise 2: Not knowing the true nature of anchors can obstruct understanding
Therefore,
Conclusion: It is preferrable to know the true nature of anchors in order to foster understanding of the case
Premise 3: Associative questioning can provide temporary explanations of the nature of anchors and inform analysis
Therefore,
Conclusion: Associative questioning can temporarily progress the analysis process and foster understanding
Premise 4: Analysis can provide evidence that either support or reject a theory
Therefore,
Conclusion: Theories can be tentatively accepted until analysis confirms or rejects the theory

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Hypothesis Generation and Testing - Hypothesis Generation
- Idea Generation - Starbursting (Generating questions)
- Assessment of cause and effect – Role Playing (see problem from offender's perspective)
- Scenarios and Indicators - Scenario Analysis (Identify multiple ways a situation might develop)
- Assessment of cause and effect – Red Hat Analysis (perceive threats and opportunities as others see them)
- Assessment of cause and effect - Key Assumption Checks (make assumptions explicit)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Biases in perceiving causality – Attribution (Judge situations based on one's own experiences and understanding rather from the other person's perspective)
- Bias in favour of causal explanations (Random events are regarded as having meaning and order, when they are in fact just random)
- Bias Favouring Perception of Centralized Direction (Actions are seen as planned actions when they are in fact unintended consequences or coincidences)
- Illusory Correlation bias (Assumes that one event caused a second event, when there is in fact no real evidence to support that)

Possible critical questions for Analytical Rationale:

- Are you keeping track of the degree of leap-of-faiths? In other words, the bigger the leap to connect the anchors, the less cogent the rationale and greater the need for analysis to make it cogent.
- Are you looking at the situation from the offender's perspective?
- Are you looking at the environmental factors that could impact the situation?
- Are you seeing too much into this situation?

Possible critical questions for Implicit Argument:

- Argument from Cause to Effect
    - How strong is the [causal or any other] connection?
    - Is the evidence cited (if there is any) strong enough to warrant the [causal or any other] generalisation?
    - Are there other [causal or any other] factors that could interfere with the production of the effect in the given case?

(EB) Testing Theories

(EB1) Through Narrative

Criminal intelligence analysts can have a task to use narrative to explain and test their theories. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that narrative is a suitable medium to foster understanding of their theories and thus test the level of cogency that their theories have. This increases their confidence that their analysis is on the correct track in solving the crime.

In EB4.1, the criminal intelligence analyst used narrative to explain the plausibility of his theories in relation to the causal events that lead to the crime being committed. When the narrative is coherent, then the theories and the supporting analysis are more likely to be accepted as the best possible explanation of the crime scenario.

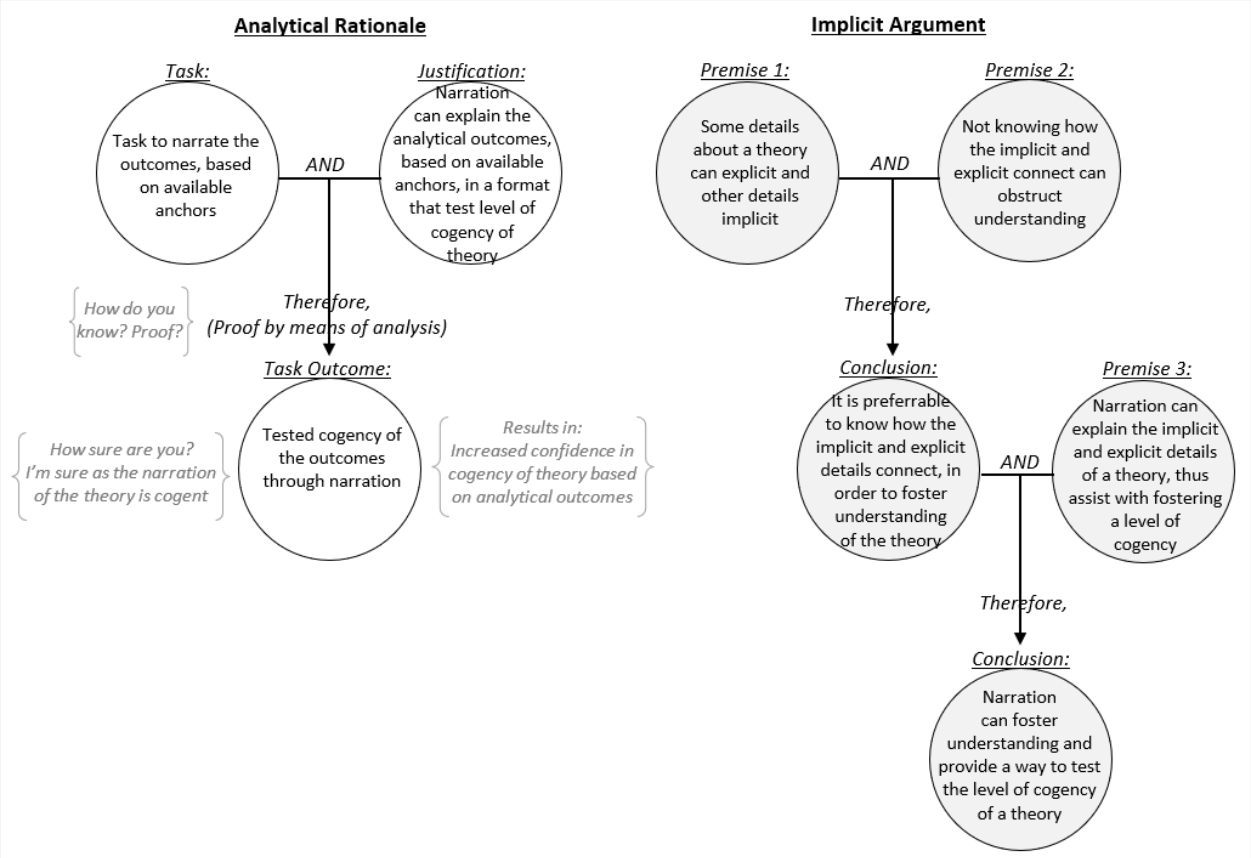
In EB4.2, the criminal intelligence analyst reported that he used narrative to explain the role of different anchors within the investigation and how it contributes to the understanding of the case.

Table 38 - Chapter 4: Study 1: NVivo coding of interview snippets for: Theorising –> Progress and Existing Theory –> By Using Narrative to Make Sense of Theories

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to narrate the outcomes, based on available anchors	Narration can explain the analytical outcomes, based on available anchors, in a format that	Increased confidence in cogency of theory based on analytical outcomes	- Are you sure that your theory is cogent? - Proof is by means of narrating the outcomes, based on available anchors	- [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence)	**[EB4.1]** (P9:9) (Participant) These two guys in a narrative way drove up to... the event... and what happened after [they arrived]?… He [the victim] got killed..." **[EB4.2**] (P9:12) ...you have the VIN number of the car and the license plate… sometimes it has its own story, its own path… combined... these used in two robberies…object stories… every object has its own story."

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
	test level of cogency of theory				

Figure 84 - Chapter 4: Study 1: Linked diagram depicting the rationale of how narrative can assist with fostering understanding and provide a way to test the level of cogency of a theory



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that your theory is cogent]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to the level of cogency that their theories have.

Figure 84 depicts a linked-diagram depicting the rationale of how narrative can assist with fostering understanding and provide a way to test the level of cogency of a theory.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: Some details about a theory can be implicit and other details explicit
Premise 2: Not knowing how the implicit and explicit connect, can obstruct understanding
Therefore,

Conclusion: It is preferrable to know how the implicit and explicit details connect in order to foster understanding of the theory
Premise 3: Narration can explain the implicit and explicit details of a theory, thus assist with fostering a level of cogency
Therefore,
Conclusion: Narration can foster understanding and provide a way to test the level of cogency of a theory

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Hypothesis Testing - Analysis of Competing Hypotheses (ACH) (Generate alternative explanations using same evidence)
- Assessment of cause and effect – Role Playing (see problem from offender's perspective)
- Scenarios and Indicators - Scenario Analysis (Identify multiple ways a situation might develop)
- Assessment of cause and effect – Red Hat Analysis (perceive threats and opportunities as others see them)
- Assessment of cause and effect - Key Assumption Checks (make assumptions explicit)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Biases in perceiving causality – Attribution (Judge situations based on one's own experiences and understanding rather from the other person's perspective)
- Bias in favour of causal explanations (Random events are regarded as having meaning and order, when they are in fact just random)
- Bias Favouring Perception of Centralized Direction (Actions are seen as planned actions when they are in fact unintended consequences or coincidences)
- Illusory Correlation bias (Assumes that one event caused a second event, when there is in fact no real evidence to support that)

Possible critical questions for Analytical Rationale:

- Are you keeping track of the degree of leap-of-faiths? In other words, the bigger the leap to connect the anchors, the less cogent the rationale and greater the need for analysis to make it cogent.
- Are you looking at the situation from the offender's perspective?
- Are you looking at the environmental factors that could impact the situation?
- Are you seeing too much into this situation?

Possible critical questions for Implicit Argument:

- Argument from Cause to Effect
    - How strong is the [causal or any other] connection?
    - Is the evidence cited (if there is any) strong enough to warrant the [causal or any other] generalisation?
    - Are there other [causal or any other] factors that could interfere with the production of the effect in the given case?

(EB2) Through Assignment

Criminal intelligence analysts can have a task to assign colleagues to test the plausibility of the analysis that supports their theories. Criminal Intelligence Analysts' engagement with this type of task is justified with the reasoning that the assignments would lead to information that would prove or disprove their theories. This increases their confidence that their anchor points and supporting analysis is on the right track in solving the crime.

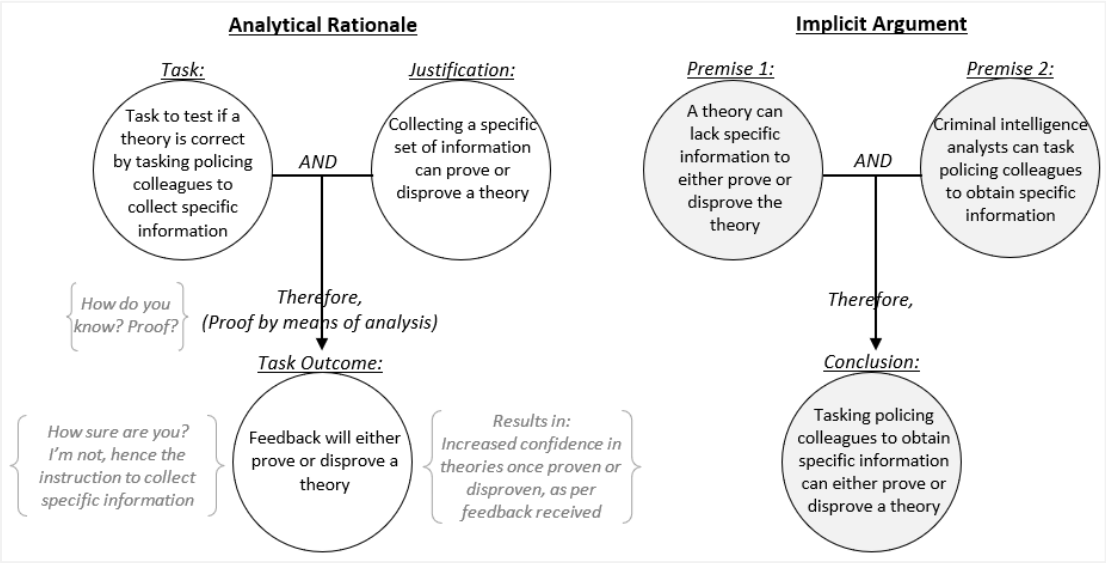
In EB2.1, the criminal intelligence analyst determined the timings of the offence periods as part of the MO. The criminal intelligence analyst theorised that the officers would find the offenders if they were to visit those locations at those times. The feedback from the officers would test the plausibility of their theory.

In EB2.2, the criminal intelligence analyst reported that his analysis led to linking an offender with a phone number. He theorised that the phone did belong to the offender, but he needed confirmation in order to strengthen his anchor point. He therefore tasked the detective squad to confirm the details.

Table 39 - Chapter 4: Study 1: NVivo coding of interview snippets for: Theorising –> Progress and Existing Theory –> By Using Narrative to Make Sense of Theories

Task	Task Rationale / Justification	Task Outcome / Achievement	Argumentation	Literature link	Interview snippets
Task to test if a theory is correct by tasking policing colleagues to collect specific information	Collecting a specific set of information can prove or disprove a theory	Increased confidence in theories once proven or disproven, as per feedback received	- Are you sure that your theories have sufficient information to prove/disprove them? - Proof is by means of feedback from policing colleagues	- [2] Step 12 – how do you know? (proof) - [2] Step 15 – are you sure? (confidence)	**[EB2.1]** (P3:170) …we can direct Officers to go to that area during those hours… **[EB2.2] (**P1:134) …First you got to establish is it his phone. Is it their phones? This is very easily established by the Detective squad.

Figure 85 - Chapter 4: Study 1: Linked diagram depicting the rationale on how theories can be tested by tasking policing colleagues to collect specific information



Criminal intelligence analysts can use Pirolli and Card's (2005) step 15 question – 'Are you sure [that your theories have sufficient information to prove or disprove them]?' to determine next steps in the analytical approach, which may be to do further analysis or to finalise the case.

Proof is linked to Pirolli and Card's (2005) step 12 question – 'How do you know?' and criminal intelligence analysts can refer to their additional analysis that they have performed. The additional analysis will either support or negate the initial analytical effort.

Figure 85 depicts a linked-diagram indicating how theories can be tested by tasking policing colleagues to collect specific information.

The implicit argument (Govier, 2014) of the analytical rationale would look as follow:

Premise 1: A theory can lack specific information to either prove or disprove the theory
Premise 2: Criminal intelligence analysts can task policing colleagues to obtains specific information
Therefore,
Conclusion: Tasking policing colleagues to obtain specific information can either prove or disprove a theory

Based on the identified task, the following analytical techniques are possible (also see Table 1):

- Hypothesis Generation and Testing - Hypothesis Generation
- Assessment of cause and effect - Key Assumption Checks (Make assumptions explicit)

Based on the identified analytical rationale, the following cognitive biases are possible:

- Anchoring Bias (Use a known starting point from which to make judgements)

Possible critical questions for Analytical Rationale:

- Are you relying solely on the information that will be reported back from the officers?

Possible critical questions for Implicit Argument:

- Argument from Expert Opinion (Adapted from Walton et al., 2008:p310)
    - What did [Officer] assert that implied [account of offender details]?
    - Is [Officer]'s assertion based on [offender details that is trusted information]?

4. Study Part 2

RQ3: Which structures do criminal intelligence analysts employ to assist with developing their analytical rationale?

4.1. Research Method

4.1.1. Knowledge elicitation using Critical Decision Method

The researcher made use of the same data set as outlined in RQ2.

4.1.2. Analysis using Qualitative Directed Content Analysis

Qualitative Directed Content Analysis (Hsieh and Shannon, 2005) was used by the researcher to find existing concepts from the literature within the transcripts as a deductive coding process (Corbin and Strauss, 2014; Khandkar, 2009). Coding was done on a per-section basis, rather than line-by-line. Each stage of the coding process is outlined in the next sections.

Stages:

In the first stage of the analysis process the researcher consulted the literature to find existing structures that could assist with answering this research question (RQ3). Klein et al.'s (2007) Data Frame Theory was a good place to start. The tacit nature of a frame proved difficult to find in the data set, because what exactly would constitute as a frame? Does it constitute the initial understanding of a problem? If so, how would finding problems in the dataset help with understanding how criminal intelligence analysts made use of structures or schemas? The researcher then consulted Selvaraj et al. (2016) as they outlined how criminal intelligence analysts made use of think-steps to approach a case and divide it into more manageable pieces. Think-steps, however, suggests working against a pre-defined crime schema. This idea would work as an overall goal to work towards to, for example, in a drug trafficking crime schema the sections would be; producing the drugs, packaging the drugs, transporting the drugs, selling the drugs, the exchange of money and the workforce in each phase (Selvaraj et al., 2016). Such a grand schema does not explain how each section within the schema gets filled. This would suggest that there is something else that would connect the Data Frame Theory with Think-Steps as both are tacit and generic concepts and the researcher was looking from something tangible.

The researcher noticed that the term 'line of enquiry' popped up in various research papers and books on criminology. But what exactly is a line of enquiry? Cook et al., (2013) claims that a line of enquiry is different to an investigative strategy. An investigative strategy is used to "progress an investigation", is "generic in nature" and "uses lists of possible options" (Cook et al., 2013). The researcher would classify Think-Steps as an investigative strategy, as it uses possible options or sections of a crime schema to progress the investigation. A line of enquiry is "more specific to key facts of an investigation" (Cook et al., 2013), so this suggests that lines of enquiry are more granular and therefore less generic than Think-Steps. Finally, Cook et al., (2013) lists "pursuing significant information" as a possible "evidence-gathering opportunity" that is "applicable at any

time during the course of an investigation". A line of enquiry is generally defined as, "(i) a line of questioning. An ordering of questions so, as to develop a particular argument. (ii) Line of reasoning, logical argument, argumentation, argument, line - a course of reasoning aimed at demonstrating a truth or falsehood; the methodical process of logical reasoning" (thefreedictionary.com, 2008).

The researcher has therefore chosen line-of-enquiry as a NVivo concept to find in the given data set, as it is related to lines-of-reasoning and the pursuit-of-significant-information. The first phase of the analysis was therefore to look for examples that would equate to the pursuit-of-significant-information.

Figure 50 provides an example of an identified line-of-enquiry (LoE). In the pursuit-of-significant-information, it emerged that the victim's death was probably as a result of being of a certain sexual orientation. The Think-Step component would be 'Victimology' in a murder schema, in other words, 'why was this victim chosen?'. So, the researcher asked the questions, "What information about this victim made it significant or relevant enough to be considered a reason for being murdered and that would lead to an evidence-gathering opportunity?"

In Figure 86, the victim's sexual orientation could be significant or relevant enough to the investigation if she/he was murdered because of the sexual orientation. The researcher therefore identified the Think-Step as 'Victimology' and the LoE as 'Victim's Sexual Orientation'. The researcher then gathered all the interview snippets pertaining to this LoE (see Figure 86)

Figure 86 – Chapter 4: Study 2: Grounded Theory – Phase 1 - Example of LoE for Victim's sexual orientation

Think-Step: Victimology	
Line of Enquiry: Victim's Sexual Orientation	
Description	**Interview Excerpt**
The victim's death was confirmed to be suspicious to detectives and emergency workers	[A1] (P1:34-35) The detectives found it [the victim's death] very suspicious. Also, the people of the ambulance [found the death suspicious].
The autopsy report confirmed that the victim was tortured	[A2] (P1:388-389) Doctor's autopsy came and [the victim] was burned all over his/her body. [The victim] was burned with hot water [and] acid.
The detectives suspect that the victim was of a certain sexual orientation	[A3] (P1:39) ... the [victim] was probably [of sexual orientation]

The second phase of the analysis was to identify how the LoE evolved over the duration of an investigation. The researcher made use of Klein et al.'s (2007) Data Frame theory. The researcher started with:

- Recognising a frame as the Creation phase of a LoE
- Elaborate a fame as the Active phase of LoE and
- Reframing as the Discarding phase of LoE.

Other LoE phases emerged during the coding process. The final LoE phases are (also see Figure 87 for an example);

- Create which corresponds to Recognising/Constructing a frame.
- Active which corresponds to Question a frame
- Stagnate which corresponds to Preserving a frame without adding anything new to it
- Discard which corresponds to Reframe/Seek a new frame as existing frame is wrong
- Revive which corresponds to Elaborate/Discovering new data and relationships
- Transform which corresponds to Reframe/Compare frames as one is more appropriate than the other
- Resolve which has no corresponding frame, but means that it is adequate in serving its purpose

Figure 87 – Chapter 4: Study 2: Grounded Theory – Phase 2 - Example of LoE Phases

Think-Step: Victimology		
Line of Enquiry: Victim's Sexual Orientation		
Line of Enquiry Phase	**Description**	**Interview Excerpt**
Create	The victim's death was confirmed to be suspicious to detectives and emergency workers	[A1] (P1:34-35) The detectives found it [the victim's death] very suspicious. Also, the people of the ambulance [found the death suspicious].
Active	The autopsy report confirmed that the victim was tortured	[A2] (P1:388-389) Doctor's autopsy came and [the victim] was burned all over his/her body. [The victim] was burned with hot water [and] acid.
Active	The detectives suspect that the victim was of a certain sexual orientation	[A3] (P1:39) ... the [victim] was probably [of sexual orientation]

The third phase of the analysis was to identify how the significance or relevance of LoE evolved over time, as new information emerged or when there was a lack of new information. The researcher uses significance and relevance to imply the same thing. The researcher started with coding relevance as: established, increased and decreased.

Subsequently, more relevance states emerged from the data as (also see Figure 88):

- Establish
- Maintain
- Increase
- Decrease
- Re-establish
- Irrelevant
- Confirmed

Each of the relevance-phases are defined in the Discussion section. The researcher included the relevance states, as the LoE might be in an active phase but is found to be irrelevant to the investigation.

Figure 88 - Chapter 4: Study 2: Grounded Theory – Phase 3 - Example of LoE Relevance States

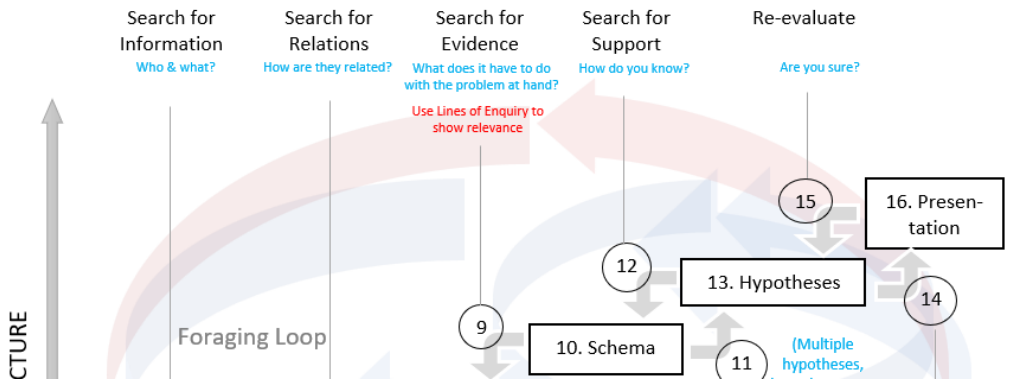
Think-Step: Victimology			
Line of Enquiry: Victim's Sexual Orientation			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	The victim's death was confirmed to be suspicious to detectives and emergency workers	[A1] (P1:34-35) The detectives found it [the victim's death] very suspicious. Also, the people of the ambulance [found the death suspicious].
Active	Increase	The autopsy report confirmed that the victim was tortured	[A2] (P1:388-389) Doctor's autopsy came and [the victim] was burned all over his/her body. [The victim] was burned with hot water [and] acid.
Active	Increase	The detectives suspect that the victim was of a certain sexual orientation	[A3] (P1:39) ... the [victim] was probably [of sexual orientation]

In the fourth phase the researcher went back to the literature in an attempt to link LoE to the concepts of argumentation. The researcher found that Pirolli and Card's (2005) notional model of sensemaking made references to a top-down approach where;

- Pirolli and Card's (2005) step 9 (what does it have to do with the problem at hand?) can be associated with determining how relevant information is for solving the case.

Pirolli and Card's (2005) step 9 in their top-down approach can therefore be used by criminal intelligence analysts as part of their bottom-up approach to create defensible assessment and to link Pirolli and Card's (2005) model to argumentation. Criminal intelligence analysts can enter into an 'argumentation loop' and establish relevance, by asking themselves Pirolli and Card's (2005) question; 'what does it have to do with the problem at hand?' or simply 'why is this relevant?'

Figure 89 - Chapter 4: Study 2: Notional Model of Analytical Sensemaking with the argumentation loop related to Lines of Enquiry. Adapted from Pirolli and Card (2005)



The argumentation loop to test relevance is not currently part of Pirolli and Card's (2005) Notional Model of Sensemaking, but the results in this chapter outline how it could form part of

Pirolli and Card's (2005) model as indicated in red within Figure 89. Pirolli and Card's (2005) step 9, also links LoE's to the argumentation question of 'what do you have to go on?' which are typically illustrated through convergent-notation in argumentation maps (Freeman, 1991).

Convergent-notation indicates that *each* premise can be used in support of the conclusion, but is not needed to accept the conclusion as cogent. So, if one of the premises are removed, then the conclusion can still be accepted as cogent. This means that each premise is "a reason for" accepting the conclusion, but not a requirement for accepting the conclusion. Similarly, a convergent-notation can be used to illustrate which of the LoE's contributed to the final analytical outcome that criminal intelligence analysts produce to answer the TOR.

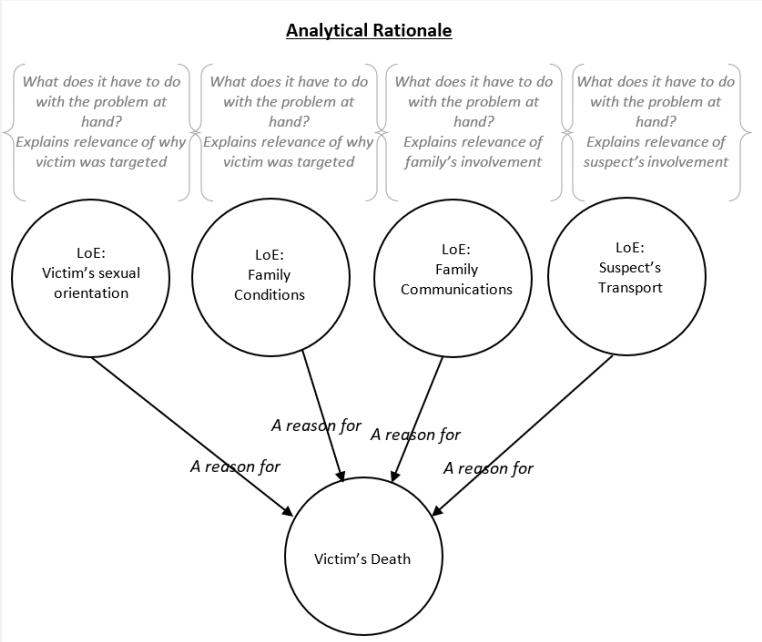
The researcher therefore included Pirolli and Card's (2005) step 9 to the analysis and were able to link the LoE to the concepts of argumentation as illustrated in Figure 90 and Figure 91.

Figure 90 illustrates that the LoE has relevance, because it explains why the victim was targeted.

Figure 90 - Chapter 4: Study 2: Grounded Theory – Phase 4 – Example of 'What does it have to do with the problem at hand?'

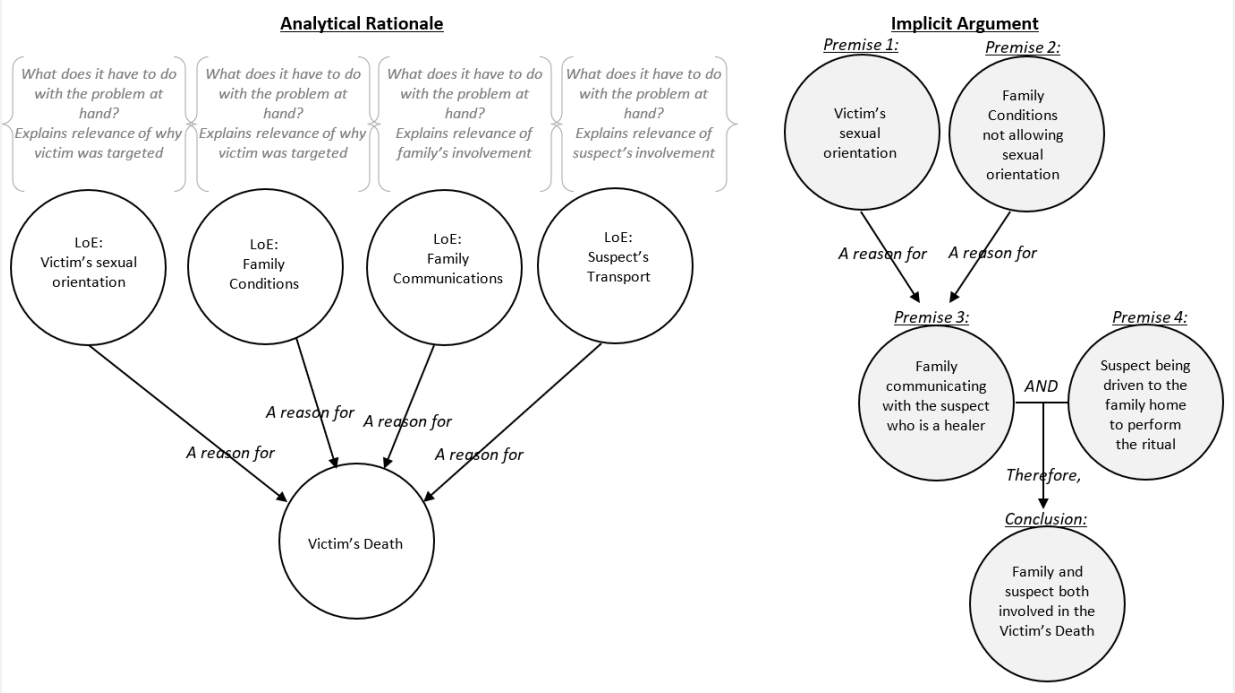
Think-Step: Victimology			
Line of Enquiry: Victim's Sexual Orientation {Explains relevance of why victim was targeted}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	The victim's death was confirmed to be suspicious to detectives and emergency workers	[A1] (P1:34-35) The detectives found it [the victim's death] very suspicious. Also, the people of the ambulance [found the death suspicious].
Active	Increase	The autopsy report confirmed that the victim was tortured	[A2] (P1:388-389) Doctor's autopsy came and [the victim] was burned all over his/her body. [The victim] was burned with hot water [and] acid.
Active	Increase	The detectives suspect that the victim was of a certain sexual orientation	[A3] (P1:39) ... the [victim] was probably [of sexual orientation]

Figure 91 – Chapter 4: Study 2: Grounded Theory – LoE - Depiction of analytical rationale



The researcher then went back to the literature in an attempt to determine how the analytical rationale could be linked to argumentation concepts. Govier (2014) demonstrated how arguments can have implicit conclusions and implicit premises. Implicitness can make an argument look cogent, but unless all of the conclusions and premises are made explicit – the ambiguity and vagueness can lead to fallacy of equivocation. The researcher went back to the analytical rationale and asked the question, "What is being argued here implicitly?". This question led to the construction of a possible implicit argument that would correspond to the analytical rationale. Premise 1 and Premise 2 are reasons that contributed to Premise 3, but the conclusion will still be cogent if omitted. Premise 3 and Premise 4 are both required to accept the conclusion (See Figure 92).

Figure 92 – Chapter 4: Study 2: Grounded Theory – LoE - Depiction of an implicit argument that corresponds to the analytical rationale



4.2. Results

A sub-section of the results reported here, is published as part of the European Intelligence and Security Informatics Conference[7]. The researcher performed the analysis for that paper and concentrated on how criminal intelligence analysts recognise significant information. Significant information was classified under phenomena that the criminal intelligence analyst deemed as

[7] Groenewald, C., Wong, B. W., Attfield, S., Passmore, P., & Kodagoda, N. (2017, September). How analysts think: How do criminal intelligence analysts recognise and manage significant information? In 2017 European Intelligence and Security Informatics Conference (EISIC) (pp. 47-53). IEEE.

certain, strange or interesting. It was the first attempt by the researcher to try and understand how criminal intelligence analysts recognise and manage the relevance of information. The co-authors helped with structuring the paper and proof-reading.

The results that follow is the continuation of that research paper and has subsequently evolved to concentrate on how lines of enquiry (LoE) evolve and the respective implicit arguments that are tied to LoE. This change in focus was made possible by the new understanding gained from the literature as described in the sections above.

4.3. Case 1 - Suspicious Death

Case 1 Synopsis

A victim was found dead in a field and the death looked suspicious due to the markings on the body. The investigators suspected that the victim was subject to a healing ritual that would cleanse the victim from being of a certain sexual orientation. The investigators had a suspect that could have performed the healing ritual and asked the criminal intelligence analyst to determine the involvement of the suspect and any other parties.

Line of Enquiry (A) – Victim's Sexual Orientation

The suspiciousness of the method used to end the victim's life created suspicion that the victim was of a certain sexual orientation, thus making the victim's sexual orientation relevant to the case (A1). The autopsy report confirmed the method used (A2) that resulted in the victim's death (A2) which made the victim's possible sexual orientation even more relevant to the case (A3).

Table 40 - Chapter 4: Study 2: Case 1: Line of Enquiry (A) - Victim's Sexual Orientation

Think Step: Victimology			
Line of Enquiry – Victim's Sexual Orientation {Explains relevance of why victim was targeted}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	The victim's death was confirmed to be suspicious to detectives and emergency workers	[A1] (P1:34-35) The detectives found it [the victim's death] very suspicious. Also, the people of the ambulance [found the death suspicious].
Active	Increase	The autopsy report confirmed that the victim was tortured	[A2] (P1:388-389) Doctor's autopsy came and [the victim] was burned all over her body. [The victim] was burned with hot water [and] acid.
Active	Increase	The detectives suspect that the victim was of a certain sexual orientation	[A3] (P1:39) ... the [victim] was probably [of sexual orientation]

Line of Enquiry (B) – Family Conditions

The criminal intelligence analyst found the victim's family's living conditions to be strange. It was strange as the victim's parents did not interact with their child's friends' parents, so they were a very isolated family (B1). These strange family conditions became relevant to the case. It was

found that the family was part of an [omitted] community that did not accept certain sexual orientations (B2) which added more relevance to how the family lived. When the detectives spoke to the neighbours, the neighbours believed that the victim was of a particular sexual orientation (B3) this making the family's conditions even more relevant.

Table 41 - Chapter 4: Study 2: Case 1: Line of Enquiry (B) - Family Conditions

Think Step: Victimology			
Line of Enquiry – Family Conditions {Explains relevance of why victim was targeted as family conditions meant they did not approve}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	The strangeness of the family's living conditions establishes the relevance that they might be involved.	[B1] (P1:189-191) But [victim's parent] doesn't get in touch with the [victim's friends' parents], so [victim's parent] is in a little [group]. Strange because... that way, there's [community group] where [victim's parent] doesn't get out of...
Active	Increase	The specific community does not view favourably on a certain sexual orientation	[B2] (P1:80-85) What is the phenomenon within the [omitted] community because of the [religion]? So as an analyst you do a little phenomenon study to know what you are dealing with.
Active	Increase	The neighbours implied that the victim was subject to being 'cleansed' of sexual orientation	[B3] (P1:40-41) After speaking with the neighbours, they [the detectives] think she was touched by a healer in the [omitted] community.

Line of Enquiry (C) – Family communications

The relevance of the victim's believed sexual orientation along with the family's cultural and religious conditions, contributed to the criminal intelligence analyst opening up a line of enquiry into the family's communications. The detectives provided the telephone communications for the suspect, the family and the victim (C1). The criminal intelligence analyst established that the suspect [a known healer (C2)] was in contact with the family's land line (C3). This made the criminal intelligence analyst suspect that the family contacted the suspect to 'heal' the victim (C4).

Table 42 - Chapter 4: Study 2: Case 1: Line of Enquiry (C) - Family Communications

Think Step: Victimology			
Line of Enquiry – Family Communications {Explains relevance of family's involvement}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	Lines of enquiry (A & B) gave rise to the belief that the family contributed to the victim's death and thus the telephone records were obtained	[C1] (P1:40) Now what [the detectives] got was the phone billings of the [offender who heals], the phone billings of the [parents] and the [victim]".
Active	Increase	The suspect is a known healer	[C2] (P1:71) I didn't identify. It was identified by the detective squad [that the suspect was a healer].
Active	Increase	The specific community does not view favourably on a certain sexual orientation	[C3] (P1:309) [there is a] connection between the [parent] and the landline [of the suspect]."
Active	Maintained	The neighbours implied that the victim was subject to being 'cleansed' of sexual orientation	[C4] (P1:366) [The victim] might be [of sexual orientation]. The [offender] has been called by the [victim's parent] ..."

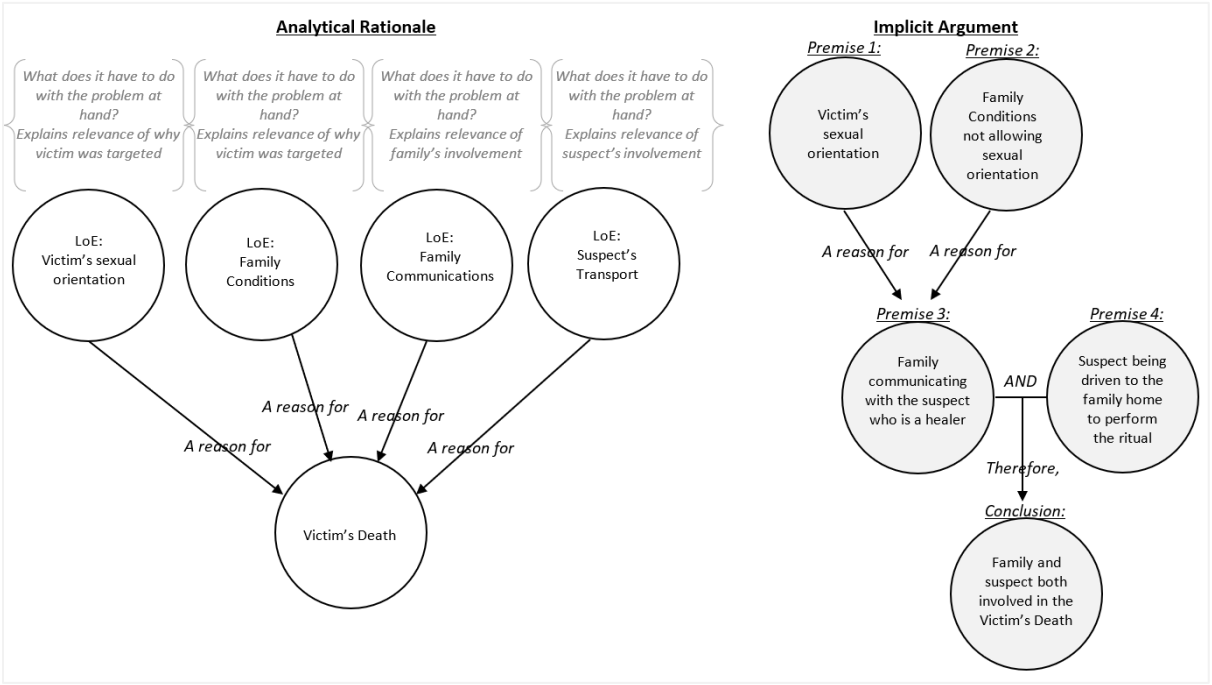
Line of Enquiry (D) – Suspect's Transport

As the criminal intelligence analyst was able to establish communication between the family and the suspect, he then had to determine if the offender was in the northern part of the town where the victim lived (D1). This is the creation of the line of enquiry into the suspect's transport. Transport could be one of the think-steps (Selvaraj et al., 2016) in a murder crime schema, as the offender would need to transport him/herself to the location of the victim, thus relevance to the analysis is established.

Table 43 - Chapter 4: Study 2: Case 1: Line of Enquiry (D) - Family Communications

Think Step: Victimology			
Line of Enquiry – Suspect's Transport {Explains relevance of suspect's involvement}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	Use known locations of victim and offender to establish a relationship	[D1] (P1:145) What I try to establish is, was [the suspect] in the Northern part of town [where the victim lived]
Active	Increase	Determine the likelihood of the offender travelling to the crime scene	[D2] (P1:124-127) I will take a map of [city]…the highway. It goes around [city] and it goes to the North [where the victim lived]… I think it is approximately [close distance] apart
Stagnate	Decrease	Discovered that the offender was unable to drive, so less likely to be at the crime scene	[D3] (P1:120-121) [The suspect] had no driver's license. [The suspect] had no car.
Revive & Resolve	Re-established & Resolved	Discovered that the offender was driven to the crime scene	[D4] (P1:374-382) I saw [the parent] call [the suspect] and apparently [the uncle] … [The uncle] is the driver, because I see [the uncle] calling the [suspect]. I see [the uncle] coming [to the suspect's location] and then going up [to the victim's location]

Figure 93 - Chapter 4: Study 2: Case 1: Analytical Rationale with corresponding implicit argument



The relevance of the line of enquiry into the suspect's transport increased when the criminal intelligence analyst realised that the location where the suspect lived and the location where the victim lived, were relatively easily linked by a highway (or expressway / freeway / motorway) (D2). The relevance of the line of enquiry into the suspect's transport decreased when the criminal intelligence analyst discovered that the suspect was unable to drive (D3), so it was unlikely that the criminal intelligence analyst could use this line of enquiry any further to solve the case.

This understanding changed when the criminal intelligence analyst found, by using maps and telephone communication data, that an uncle of the victim drove the suspect to the victim's location (D4). The line of enquiry into the suspect's transport became relevant again, thus relevance was re-established.

Figure 93 illustrates how each line of enquiry is a reason for explaining the victim's death. The implicit argument illustrates that even if premises 1 and 2 are omitted, the conclusion is still cogent. Table 44 and Table 45 is a graphical representation of LoE to assist the reader with understanding the LoE changes over time for Case 1. By tracking the changes in relevance over the course of the investigation, could help criminal intelligence analysts answer Pirolli and Card's question in step 9, 'What does it have to do with the problem at hand?'.

Table 44 - Chapter 4: Study 2: Case 1 - Lines of Enquiry over time

KEY: Create/Revive	Resolve	Active	Stagnate	Transform/Discard

Line of Enquiry	Depiction of each line of enquiry's existence over time																		
	Beginning phase of the investigation...					… elapsed time …							...Ending phase of the investigation						
V.'s Sexual Orientation	A1	A2	A3																
Family Conditions			B1	B2	B3														
Family Comms.						C1	C2	C3	C4										
Suspect's Transport										D1	D2	D3	D4						

Table 45 – Chapter 4: Case 1 - Relevance of Lines of Enquiry over time

KEY: Establish/Re-Establish	Maintain	Increase	Confirm	Decrease	Irrelevant

Line of Enquiry	Depiction of changes in significance of relevance throughout each line of enquiry's existence																		
	Beginning phase of the investigation...					… elapsed time …							Ending phase of the investigation						
V.'s Sexual Orientation	A1	A2	A3																
Family Conditions			B1	B2	B3														
Family Comms.						C1	C2	C3	C4										
Suspect's Transport										D1	D2	D3	D4						

4.4. Case 2 – The robbery of the jewellery seller

Case 2 Synopsis

A jewellery seller (as the victim) got robbed in a busy city centre. The victim sells jewellery every month in the city centre and this time the victim was convinced that he was being followed. The victim started to panic and then went back to the central train station. After a while, the victim went to a restaurant that the victim was acquainted with and therefore thought that he would be safe there. It was not long before a group of robbers entered the restaurant and took the bag of jewels from the victim. They fled on foot.

Line of Enquiry (A) – Suspect communication

One of the Think-Step components for a robbery crime schema would be related to how the offenders planned to execute the attack. This would be where the offenders communicate with each other to plan and coordinate the attack. The criminal intelligence analyst noticed that a witness reported that one of the offenders talked over a mobile phone shortly before the robbery took place [A1.1]. At this point in time, the criminal intelligence analyst has established communication between the offenders and thus opened an 'offender communication' line of enquiry.

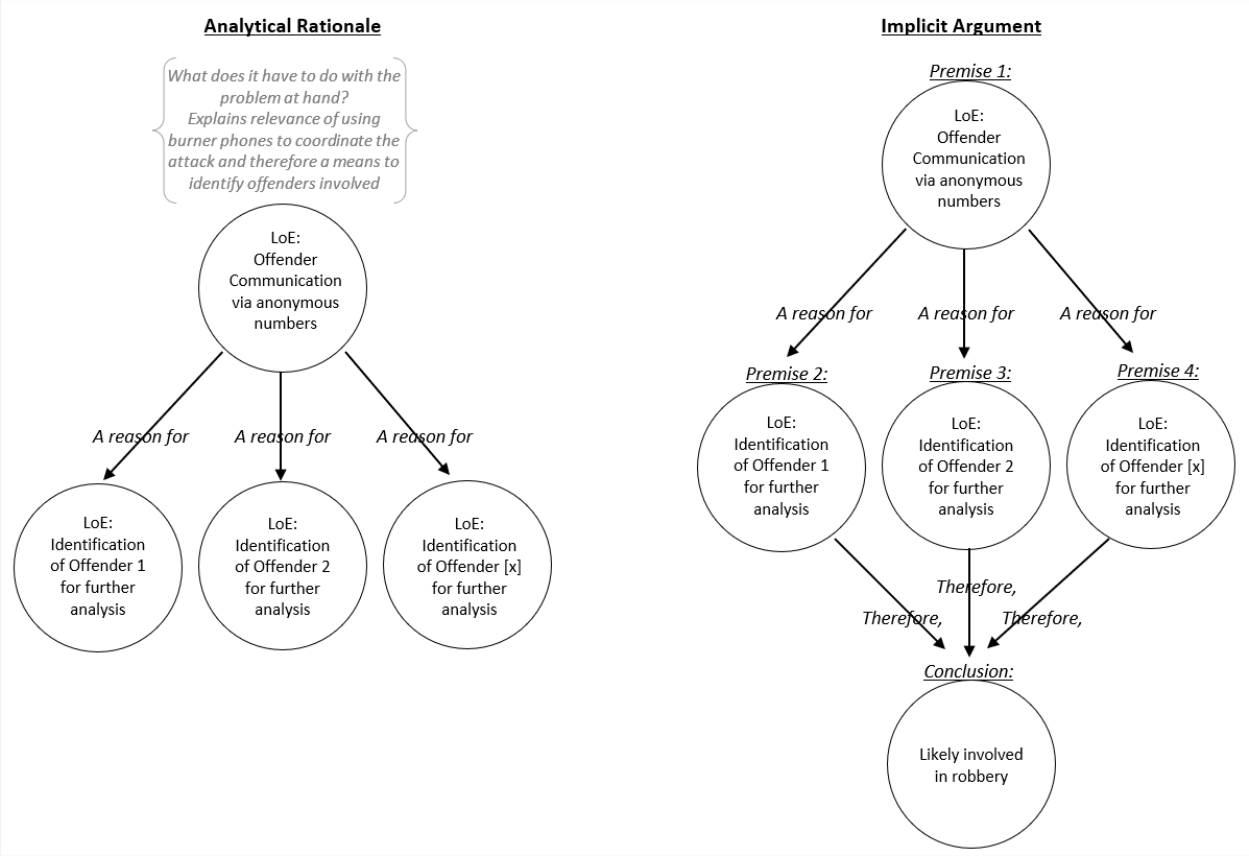
Table 46 - Chapter 4: Study 2: Case 2: Line of Enquiry (A) - The robbery of the jewellery seller

Think Step: Attack Execution			
Line of Enquiry – Offender Communication via anonymous numbers {Explains relevance of using burner phones to coordinate the attack}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	Discover interesting information: An offender used his phone and then more offenders arrive	[A1.1] (P7:63-69) ... So, I start reading the [witness] testimonies, what struck me was that one of the witnesses in the restaurant, he said I was sitting by the window and when the [victim] came in, very shortly after he came in two [offenders] appeared at the window, they looked in – I don't know what they were looking at but one of the [offenders], took his cell phone, he called and all of a sudden there were five [offenders], and when they were five they came in and then the robbery took place. [A1.2] (P7:88-90) ...all of the [telephone] numbers were pre-paid numbers, so anonymous. Okay, so that [group of telephone numbers] I thought of as most interesting…
Active	Increase	Discover a pattern	[A2] (P7:90-91) … so I checked whether that group of numbers appeared over the entire period the [victim] was there...
Active	Maintained	Established communication	[A3] (P7:243-244) you make a timeline you can really see them going about and calling each other, seeing the [phone] towers...
Active	Maintained	Explore a hunch	[A4] (P7:92-93) I was convinced that this could be the group of perpetrators...
Transform	Confirmed	Confirm identities of Offender 1, Offender 2… Offender [x] for further analysis	[A5] (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...

The telephone communication data set was large holding many telephone numbers. It was not possible for the criminal intelligence analyst to go through all the telephone numbers to try and find the identities of the offenders. The criminal intelligence analyst therefore looked for a phenomenon that fits in with the line of enquiry. In this instance, there were anonymous pre-paid telephone numbers (burner phones) [A1.2], so the criminal intelligence analyst focused on those telephone numbers, as offenders tend to try and hide their identities as much as possible. The line of enquiry is thus related to the offender's communication via anonymous numbers.

Figure 94 - Chapter 4: Study 2: Case 2: Analytical Rationale with corresponding implicit argument



As the analysis progressed, the relevance of the group of anonymous telephone numbers increased as the criminal intelligence analyst discovered a pattern where the anonymous telephone numbers were in the city centre at the same times and places the victim was [A2].

The criminal intelligence analyst found that those telephone numbers were actively calling each other prior to the robbery and was convinced that the anonymous telephone numbers belonged to the offenders [A3]. Relevance of these anonymous telephone numbers was thus maintained.

The criminal intelligence analyst extended the line of enquiry into the anonymous telephone numbers by further analysing the information to confirm the belief that the anonymous numbers belonged to the offenders [A4].

The criminal intelligence analyst was able to reference the anonymous telephone numbers within the police database and found a match to known offenders. Relevance was thus maintained. The criminal intelligence analyst could then reference the closed-circuit television (CCTV) footage that appeared in a different line of enquiry, with the images of known offenders in the police database [A5]. This led to the line of enquiry into the anonymous telephone numbers to be transformed into the identities of the offenders. Relevance of the anonymous telephone numbers was thus confirmed and new lines of enquiries for each of the identified offenders could be opened.

Figure 94 illustrates how each line of enquiry is a reason for identifying each offender for further analysis. The implicit argument illustrates that if one of the premises are omitted, the conclusion is still cogent. Table 47 and Table 48 are a graphical representation of LoE to assist the reader with understanding the LoE changes over time for Case 2. By tracking the changes in relevance over the course of the investigation, could help criminal intelligence analysts answer Pirolli and Card's question in step 9, 'What does it have to do with the problem at hand?'.

Table 47 - Chapter 4: Study 2: Case 2 - Lines of Enquiry over time

KEY: Create/Revive	**Resolve**	**Active**	**Stagnate**	**Transform/Discard**

Line of Enquiry	**Depiction of each line of enquiry's existence over time**									
	Beginning phase of the investigation...			… elapsed time …			...Ending phase of the investigation			
Offender comms via anonymous numbers	A1.1 A1.2	A2	A3	A4	A5					
Offender 1					New LoE					
Offender 2					New LoE					
Offender [x]					New LoE					

Table 48 - Chapter 4: Study 2: Case 2 - Relevance of Lines of Enquiry over time

KEY: Establish/Re-Establish	**Maintain**	**Increase**	**Confirm**	**Decrease**	**Irrelevant**

Line of Enquiry	**Depiction of changes in significance of relevance throughout each line of enquiry's existence**									
	Beginning phase of the investigation...			… elapsed time …			Ending phase of the investigation			
Offender comms via anonymous numbers	A1.1 A1.2	A2	A3	A4	A5					
Offender 1					New LoE					
Offender 2					New LoE					
Offender [x]					New LoE					

4.5. Case 3 – Burglary of Vehicles

Case 3 Synopsis

The criminal intelligence analyst investigated an instance where vehicles were broken into by smashing one of the windows and stealing the console (i.e. SATNAV). The activity would stop for a while and then it would start up again. There was no particular pattern that the burglaries followed. The criminal intelligence analyst was asked to find links between the crimes and their offending patterns to attempt to discover the identities of the offenders.

The crime schema for this case is a Burglary of Vehicles and some of the think-steps would be; Modus Operandi, Offending Location, Offender Business, Forensic Evidence and Strategy.

The next sections explore the lines of enquiry into each of the identified think-steps.

Line of Enquiry (A) - Console MO

The Console MO line of enquiry (LoE) was created when the criminal intelligence analyst first discovered a pattern [A1] in the vehicle burglaries. In all of the cases, either the driver's side or the passenger's side front windows was broken. The discovery of the pattern made the line of enquiry relevant to the investigation.

The Console MO LoE became less relevant when the offending activity ceased, but the identities of the offenders were not discovered [A2].

The Console MO LoE became relevant again when the criminal intelligence analysts found new cases with the same MO [A3].

The Console MO LoE became less relevant again as there was no new information that could assist the criminal intelligence analyst with predicting when the next wave of offences would occur. So, the fact that the criminal intelligence analyst was seeing new cases, would not lead to the identities of the offenders. This line of enquiry was therefore less relevant in finding the identities of the offenders.

Table 49 provides a summary of the Console MO LoE.

Table 49 - Chapter 4: Study 2: Case 3: Line of Enquiry (A) – Console MO

Think Step: Modus Operandi			
Line of Enquiry – Console (MO) {Explains relevance of method used to carry out the activity}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	MO starts	[A1] (P5:2-8) What happened was we had a specific Mo being used where either the driver side window or the passenger side front windows were being smashed.
Discard	Decrease	Burglary activities cease	[A2] (P5:22) … we stopped [the burglary activity], but did not get the results we would have liked [as the offenders were still unknown]

Revive	Re-established	Burglary activities restart	[A3] (P5:39-41) … and in the October, [the offending] started, I started to see one or two of [those cases] again. We'd have a little break [in offending] and we'd have more [offending].”
Active	Decrease	No pattern in burglary activities	[A4] (P5:200-201) … it was like we couldn't predict the gap time between offending...
Stagnate	Decrease	No new patterns in burglary activities	[A5] (P5:202-204) …they have favourite days that they went in, but we couldn't turn around and say, well it's definitely going to be this week...

Line of Enquiry (B) – LPU Boundary

As the criminal intelligence analyst could not progress the case with the Console MO LoE, the geographical area within the Local Policing Unit (LPU) boundary was taken into consideration.

LPU-Boundary LoE was created when the criminal intelligence analyst noticed that the offenders operated in a very wide geographical area [B1], making it relevant to the investigation, thus relevance was established.

LPU-Boundary LoE became more relevant when the criminal intelligence analyst saw that they were committing crimes in four different LPU Boundary locations [B2]. Relevance thus increased.

LPU-Boundary LoE became less relevant when the criminal intelligence analyst was unable to determine how the offenders entered and exited the LPU boundary [B3]. Relevance thus decreased. If the criminal intelligence was able to determine the entry and exit points, then it would have indicated if the offenders were local or cross-border offenders, and he/she could devise strategies accordingly.

LPU-Boundary LoE became relevant again at the point when the criminal intelligence analyst noticed the two motorways that ran through the LPU Boundaries [B4]. Relevance thus increased.

The criminal intelligence continued to progress the relevance of LPU-Boundary LoE through further analysis and though organising patrols [B5] in areas where the criminal intelligence analyst believed the offenders would enter and exit. Relevance was thus maintained.

The criminal intelligence continued to progress the relevance of LPU-Boundary LoE, by analysing the data further and to try and determine the offending periods [B6] that could be used to direct the patrols. Relevance was thus maintained.

Due to the excessive number of routes in and out of the LPU, the criminal intelligence analyst realised that the LPU-Boundary LoE would not yield any results [B7]. The relevance thus decreased.

This led to the abandonment of the LPU-Boundary LoE [B8] in favour of the Directional-Movements LoE. LPU-Boundary LoE thus became irrelevant in solving the case. This shift was due to new information that the criminal intelligence found that was more factual.

Table 50 - Chapter 4: Study 2: Case 3: Line of Enquiry (B) – LPU Boundary

Think Step: Offending Location			
Line of Enquiry – LPU Boundary {Explains relevance of the LPU Boundary in relation to identify the offenders}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	Taking the LPU Boundary into consideration	[B1] (P5:30-31) "It was a very wide geographical area."
Active	Increase	Link multiple locations to the crime	[B2] (P5:31-32) "They would go in and hit 3 or 4 different locations across the LPU."
Active	Decrease	Unable to determine a pattern	[B3] (P5:32-35) "We did not know where they were coming in to the LPU Boundary, where they were leaving…we did not know if they were local offenders or if they were cross-border offenders"
Active	Increase	Notice new information that assist with the investigation	[B4] (P5:35) "...we've got two motorway links coming in to [District]..."
Active	Maintained	Adding patrols	[B5] (P5:68-69) "…I did further work trying to predict where they were going to be coming in and coming out to be added to the patrol areas."
Active	Maintained	Considering times and locations of offences	[B6] (P5:69-72) "…So I did a lot of work around sequencing out into detail each offending period and then mapping them and then highlighting the routes where the offending started on the LPU, where the offending ended on the LPU. I just started on the arterials to start off with to give us the general direction..."
Active	Decrease	Realising that too many options exist	[B7] (P5:69-72) "…the arterial routes... there is so many ways through the LPU …"
Transform	Irrelevant	Find new information that makes the LPU Boundary redundant	[B8] (P5:167-172)"…a lot of the offending was very extended… ten o'clock in the evening and half six in the morning…so what I also did was I used the information from the [system]…now that gave a more confirmed time of offending"

Line of Enquiry (C) – Directional Movements

The line of enquiry into the directional movements of the offenders became relevant when the criminal intelligence analyst found data with very specific timestamps that could narrow down the offending periods [C1]. The criminal intelligence analyst conceptualised the information as directional movements (i.e. north, south, east, west), rather than actual road names. This was the creation of the Directional-Movements LoE and replaced the LPU-Boundary LoE.

The Directional-Movements LoE remained relevant as the criminal intelligence analyst could determine when the earliest offending start time was and what the end time was [C2]. Relevance was therefore maintained.

The Directional-Movements LoE remained relevant as the criminal intelligence analyst could group cases together that were deemed to fall within the same offending period [C3]. Relevance was therefore maintained.

The Directional-Movements LoE remained relevant as the criminal intelligence analyst was now able to establish in which direction the offenders were offending. It was less specific than actual road names but provided a clearer picture into how the offenders moved through the area [C4]. Relevance was therefore increased.

The Directional-Movements LoE remained relevant as the criminal intelligence analyst could better predict where the offenders would move to next and thus send patrols to the appropriate locations, to anticipate the arrival of the offenders [C5]. Relevance was therefore maintained. From these patterns, the criminal intelligence analyst was able to anticipate the movements where the offenders would likely exit the offending area with the stolen goods and send patrols to anticipate the arrival of the offenders [C6]. Relevance was therefore maintained.

The criminal intelligence analyst's predictions were confirmed by external intelligence from the patrols [C7]. Relevance was therefore confirmed.

Table 51 provides a summary of the Directional-Movements LoE.

Table 51 - Chapter 4: Study 2: Case 3: Line of Enquiry (C) – Directional Movements

Think Step: Offending Location			
Line of Enquiry – Directional Movements {Explains relevance of how the direction that the offenders move in, could identify their identities}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	Find new information that makes the LPU Boundary redundant. Criminal intelligence analyst starts to think of a fictional compass	[C1] (P5:178-179) …[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.
Active	Maintained	Determine earliest start and end point	[C2] (P5:179-180) …so from that point I could work out what was my earliest offending period, start time, and what was my end time.
Active	Maintained	Grouping and clustering activities	[C3] (P5:180-182) …and then from that look at the grouping to see, well, those are all potentially in the same period. So, I clustered them by same period. ...
Active	Increased	Determine direction in which the offenders start and end	[C4] (P5:182-184) ...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...
Active	Maintained	Better understanding of start and end locations	[C5] (P5:79-84) …quite often our offending would start down in the southern part of the LPU [Location A]…but it wasn't always the case. Sometimes we would get calls from [Location B].
Active	Maintained	Send patrols to anticipated offender's arrival	[C6] (P5:87-90) …if it came in at [Location A], then officers need to be patrolling [Location B] and ready for the move up and also on the border we have with the next LPU [District], because that is the mapping point they seem to be going out...
Resolve	Confirmed	Intelligence confirms direction of movements that criminal intelligence analyst determined	[C7] (P5:107-110) … The intelligence actually supported my way of thinking and the way my mapping was going, because it was some [District] nominals who lived in the area committing the offences, that we then focused our resources on [those nominals]...

Line of Enquiry (D) – Patrol Plan

The line of enquiry into the patrol plan played an active part in gathering new information and intelligence from the field. The Patrol-Plan LoE became relevant when the criminal intelligence analyst created a detailed patrol plan based on the analysis, he/she performed [D1]. The relevance was therefore established.

The patrol plan was disseminated across the four LPU boundaries where the offences took place [D2]. The relevance therefore increased.

The Patrol-Plan LoE became less relevant when the other police forces reported that they had no information that could help solve the case [D3]. The relevance was therefore decreased. The Patrol-Plan LoE remained less relevant in solving the case, when additional patrols yielded no results [D4]. The relevance was therefore decreased. The Patrol-Plan LoE remained less relevant in solving the case when the criminal intelligence analyst tried in vain to herd the offenders into a particular location, by placing high-visibility officers in one location and undercover officers in the location in which they wanted to herd the offenders to [D5, D6]. The relevance was therefore decreased. The Patrol-Plan LoE became irrelevant in solving the case and the criminal intelligence analyst opted for other lines of enquiry, especially when the criminal intelligence analyst realised that Vehicle Registration Mark (VRM) theft was occurring just before the vehicle offences occurred [D7]. This would be the creation of the line of enquiry into the VRM Modus Operandi (MO).

Table 52 provides a summary of the Patrol-Plan LoE.

Table 52 - Chapter 4: Study 2: Case 3: Line of Enquiry (D) – Patrol Plan

Think Step: Strategy			
Line of Enquiry – Patrol Plan {Explains relevance of how the devised patrol plan could assist with identifying the offenders}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	Create the patrol plan	[D1] (P5:58) …we started to put together a very detailed patrol plan
Active	Increase	Extend the patrol plan cross-border	[D2] (P5:59-60) It went out to all cross-border bulletins about offenders and potential vehicles and basically trying to get as much cooperation from the other force areas...
Active	Decrease	Ask other LPU's for information as criminal intelligence analyst was getting stuck	[D3] (P5:62-63) ...who were having similar problems to see if they had intelligence or anything they could offer us as we were pretty much in the dark as to who could be offending against us...
Active	Decrease	Weekly patrol plans yielded nothing new	[D4] (P5:64-65) …we were literally out doing us specific patrol plans every week. We weren't even limiting it; we were doing it on the specific nights and in the specific areas and we were still not halting the offences.
Active	Decrease	Displacements yielded nothing new	[D5] (P5:222-223) we looked at displacement as well…if you got a visible presence, they will go somewhere else...
Active	Decrease	Patrols yielded nothing new	[D6] (P5:65-67) …I got to the point where I was looking to well if we were not working by going in by the high vis and patrols and covert work with people in the plain clothes, what else could we do?
Transform	Irrelevant	Found other information that could help analysis	[D7] (P5:562-563) "...I said, I'm sure that we have a Vehicle Registration Mark (VRM) theft literally just prior to these events happening..."

Line of Enquiry (E) – Offender Business

The criminal intelligence analyst remembered that they have previously arrested someone who committed similar offences [E1]. The criminal intelligence analyst wanted to determine if the same business was in operation for these vehicle offences. This was the creation of the line of enquiry into the business of the offenders. The relevance was therefore established.

The Offender-Business LoE remained relevant when the criminal intelligence analyst tried to establish if the same offender business was in operation again [E2]. The relevance was therefore maintained. The Offender-Business LoE became less relevant when the criminal intelligence analyst was unable to find any new offender business activity [E3]. The relevance therefore decreased.

Offender-Business LoE became more relevant when the criminal intelligence analyst theorised that the offenders had an empty car when they entered the area [E4]. That way they could avoid detection if stopped by patrols. The relevance therefore increased. Thereafter they could fill the car with stolen goods and then quickly leave the affected area to offload the stolen goods, before they ran into another police patrol [E5]. The relevance was therefore maintained.

Table 53 provides a summary of the Offender-Business LoE.

Table 53 - Chapter 4: Study 2: Case 3: Line of Enquiry (E) – Offender Business

Think Step: Offender Business			
Line of Enquiry – Offender Business {Explains relevance of how off-loading the stolen goods could assist with identifying the offenders}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	Check previous arrests	[E1] (P5:11-12) We actually arrested someone for it… we identified somebody from [Company]. We found a unit with hundreds of satnavs in and the offences had actually ceased at that point...”
Active	Maintained	Check if previous company was back in operation	[E2] (P5:53-55) we also went back and revisited the intelligence and the offenders we had the last time to see whether or not the business set up on [Company] again.”
Stagnate	Decrease	Hit a dead end	[E3] (P5:57) …they didn't seem to be the outlets that we'd identified via [Company], so that sort of a bit of a dead-end.
Revive	Increase	New idea that offenders are entering the LPU with an empty car	[E4] (P5: 120-123) …so it is probably better if you have an empty car at that point [Location A], because even if you get stopped by police officers, and you haven't committed any offences, that's ok, because you still have other areas to go to...
Resolved	Maintained	New idea that they offenders offend close to area where they escape	[E5] (P5:149:152) …Once they move into [Location] B, yes, slightly riskier, there's more people around, but they are close to home. They are close to where they can actually get rid of their items to their handler or the storage area. You know, they can offload quick and get to where they need to be...

Line of Enquiry (F) – Fingerprint

The criminal intelligence analyst received intelligence that a fingerprint was found at a similar crime scene [F1]. This made the fingerprint relevant to the case to try and identify the offenders

and thus the line of enquiry into the fingerprint was created. Relevance was therefore established.

The Fingerprint LoE became more relevant when the police database found a match and provided the criminal intelligence a person to investigate [F2]. Relevance therefore increased. The Fingerprint LoE became less relevant when the criminal intelligence analyst found that they had the wrong suspect [F3]. The line of enquiry was therefore considered irrelevant.

Table 54 provides a summary of the Fingerprint LoE.

Table 54 - Chapter 4: Study 2: Case 3: Line of Enquiry (F) – Fingerprint

Think Step: Forensic Evidence			
Line of Enquiry – Fingerprint {Explains relevance of how forensic evidence could assist with identifying the offenders}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	Link to known offenders	[F1] (P5:232-233) We used intelligence that we had and also intelligence that we found about people who had done this kind of offence as well...
Active	Increase	Found a fingerprint that could link to known offenders	[F2] (P5:234) … a fingerprint came back, I think it was [Country], a gentleman from a different [Force area], so we did some work on him...
Discard	Irrelevant	Not the person they were looking for	[F3] (P5:236-237) ...was the wrong gentleman who had the same name from the same county...

Line of Enquiry (G) – VRM Thefts

The criminal intelligence analyst found information that revealed a series of Vehicle Registration Mark (VRM) thefts just outside the LPU where the console thefts occurred [G1]. These VRM thefts became relevant to the case and this was the creation of the line of enquiry into the VRM thefts. Relevance was therefore established.

The VRM-Theft LoE became more relevant to the case when the criminal intelligence analyst realised that the offenders were stealing VRM's (license plates) from law abiding citizens' cars. They would then drive to the offending location with the stolen license plates, knowing that they would not raise suspicion if stopped by patrols, as the thefts would not have been reported by the victims of the VRM thefts, at the time the patrol took place. They could then commit their crimes and leave the area without be arrested [G2]. Relevance was therefore confirmed. Table 55 provides a summary of the VRM-thefts LoE.

Table 55 - Chapter 4: Study 2: Case 3: Summary of the line of enquiry into the VRM thefts

Think Step: Offending Location			
Line of Enquiry – VRM-Thefts {Explains relevance of how VRM thefts before the console thefts could assist with identifying the offenders}			
Line of Enquiry Phase	**Relevance**	**Description**	**Interview Excerpt**
Create	Established	Spot VRM thefts	[G1] (Intv10:567-569) …looking at the data, the patterns, because we'd have like, the series sort of stats, and literally just outside the area of where we were having the offences that night, we were having VRM theft...

Resolve	Confirmed	Realising how the crimes were committed	[G2] (Intv10:136-139) …so the car that they were driving would be bearing legitimate number plates, but it may not be particularly for the car that they were driving… but they know that it would be highly unlikely that the theft of the VRN would be reported there and then...

Table 56 depicts how the Lines of Enquiry evolved over time. The Directional-Movements, Offender-Business and VRM-Thefts Lines of Enquiries were the most effective in resolving the case. Table 57 depicts the same information as Table 56, but offers a graphical representation on how the relevance of each line of enquiry changed over time. By tracking the changes in relevance over the course of the investigation, could help criminal intelligence analysts answer Pirolli and Card's question in step 9, 'What does it have to do with the problem at hand?'.

Table 56 – Chapter 4: Study 2: Case 3 - Depiction of the lines of enquiry over time

KEY: Create/Revive	Resolve	Active	Stagnate	Transform/Discard

Line of Enquiry	Depiction of each line of enquiry's existence over time																		
	Beginning phase of the investigation...			... elapsed time ...													...Ending phase of the investigation		
Console-MO	A1	A2	A3					A4	A5										
LPU-Boundary				B1	B2	B3	B4	B5	B6	B7	B8								
Directional Movements											C1	C2	C3	C4	C5	C6	C7		
Patrol-Plan				D1	D2	D3	D4	D5					D6	D7					
Offender-Business				E1	E2	E3											E4	E5	
Fingerprint									F1	F2	F3								
VRM-MO														G1					G2

Table 57 – Chapter 4: Study 2: Case 3 - Depiction of the changes in relevance with regards the lines of enquiry

KEY: Establish/Re-Establish	Maintain	Increase	Confirm	Decrease	Irrelevant

Line of Enquiry	Depiction of changes in significance throughout each line of enquiry's existence																		
	Beginning phase of the investigation...			... elapsed time ...													Ending phase of the investigation		
Console-MO	A1	A2	A3					A4	A5										
LPU-Boundary				B1	B2	B3	B4	B5	B6	B7	B8								
Directional Movements											C1	C2	C3	C4	C5	C6	C7		
Patrol-Plan				D1	D2	D3	D4	D5					D6	D7					
Offender-Business				E1	E2	E3											E4	E5	
Fingerprint									F1	F2	F3								
VRM-MO														G1					G2

Figure 95 depicts the completed crime schema for burglary of vehicle as seen in case 3. It is a representation of how various lines of enquiry fit into the high-level areas (think-steps) of the crime schema.

In Figure 96, the analytical rationale is outlined for case 3. It indicates that:

- The Forensic-Evidence LoE had no relevance to the case, even though the underlying analysis had been relevant to determine the non-relevance of the LoE.
- E1-E3 was a reason for the criminal intelligence analyst to theorise about the possibility of the offenders using an empty car to enter the offending location, but the conclusion would still be cogent if omitted.
- The analysis pertaining to the LPU-Boundary LoE and the Patrol-Plan LoE were needed as reasons for analysis C1, C2, C3, C5 and C6, but the conclusion would still be cogent if omitted.
- The extra analysis within A2, A4 and A5 did not contribute anything to the Console-MO LoE and the conclusion would still be cogent if omitted.
- The implicit argument indicates that the following lines of enquiry are needed to support the conclusion on why those particular offenders were apprehended: Console-MO, VRM-Thefts and the Directional-Movements.

Figure 96 does not outline the analytical rationale for each analytical task as the purpose of RQ2 was to understand relevance. It would be possible to include each task/justification/outcome combination for each node as outlined in RQ1.

5. Discussion

The results from RQ2 and RQ3 illustrated how Pirolli and Card's (2005) Notional Model of Sensemaking can be expanded to include an argumentation loop (see Figure 97). It has been shown in the results sections how steps 9, 12 and 15 from the top-down approach can be adapted to make it part of criminal intelligence analysts' bottom-up approach:

- To answer step-9's question, 'what does it have to do with the problem at hand?', criminal intelligence analysts can use various lines of enquiry to show and track the relevance of information. This question is similar to Freeman's (1991) argumentation question, 'what do you have to go on?' and can be externalised using convergent-notation in an argumentation map. Convergent-notation can be used when people are giving reasons-for accepting a conclusion as cogent. Each reason contributes to accepting the conclusion as cogent, but if a reason is omitted, then the conclusion would still be considered as cogent.
- To answer step-12's question, 'how do you know?', criminal intelligence analysts can use the various outcomes from the analytical tasks as proof.

Figure 95 - Chapter 4: Study 2: RQ3: Case 3 - Complete Crime Schema for Burglary of Vehicle, with LoE.

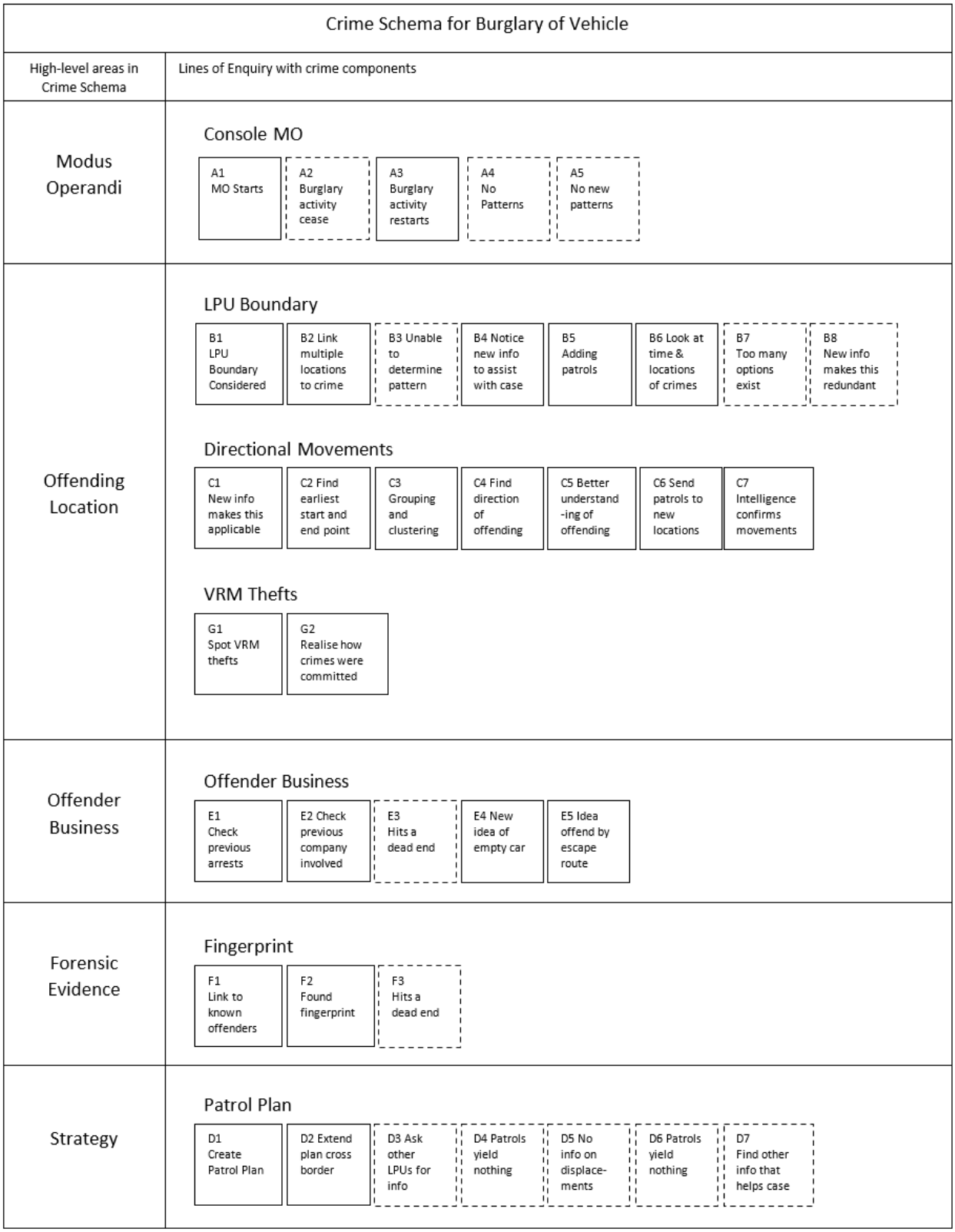
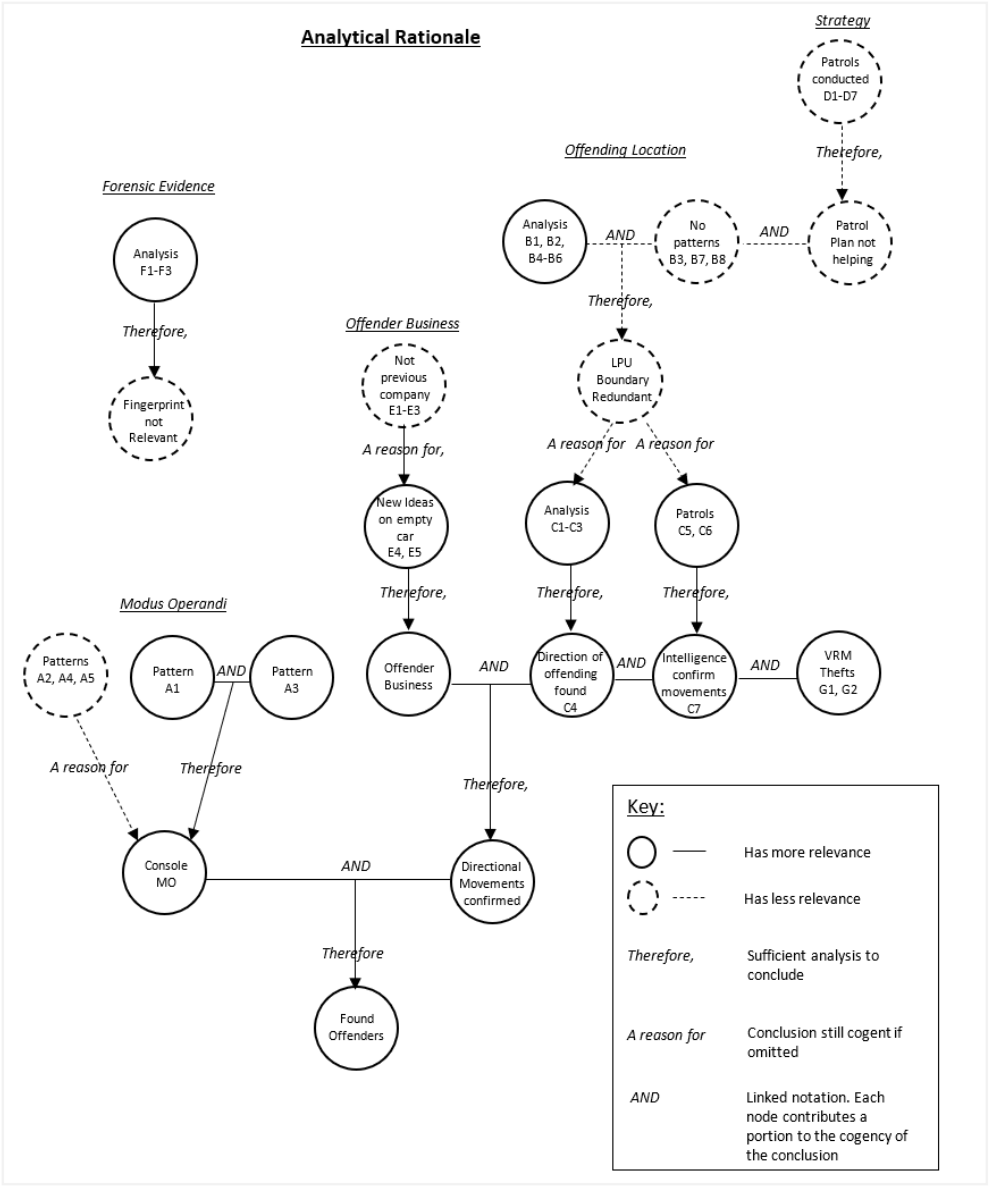
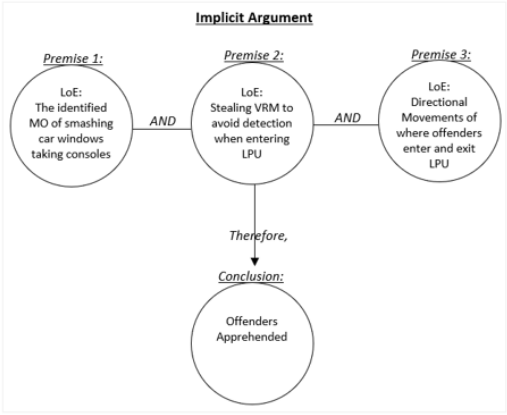


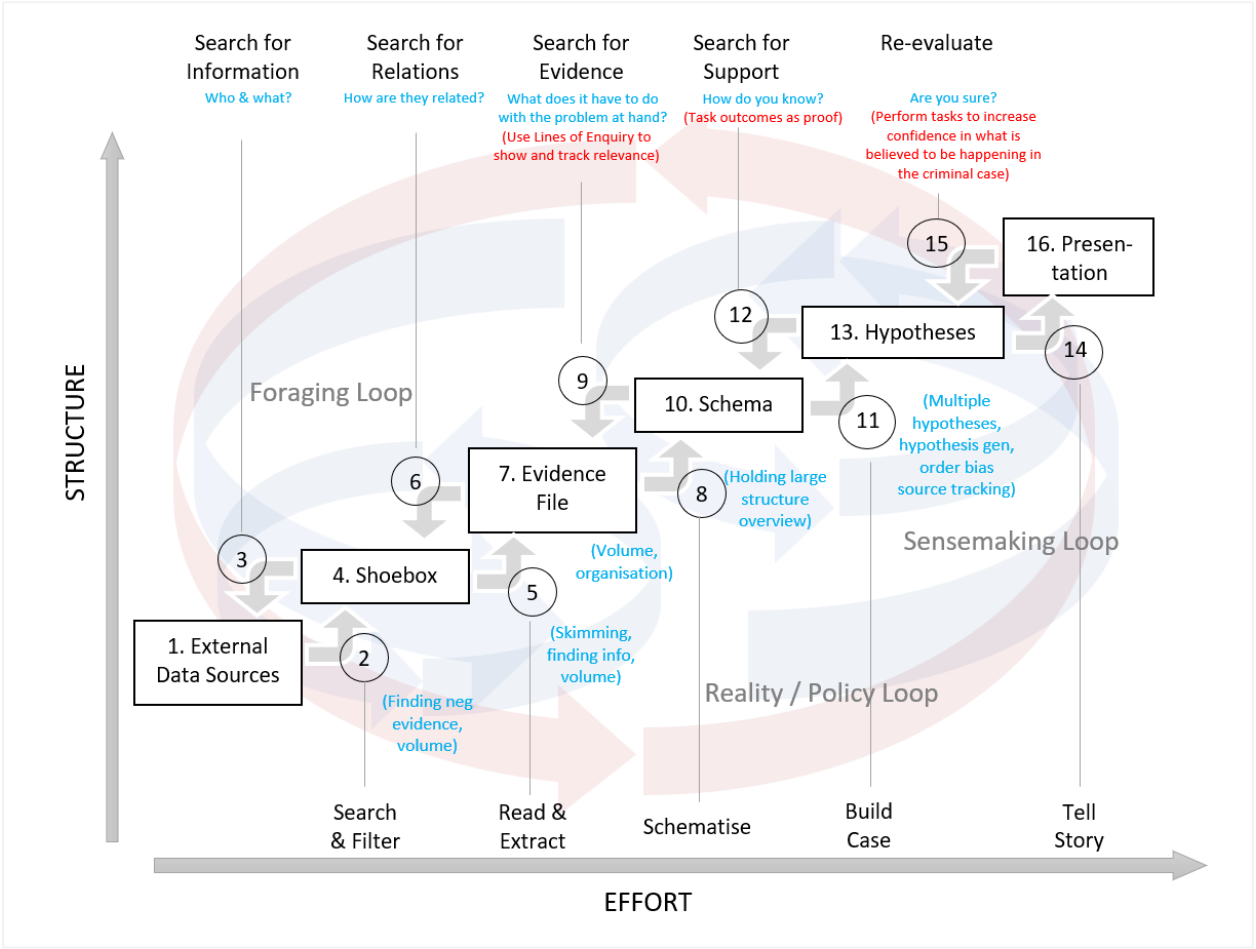
Figure 96 - Chapter 4: Study 2: RQ3: Case 3 – Depiction of the analytical rationale and the respective implicit argument





- To answer step-15's question, 'are you sure?', criminal intelligence analysts can refer to the various tasks and justifications for performing those tasks and how it influenced their level of confidence. This question is similar to Freeman's (1991) argumentation question, 'how sure are you?' and can be externalised using linked-notation in an argumentation map. Linked-notation can be used when people are illustrating 'therefore' as an indication of accepting the conclusion as cogent. In linked-notation, all the premises are needed to accept the conclusion as cogent. If one of the premises is omitted then the conclusion would no longer be considered as cogent.

Figure 97 - Chapter 4: Argumentation Loop (in red) covering Relevance and Confidence (Adapted from Pirolli and Card, 2005)



RQ2 and RQ3 further extends Pirolli and Card's (2005) Notional Model of Sensemaking by providing granular details on the analytical reasoning process within the stages ranging from External Data Sources up to Hypotheses.

The emerging thematic groups within the results section for RQ1 can be summarised as follow (also see Figure 100):

- Foreground information seeking is where criminal intelligence analysts actively work with the information as part of the Pirolli and Card's (2005) Foraging Loop and moving information from External Data Sources to the Shoebox and eventually to the Evidence File.
- Generic Background information seeking is where criminal intelligence analysts need help from colleagues and external sources to gather further information or increase understanding. It fits in with Pirolli and Card's (2005) Foraging and Sensemaking loops.
- Information pre-processing is where criminal intelligence analysts prepare information for analysis or where they verify completeness of the analysis process. This consists out of activities such resolving errors in the information or broadening/narrowing activities. It fits in with Pirolli and Card's (2005) Foraging loop, where information from external sources needs to be transformed into a more meaningful format to derive meaning from it. It also fits in with the sensemaking loop in situations where criminal intelligence analysts are unable to make sense of the information in its raw, unaltered format. The activity of verifying the completeness of the analysis is part of the top-down approach.
- Information Structuring is where criminal intelligence analysts transform the information into a structured format that would allow them to derive further meaning. This is the equivalent of Pirolli and Card's (2005) Schema box.
- Theorising is where criminal intelligence analysts try to temporarily link anchors together to progress the investigation or where they test the plausibility of a theory. This is the equivalent of Pirolli and Card's (2005) Sensemaking loop, where hypothesis generation takes place.

The thematic groups from RQ2 provides researchers with specific examples of what happens at each stage of the analytical process. It therefore extends Pirolli and Card's (2005) 'broad-brush' depiction of the sensemaking process into something more granular and includes concrete examples of the analytical reasoning process at each stage of the sensemaking process. Chapter 3 outlines how criminal intelligence analysts currently externalise their analytical rationale using the task-justification-outcome format by making use of pen and paper (referred to as a day-book). Each example in RQ2 is therefore accompanied with a depiction of the criminal intelligence analyst's analytical rationale that corresponds to the identified task-justification-outcome combination of Chapter 3.

RQ2 took this a step further to depict how the task-justification-outcome combination could be externalised using argumentation linked-notation format (See Figure 47 to Figure 85). This can serve as a first step to externalise the analytical rationale in a format that resembles argumentation, without the need for criminal intelligence analysts to understand formal argumentation notation or to switch between the fluid analytical activities and rigorous argumentation activities (Wong, 2018).

RQ2 further depicts how the task-justification-outcome combination can be used to derive the implicit argument (Govier, 2014) that corresponds with that combination. The task-justification-outcome combination therefore serves as the 'human-readable' version. The implicit argument can serve as the 'formal-argumentation' version for researchers and/or artificial agents. RQ2 therefore also linked possible cognitive biases (Heuer, 1999; US Government, 2009; MITRE, 2016) that could emerge as a result of the task-justification-outcome combination and listed possible critical questions in plain English to assist with the 'human-readable' version. The respective critical questions using Argumentation Schemes (Walton et al., 2008) is provided to assist with the 'formal-argumentation' version and which relates to the derived implicit argument. Each task-justification-outcome combination is accompanied with possible APP analytical techniques and/or possible Structured Analytical Techniques (SAT) (Heuer and Pherson, 2015). It should be noted that the SAT techniques were added on a best-fit basis. This means that the selected SAT technique would need to be adapted to fit in with criminal intelligence analysis. For example, the brainstorming SAT requires a group of analysts to be in a room with sticky notes. Criminal intelligence analyst might just want to pop over to a colleague and ask some questions and consider that as brainstorming.

Each of the analytical reasoning examples can therefore serve as a self-contained template to illustrate what is happening at specific points in time during the analytical reasoning process.

RQ3 extends Pirolli and Card's (2005) Notional Model of Sensemaking by providing granular details on how criminal intelligence analysts use Lines of Enquiry (LoE) to track and manage the relevance of information. It fits in with Pirolli and Card's (2005) Sensemaking loop as well as the Schema box. Pirolli and Card's (2005) schema box can be divided into granular schemas that assist with information structuring such as maps and timelines (see RQ2) and a universal crime schema that consist out of various crime components and the respective LoE that makes up each crime component.

Figure 98 - Chapter 4: A concept diagram illustrates how lines of inquiry fit into a broader crime schema when criminal intelligence analysts work with ambiguous information that have changing levels of relevance.

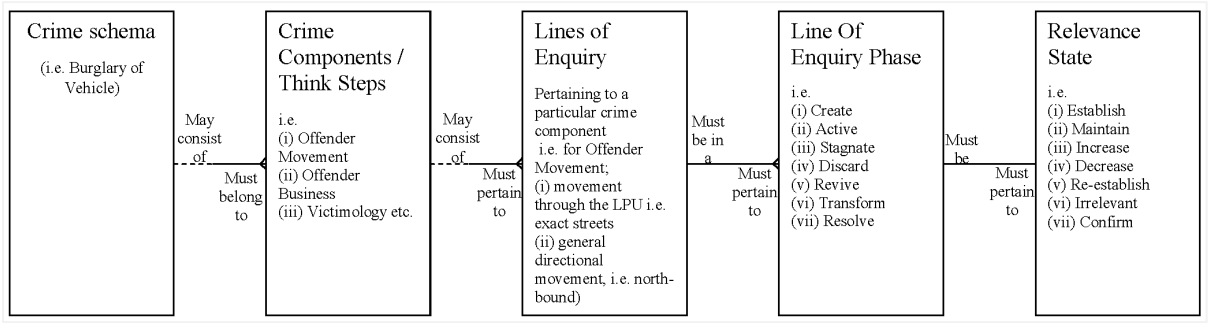


Figure 98 illustrates how a crime schema (for example Burglary of Vehicles) can be divided into different crime components or think-steps (Selvaraj et al., 2015). Each crime component can consist out of one or more LoE and each LoE can undergo various phases. The information that makes up the LoE can undergo various relevance states. So, it is possible for a LoE to be in an

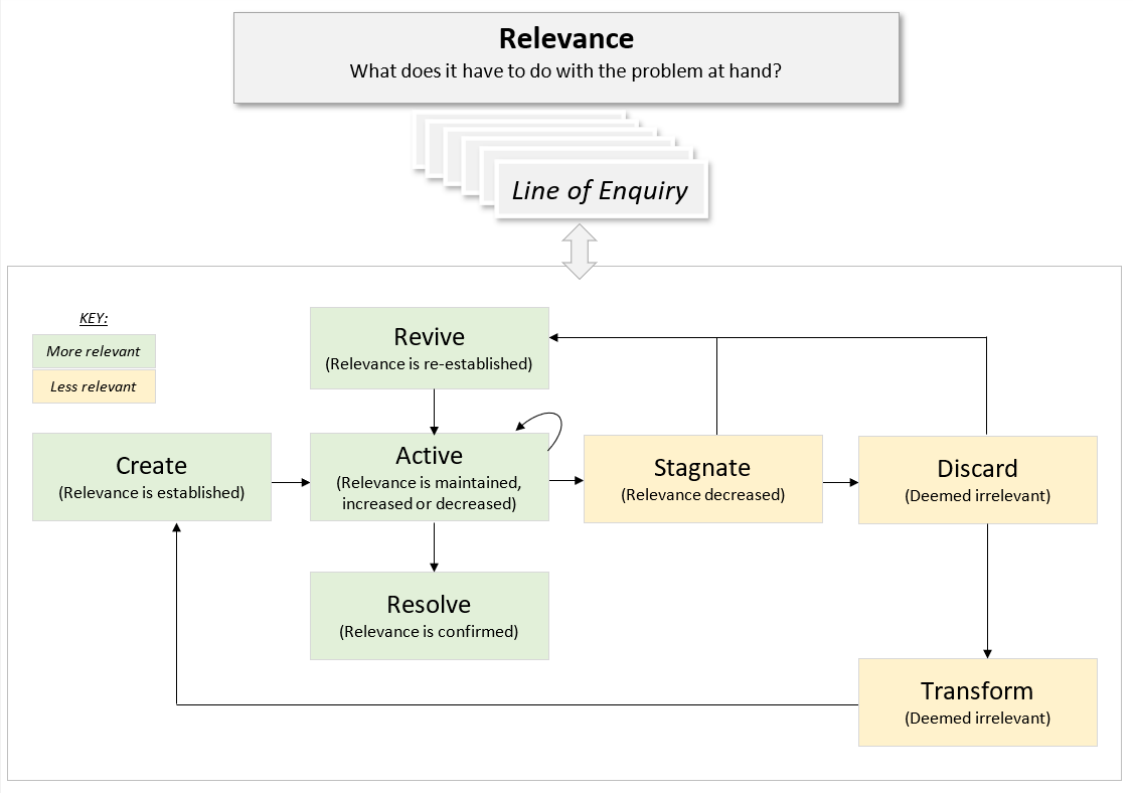
Active state, but the information that makes up the LoE can make the criminal intelligence analyst deem it as irrelevant to the case (see Fingerprint LoE) and thus discard the LoE.

The LoE states that emerged from RQ2 can be summarised as follow:

- Create - The LoE is created as the relevance is established for that line of enquiry.
- Active - The LoE is actively worked on, so relevance to the analysis and the case, is either maintained, increased or decreased.
- Stagnate - The LoE 'dries up' as there is no new information that could assist the criminal intelligence analyst, therefore relevance decreases.
- Discard - The LoE reaches a dead-end and therefore becomes irrelevant to the analysis and the case.
- Revive - A LoE that was in a stagnated or discarded state, becomes relevant again as new information emerges, thus relevance is re-established.
- Transform - A LoE reaches a point where the criminal intelligence gains new insights and therefore considers the analytical problem from a different angle or understanding. Relevance of the LoE is thus deemed irrelevant in favour of a different LoE.
- Resolve - The analysis performed in relation to the LoE is such, that it is essential for proving the case, therefore relevance is confirmed.

The LoE states is illustrated in Figure 99.

Figure 99 - Chapter 4: LoE phases and respective relevance states



Although the examples for RQ3 suggests a chronological order for the creation of LoE, criminal intelligence analysts would work on multiple LoE at a time. The crime schema, the information that is available and the time criminal intelligence analysts have to solve the case would also influence the order in which the LoE are created.

Figure 100 – Chapter 4: RQ1 and RQ2 results in relation to the components of Pirolli and Card's (2005) model (in blue)

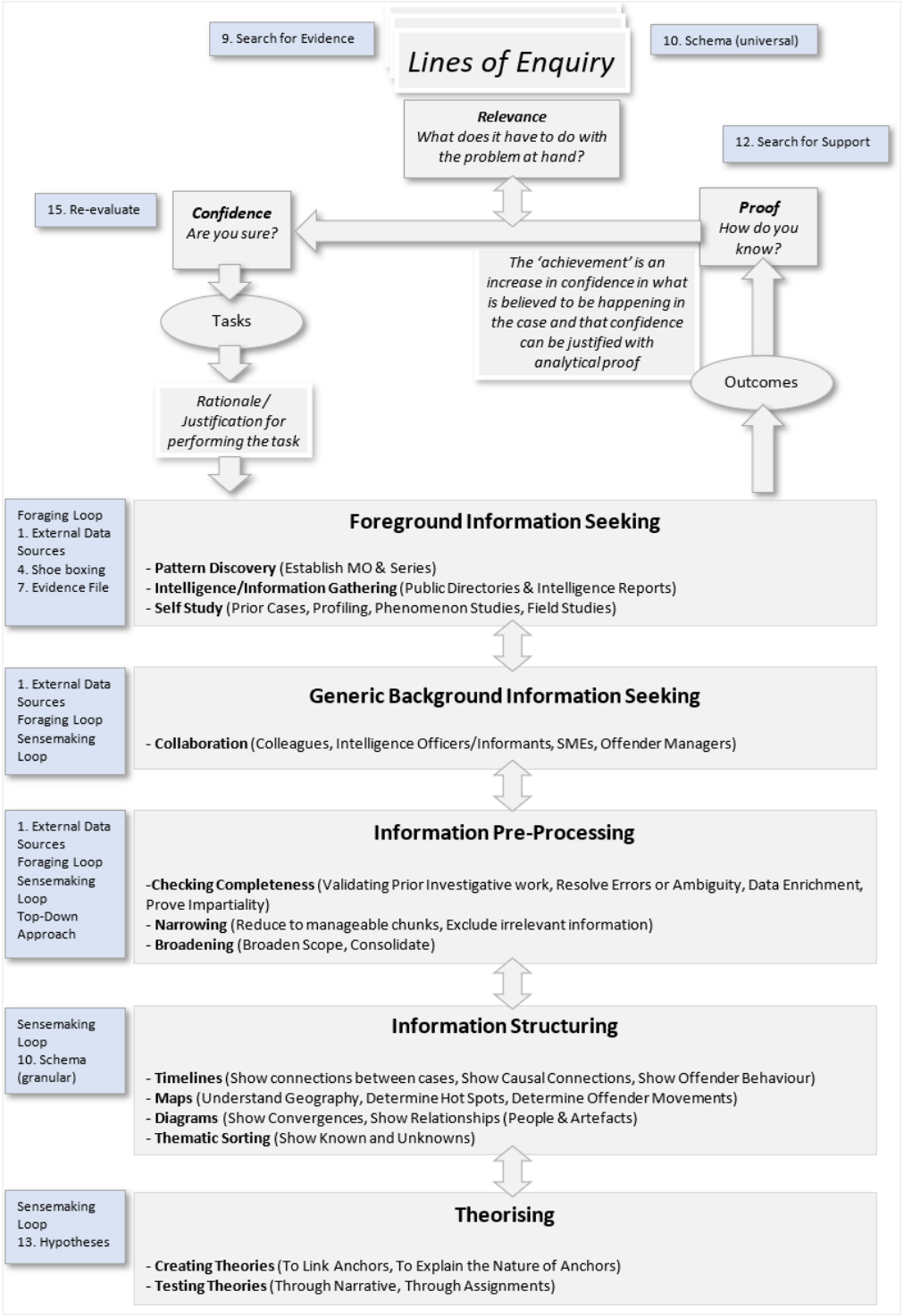
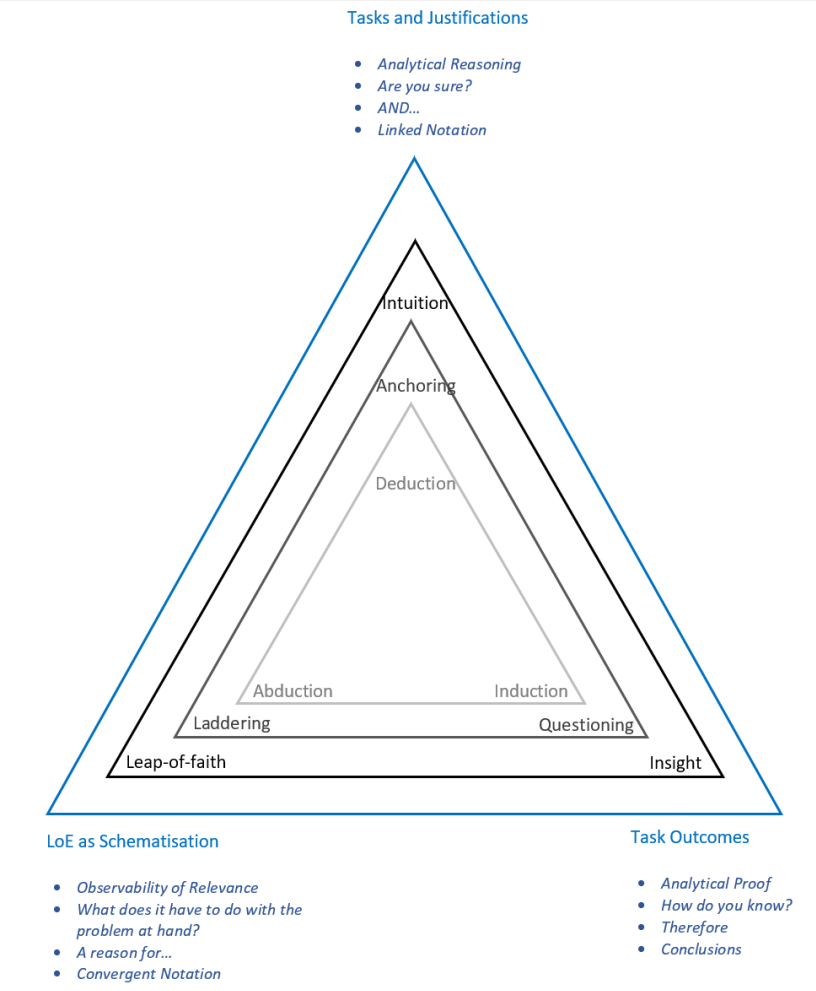


Figure 100 depicts the concepts, as a result from RQ2 and RQ3, and how it fits in with Pirolli and Card's (2005) Notional Model of Sensemaking (depicted as the blue boxes). It therefore does not replace Pirolli and Card's (2005) model, but serves as additional information on how criminal intelligence analysts' analytical rationale develop alongside the sensemaking process.

The combined results from RQ2 and RQ3 contribute to the sensemaking triangle (Wong and Kodagoda, 2015, 2016; Gerber et al., 2016) by providing a fourth externalisation layer to the triangle (see Figure 101).

Figure 101 – Chapter 4: Additional Fourth Externalisation Layer to the Sensemaking Triangle. (Adapted from Wong and Kodagoda (2015, 2016) and Gerber et al., (2016))



Abduction, deduction, induction, anchoring, laddering, associative questioning, insight, intuition and leaps-of-faith are all tacit sensemaking and reasoning concepts. One way of externalising these tacit concepts for criminal intelligence analysts' analytical rationale, is through:

- Tasks and justifications to express analytical reasoning. It answers Pirolli and Card's (2005) question, 'Are you sure?' and can be expressed using argumentation's linked

notation to indicate the AND operator. This indicates that the task and the justification is needed to support the task outcome.

- Task outcomes to serve as analytical proof. It answers Pirolli and Card's (2005) question, 'How do you know?' and can be expressed as the 'conclusion' to indicate 'therefore'. This indicates that the task and the justification led to the conclusion.
- Lines of Enquiry as Schematisation to capture the observability of relevance. It answers Pirolli and Card's (2005) question, 'What does it have to do with the problem at hand?' and can be expressed using argumentation's convergent notation to indicate 'a reason for'. This indicates that line of enquiry is a reason for accepting the case outcome (main conclusion) as cogent.

This chapter answered Research Question 2, 3 and 4 (as described in Chapter 1) in the following ways:

Research Question 2: How do criminal intelligence analysts develop confidence in their analytical rationale, so that they are confident that the Terms of Reference (TOR) is sufficiently addressed by the intelligence products that they produced?

Answer*:* Criminal intelligence analysts make use of the justification-outcome combination to evaluate the degree that the task's outcome supports the task's justification. If the outcome sufficiently supports the justification for performing that task, then they have greater confidence in the next set of tasks (as laddering) that emerge as a direct result from that task's outcome (as anchoring).

If the task's outcome does not support the task's justification, then they know that the analytical process is going off course or that the current analytical approach needs adjustment. The next set of tasks that they undertake would be to provide the analytical adjustment or re-focus.

Each task's outcome allows them to progress weak anchors, such as professional guesses or leaps-of-faith, into stronger anchors that are supported with underlying analytical proof. Each anchor that is supported by underlying analytical proof increases their confidence, that the next set of analytical tasks are sufficiently supported (laddering), thus the final outcome/conclusion will be sufficiently supported in answering the TOR. This continual evaluation of the justification-outcome combination allows for strong confidence in the development of their analytical rationale (as a laddering process) to meet the requirements of the TOR.

Cognitive biases can however foster erroneous confidence levels, therefore each section in study part 1 of this chapter, is accompanied by possible cognitive biases that can influence the analytical rationale during that particular analytical task and the possible critical questions to assist with the reduction and mitigation of erroneous confidence levels.

Research Question 3: Which structures do criminal intelligence analysts employ to assist with developing their analytical rationale?

Answer: Granular structures such as timelines and maps assist criminal intelligence analysts with their sensemaking tasks. Their analytical rationale is however supported by universal structures that consist out of crime-schema->crime-component->line-of-enquiry->relevance combination. Lines of enquiry that have relevance in answering the TOR will become part of criminal intelligence analysts' analytical rationale. It will serve as the reasons for accepting the final outcome in support of the TOR, as cogent.

Research Question 4: How relatable is the analytical reasoning process with formal argumentation?

Please note that RQ4 is embedded within the results sections of RQ2 and RQ3.

Answer: It was shown how Pirolli and Cards (2005) Notional Model of Sensemaking includes questions that relate to formal argumentation.

Step 9 (what does it have to do with the problem at hand?) covers relevance, that can be externalised on an argumentation map using convergent-notation and interpreted as meaning 'a reason for' (Freeman, 1991). LoE can be used to determine which information is relevant to answering the TOR and which information is not relevant. Freeman's (1991) equivalent to the concept of LoE is referred to as the macro-structure of arguments. The macro structure of an argument is where the focus is on which statements as a whole, were entered into the argument.

Step 15 (are you sure?) covers confidence, that can be externalised on an argumentation map using linked-notation as meaning 'therefore' (Freeman, 1991). The various task-justification-outcome combinations are used to develop a cogent analytical rationale. Each task-justification-outcome combination can be translated into the equivalent implicit argument (Govier, 2014) for formal argumentation purposes, such as evaluating the level of cogency. Freeman's (1991) equivalent to the task-justification-outcome combination is referred to the micro structure of arguments. The micro structure of arguments has to do with assessing the logical structure of the argument, such as determining if the premises logically support the conclusion. It is more appropriate to consider cogency of the analytical rationale rather than logical support, due to the uncertain and ambiguous nature of the fluid sensemaking phase. This is because cogency has to do with it being reasonably acceptable to make the link from the premise to the conclusion without it necessarily being logically sound to make that link (Govier, 2014), such as when leaps-of-faith are used to make the link.

Step 12 (how do you know?) covers proof or evidence, that can be externalised on an argumentation map in many different ways (see section 3.2), such as using circle, square or triangles nodes (Wigmore, 1931) or as a datum (Toulmin, 2003). The analysis that has been conducted as part of the analytical task serve as the analytical proof that supports the outcome.

Criminal intelligence analysts can therefore use the task-justification-outcome combination to structure non-argument components into a structure that not only resembles formal argumentation constructs, but that is also translatable into the equivalent formal argumentation constructs (See Figure 47 to Figure 85). This allows criminal intelligence analysts to work with the constructs that they are familiar with and that can assist with the development of their analytical rationale during the fluid phases of sensemaking, without the need for them to understand formal argumentation constructs and the rigorous formal logic that is required when evaluating arguments soundness, as they may not be proficient in it.

The task-justification-outcome combination allows for critical questions in a human-readable format and which fits in with the analytical rationale, with the purpose of addressing cognitive biases pertaining to that combination. The equivalent critical questions within argumentation schemes can be applied to the respective implicit formal argument that can be derived from the task-justification-outcome combination as extra 'behind-the-scenes' support.

This chapter serves as an extension of chapter 3's research by extending the task-justification-outcome combination and linking it to argumentation concepts. It also provides the concept of how LoE can be used as a structure to inform relevance.

The next chapter combines the research outputs from chapter 3 and chapter 4 to create a theoretical argument-based framework, with the aim to inform analytical software designs on how to incorporate analytical reasoning alongside sensemaking activities and how it bridges with argumentation constructs.

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Chapter Five
Designing for Analytical Rationale

1. Introduction

Chapter 3 outlines how criminal intelligence analysts currently record their analytical rationale using pen and paper (known as a day-book) in the format of task-justification-outcome combination. Figure 34 illustrates the components of the day-book and the process criminal intelligence analysts follow to record their analytical rationale. Figure 34 can be used by developers as-is to digitise the day-book process as part of new initiatives such as the National Policing Digital Strategy:2020–2030 (NPDS) (APCC/NPCC, 2020).

Chapter 4 extends our understanding of the day-book process. The results from chapter 4 shows how Pirolli and Card's (2005) Notional Model of Sensemaking encapsulates the concepts of confidence, proof and relevance and that these concepts support the formulation of criminal intelligence analysts' analytical rationale, alongside the sensemaking process. Chapter 4 further shows how the task-justification-outcome combination can be translated to implicit formal arguments. This allows criminal intelligence analysts to use fluid constructs that they are familiar with to formulate their rationale alongside the sensemaking process, but those fluid constructs are compatible with rigorous argumentation constructs that can be used to assist with rigorous verification activities such as illustrated by Wong's (2018) fluidity and rigour model (see Figure 14).

Chapter 5 extends the concepts from chapter 3 and chapter 4 and proposes an Argumentation Theory-Based Framework (see Figure 102) that not only supports criminal intelligence analysts with formulating their analytical rationale, but also with the externalisation of that rationale alongside the fluid sensemaking process.

It is the first attempt by the researcher to formulate design guidelines for externalising analytical reasoning alongside sensemaking activities in criminal intelligence analysis. The guidelines that are accompanied by the framework aims to be user-centric by design (Norman, 2002). The framework is constructed through the information in the literature review of chapter 2 and the research results from chapter 3 and chapter 4 that made use of experienced criminal intelligence analysts. The aim of the framework is to instruct developers how to cater for rationale-formulating activities alongside sensemaking activities withing visual analytics system and how such a design can bridge formal argumentation structures.

2. Creating the argumentation theory-based framework

The Argumentation Theory-Based Framework is depicted in Figure 102 and consists out of four broad categories namely; pragmatic sensemaking concepts, culturally specific processes and procedural concepts, information/categorical/schema concepts and argumentation concepts. The sections that follow explain how the components were selected for each category.

2.1. Pragmatic sensemaking concepts

This category consists out of concepts that are practical in nature, and which assists with analytical and sensemaking activities. It is the space where the analytical work and manipulation of information resides. Wong and Varga (2012) refer to this as the 'analysis space' within their design guidelines for visual analytics systems. Tonilio et al. (2015) refers to it as a 'WorkBox'. Within NIM (ACPO/Centrex, 2007), the analysis space is covered in element 7 where research, development and analysis take place. In Pirolli and Card's (2005) model it refers to the activities that contribute to shoe-boxing and the creation of the evidence file.

Chapter 3 and 4 reveals that criminal intelligence analysts' make use of the task-justification-output combination to formulate their analytical rationale. Chapter 4 provides ample details on how each task-justification-output combination is linked to Pirolli and Card's (2005) model. Tasks, Sub-Tasks, Justifications and Task-Outcomes have therefore been selected as pragmatic sensemaking concepts.

Various analytical techniques are outlined in chapter 2, section 1.4 of the literature review. Some of the techniques represent data in a visual format such as diagrams and hot-spots on maps. Other analytical techniques rely on the visual ability to conceptualise and manipulate the information, such as by using tables and spreadsheets. Visualisations assist criminal intelligence analysts with their inferencing process (deductive, inductive and abductive) which allows them to make use of the anchoring, laddering and associative questioning process (Wong and Kodagoda, 2015) to progress the case. The results in chapter 4 links each task-justification-output to the concepts from Wong and Kodagoda (2015). The Views-of-Data and Inferences have therefore been selected as pragmatic sensemaking concepts.

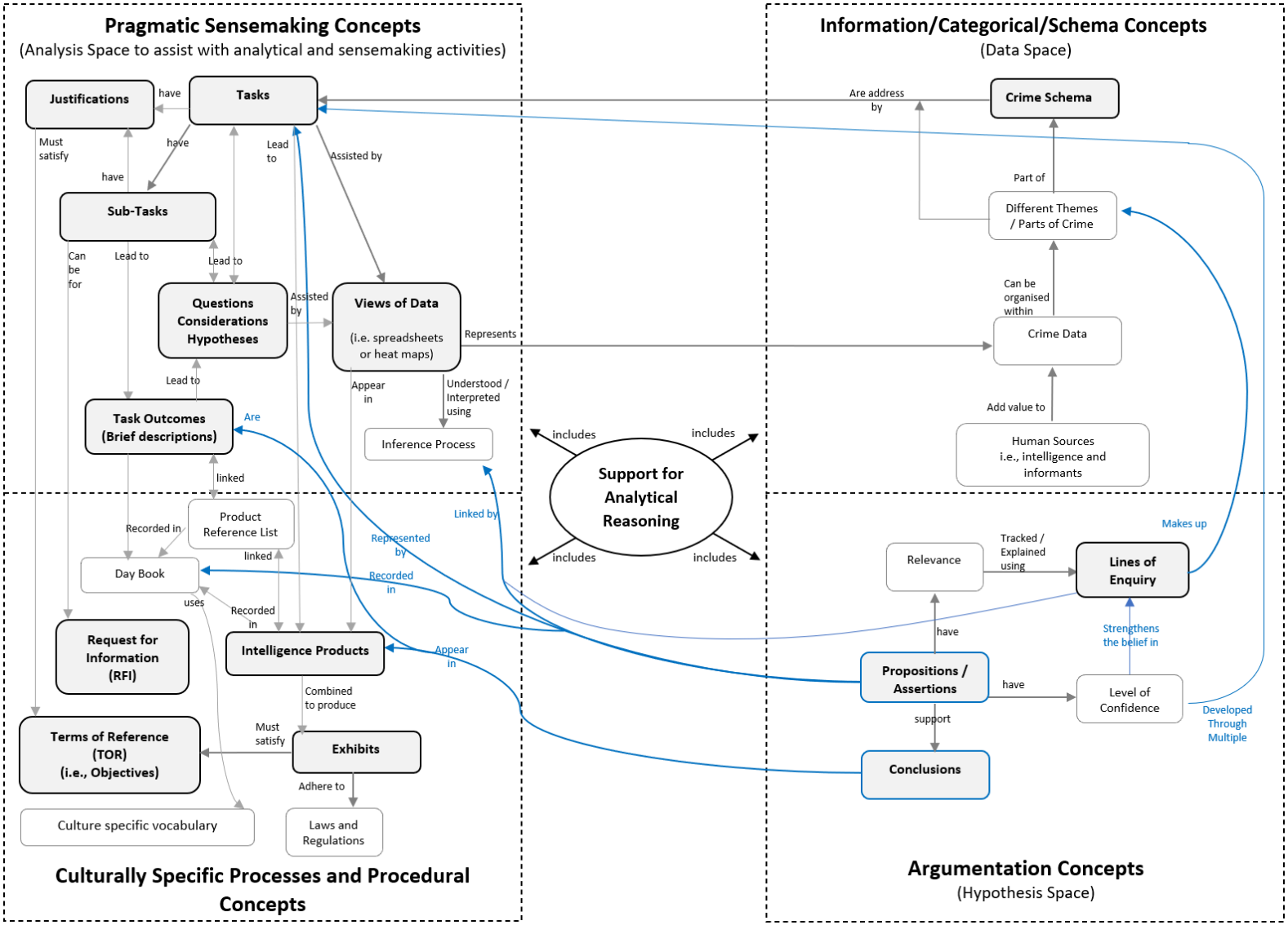
Chapter 3 reveals how the Task-Outputs lead to further Questions, Considerations and Hypotheses, which in turn lead to the creation of further tasks and those tasks will makes use of the available Views-of-Data that require the Inferencing-Process to derive meaning. Questions, Considerations and Hypotheses have therefore been selected as pragmatic sensemaking concepts.

2.2. Culturally Specific Processes and Procedural concepts

Chapter 3 reveals that specific vocabulary may exist within the criminal intelligence analysts' policing culture. An example is that criminal intelligence analysts refer to argumentation as the process of creating defensible assessments that capture their analytical rationale and that the rationale is recorded in a day-book. The day-book is a physical medium (pen and paper). The analytical rationale is recorded using a task-justification-outcome combination within the day-book. Each task's justification for performing that task must satisfy the Terms of Reference (TOR). The TOR refers to the larger objective that the criminal intelligence analyst is working towards, as provided by the Investigative Officer. Specific Tasks are referenced using specific terminology, such as RFI which stands for Request for Information. This is when criminal intelligence analysts reach out to other colleagues to ask more information. Different cultures will have naming conventions that are specific and meaningful to them and may not be the same as what criminal intelligence analysts use.

NIM's (ACPO/Centrex, 2007) eight element refers to the process of assessing and prioritising the intelligence contained in Intelligence Products for action. This is supported in chapter 3 which reveals how Intelligence Products are the outputs of analytical work (via tasks).

Figure 102 – Chapter 5: Argumentation Theory-based Framework



So, Intelligence-Products may contain specific Views-of-Data such as crime data in spreadsheets or timelines that the criminal intelligence analyst constructed. Each product is given a number, which is referenced in a Product Reference List, which is referenced against each Task Outcome. This allows criminal intelligence analysts to keep track of, and link, specific products to specific task outcomes. Multiple products combined are used as Exhibits that can go to a court of law if requested by the defence. Exhibits therefore need to adhere to the appropriate laws and regulations that govern the policing communities.

The Day-Book, Product-Reference-List, Intelligence-Products, Exhibits, Laws and Regulations, RFI, TOR and Culture-specific-vocabulary have therefore been selected as Culturally Specific Processes and Procedural concepts.

2.3.Information/Categorical/Schema Concepts

Wong and Varga (2012) refer to the Information/Categorical/Schema Concepts as the 'data space' within their design guidelines for visual analytics systems. NIM's (ACPO/Centrex, 2007) first five elements represent this space as the assets and information sources that must be in place for criminal intelligence analysts to effectively produce intelligence products. In Pirolli and Card's (2005) model it refers to the external data sources and schematisation.

The literature review outlines how criminal intelligence analysts work with information, such as crime data, to produce intelligence products. It also outlines that criminal intelligence analysts can work with information as intelligence and that the intelligence can come from other colleagues or informants. This type of intelligence must be evaluated using the 5x5x5 process before it can be used (Ratcliffe, 2003; ACPO/Centrex, 2007; UNODC, 2011). Intelligence from human sources therefore adds value to the crime data set. NIM's (ACPO/Centrex, 2007) sixth element refers to this information evaluation process as Information and Intelligence Recording.

Crime data can be organised within different categories such as 'burglary of vehicle' or 'burglary of dwelling' or it can be organised under different themes, such as victimology or modus operandi. The different categories or themes form part of a holistic crime schema depending on the type of crime that the criminal intelligence analyst is analysing. Selvaraj et al. (2015) refers to this type of schematisation as Think-Steps.

The crime schema or the different parts/themes of the crime schema can be addressed by the criminal intelligence analysts using various analytical tasks. The task may be to determine the modus operandi of a 'burglary of vehicle' crime data set. The task may be assisted by various different Views-of-Data that form a representation of the underlying crime data set.

Human Sources, Crime Data, Different Themes / Parts of Crime and Crime Schema have therefore been selected as Information/Categorical/Schema Concepts.

2.4.Argumentation Concepts

Wong and Varga (2012) cover argumentation as part of the 'hypothesis space' within their design guidelines for visual analytics systems. The hypothesis space is where collated information/evidence is assembled to "offer frames of explanations that could lead to

meaningful explanations" (Wong and Varga, 2012). In Pirolli and Card's (2005) model it refers to hypothesis generation.

Chapter 4 reveals how criminal intelligence analysts can make use of Lines of Enquiry (LoE) to determine and track relevance of information and how each LoE fits within broader crime components and crime schemas (see Figure 93). Relevance can be externalised using convergent notation in formal argumentation maps (see Figure 94's depiction of different LoE as an argumentation map).

Chapter 4 also reveals how criminal intelligence analysts can progress the level of confidence that they have in their belief of what is happening in the crime scenario that they are investigating. This is achieved through the evaluation of the various task-justification-outcome combinations, specifically with the evaluation if the task's outcome meets the task's justification (see Figure 47 to Figure 85). Formal argumentation's concept of proposition is represented by the various tasks and task justifications. Formal argumentation's concept of conclusion is represented by the various task outcomes and conclusions appear in the intelligence products that the criminal intelligence analyst produced.

Propositions, Conclusions, Relevance, Lines of Enquiry and Level of Confidence have therefore been selected as Argumentation Concepts.

3. Evaluating the argumentation theory-based framework

3.1. Method

The study made use of 'paper prototype testing' as a participatory design method over an electronic medium (Dwivedi et al., 2012).

The study made use of a Likert scale (Likert, 1932) questionnaire to capture the participant's views on following categories: about each participant, general details; concept applicability; sensemaking orientation; sensemaking exploration; sensemaking verification; practical use and other feedback.

A non-parametric, one sample z-test[8] was used for reporting the statistical results. The significance is at 5% (α=0.05) against a median of 3 for the z-test, where μ =3 represents neutral. In the instances where the sample was inadequate for a z-test (i.e., all participants answered the same), a t-test was used. In the instances where the sample size was too small and inadequate, the statistical result was marked as inconclusive and H_0 was accepted.

Statistical results were not added for the categories of: about each participant and general details. This is because those two categories served as general information and do not have anything statistically significant to contribute. They do provide an overview of the participants and their expert experience levels.

3.1.1. Participants

The evaluation study was performed over the span of two days with eight experienced criminal intelligence analysts from West Midlands Police (UK) and the Belgium Police. Each evaluation study per participant was ninety minutes in duration. The aim of the evaluation

[8] The Z-test was performed in Microsoft Excel using the ZTEST formula

study was to determine the applicability and practicality of the framework's concepts that were included as described in section 2 above.

3.1.2. Design

3.1.2.1. *Implementation and representation of framework concepts*

The framework concepts that were included in the low fidelity prototype are: Terms of Reference (TOR); Request for Information (RFI); Question, Task / Sub-Task, Visualisation/Source, Assertion, Conclusion, Schema / Think-Steps / Theme, Product and Entity List (as part of LoE).

Each concept was created by means of grouping text-boxes together in a Microsoft (MS) Word document in order to give the visual effect of widgets in a web-based application (see Figure 103). The framework concepts were arranged in a horizontal order at the top of the MS Word document page to simulate icons on a horizontal toolbar. In addition to the framework concepts, a range of connector icons such as arrows of various colours (black, red and green) and styles (solid and dashed lines) were included. This was to make it consistent with what one would normally find in formal argumentation diagrams. Free-text text boxes were added in case the participants wanted to add a component that was not represented/contained within the framework. This was to give the low fidelity prototype more flexibility and an opportunity to the participants to include concepts that may have been missed by the researcher.

3.1.2.2. Physical setup

A 24-inch high-definition monitor was attached to a laptop with extended display. The participants had their own 'qwerty' keyboard and mouse. The evaluator (researcher) made use of the laptop, whilst the participants made use of the external display monitor, keyboard and mouse. The MS word document was maximised on the external display monitor for the use of the participants. Screen capturing software was visible on the evaluator's laptop display.

3.1.2.3. Recording Media

Each participant's interactions with the prototype were recorded using BB Flashback Recording Software (Blueberry Software, 2017). It captured the participant's screen interactions. In addition to this, the participant's voice was recorded using a separate voice recorder. The entire session was also recorded using a high-definition video recorder on a tri-pod, which recorded the participant's screen over his/her right shoulder. This was a backup in case the computer recording software or the voice recorder failed.

3.1.2.4. Scenario

The fictional crime scenario made use of actual crime data from West Midlands police that was anonymised (see Figure 104). Due to the limited functionality of the prototype, the study only used a small subset of the available data. The scenario described an assault case where the victim identified the main offender. The main offender denied the attack. The second offender could not be identified by the victim, as the second offender wore a ski-mask and did not say anything during the attack. The participants were given a list of possible co-

offenders based on the offending location (i.e., the co-offenders committed similar types of crimes in the same location as the main offender). The offender information was collated in a Microsoft (MS) Excel spreadsheet where each offender's information was on a different worksheet. The available data for each offender was: name, surname, gender, age, sex, town, street, postcode, beat number, victim profile, type of assaults, location coordinates, distance from offence and crime record numbers. There was a total of eight offenders of which seven were male and one was a female. The participants were instructed to use the available data to recommend who the likely co-offender was and to use the low fidelity prototype (MS word document) to record their rationale.

3.1.2.5. *Procedure*

At the beginning of the study, each participant filled in a consent form and was aware that the computer screen and their voice was being recorded. Due to the nature of the work that the participants are involved in, each participant was aware that their face would not be recorded. Each participant underwent a fifteen-minute overview of the different prototype widgets that was available to them as well as the crime data set.

The participant listened as the researcher explained each of the Microsoft Excel column headers. The researcher did not explain the actual data within the Excel spreadsheet as the goal of the experiment was for the participants to make sense of the data and develop their reasoning accordingly. Each participant made a copy of one or more of the available widgets that they wanted to work with. They pasted it on the blank MS Work document page as they deemed fit. The participants were aware that they could use as many or as little of the widgets as they deemed fit. The participants were also aware that they could alter the widgets if it did not fit their needs.

Each participant spent up to sixty minutes to work through the given scenario. The participants were aware that they could stop at any given time. After the study, the participants completed a questionnaire that consisted out of numerous Likert scales (Likert, 1932) to capture their thoughts on the applicability and practicality of the framework's components that were available to them. After the questionnaire, each participant answered a few open-ended questions, based on the observations that the researcher made during the study.

3.1.2.6. *Limitations*

It was planned that the low fidelity prototype was supposed to have run alongside the main Visual Analytics for Sensemaking in Criminal Intelligence Analysis (VALCRI) application, in order to allow participants to make screen captures of the available visualisations (maps, timelines, charts etc.) and to use those screen captures as part of their rationale. Unfortunately, not all of the equipment made it to the experiment location, so the VALCRI application and the VALCRI xy-touch-display setup could not be used as part of the study.

This meant that the study had to be altered on the day to run without the VALCRI application. The VALCRI crime data was extracted from the database into a spreadsheet by Nadeem Kazi. The researcher selected an appropriate sub-set of crime data to construct the scenario as outlined in section 3.1.2.4 above.

Figure 103 – Chapter 5: Depiction of Groenewald et. al.'s (2018) primary argumentation concept which resembled 'widgets' as part of their low fidelity prototype

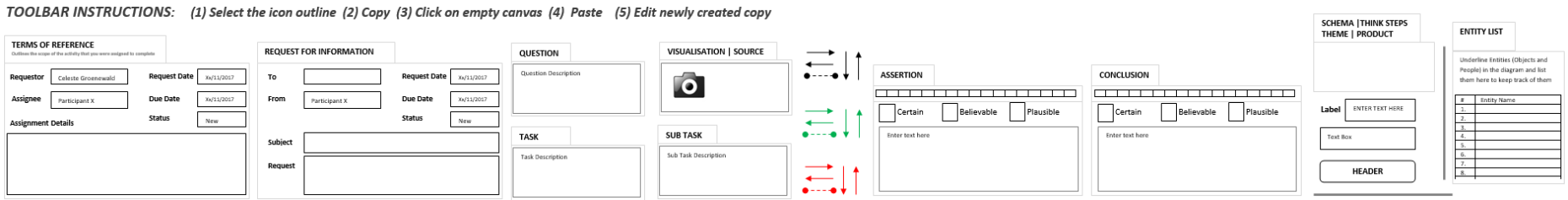
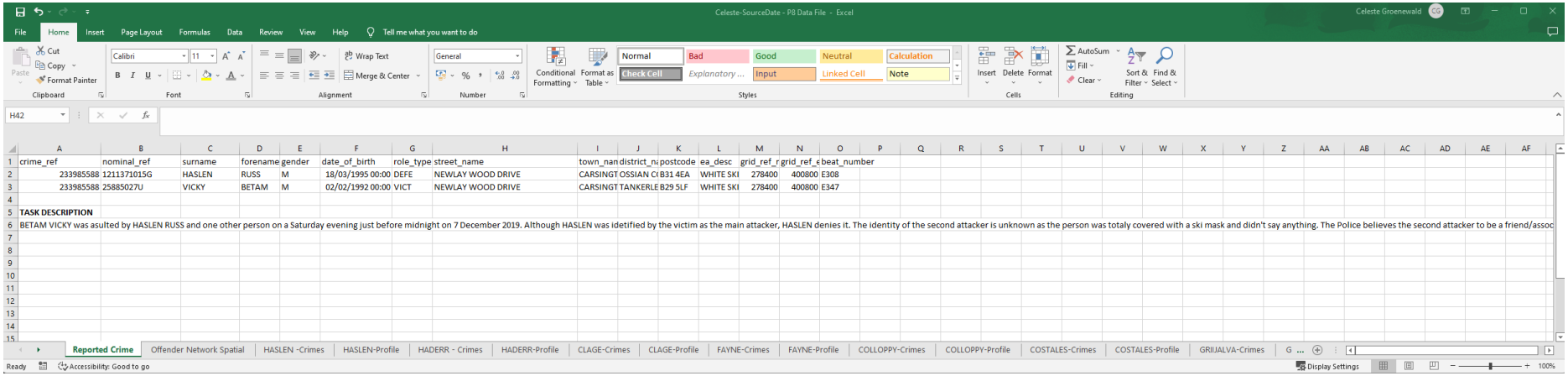


Figure 104 - Chapter 5: Excel Spreadsheet containing data



3.2. Results

A subpart of the results reported here were published in Springer[9] journal. The researcher performed the analysis for that paper, the construction of the framework, the design of the study, the execution of the study, the analysis of the results and the write-up of the results. Co-authors Peter Passmore, William Wong and Neesha Kodagoda assisted with proof-reading the paper after the researcher wrote it.

Co-author Simon Attfield, assisted with reviewing the framework that the researcher produced and offered his recommendations on which framework concepts to include in the study as widgets. The researcher created the actual prototype and conducted the study herself. The researcher produced the statistics and produced the writeup of the results accordingly. Simon Attfield reviewed the statistic results and provided feedback.

Nadeem Kazi, assisted by extracting the crime data set into a spreadsheet from the main database. The researcher selected the appropriate data for the crime scenario that were to be included in the study and produced the final spreadsheet that was used in the study.

The published results were the first attempt by the researcher to try and understand how translatable and usable the frameworks concepts were to criminal intelligence analysts, when developing their analytical rationale alongside the sensemaking process.

The research questions that the study address is as follow:

- Q1: Which of the framework's concepts are applicable to criminal intelligence analysts sensemaking and reasoning activities?
- Q2: How do the framework's concepts assist criminal intelligence analysts with orienting themselves in the analytical and sensemaking process?
- Q3: How do the framework's concepts assist the criminal intelligence analyst with exploring alternative pathways (lines of enquiry) during analytical and sensemaking tasks?
- Q4: How do the framework's concepts assist the criminal intelligence analyst with verifying their reasoning process?
- Q5: How is the framework's concepts of practical use to criminal intelligence analysts?

3.2.1. Participants Rationale-Formulation Process

The next few pages depict the rationale that the participant formulated whilst using the low fidelity prototype.

[9] Groenewald C, Attfield S, Passmore P, Wong BLW, Kodagoda N (2018) A Descriptive, Practical, Hybrid Argumentation Model to Assist With the Formulation of Defensible Assessments in Uncertain Sensemaking Environments. In Leventakis M, Haberfeld R (2018) Community-Oriented Policing and Technological Innovations. Springer. 64-84. https://doi.org/10.1007/978-3-319-89294-8

Groenewald, C., Attfield, S., Passmore, P. et al. Cogn Tech Work (2018b). A descriptive, practical, hybrid argumentation model to assist with the formulation of defensible assessments in uncertain sensemaking environments: an initial evaluation. Springer. 20(529). doi.org/10.1007/s10111-018-0495-x

Figure 105 - Chapter 5: Depiction of Participant's 1 rationale using the framework's concepts

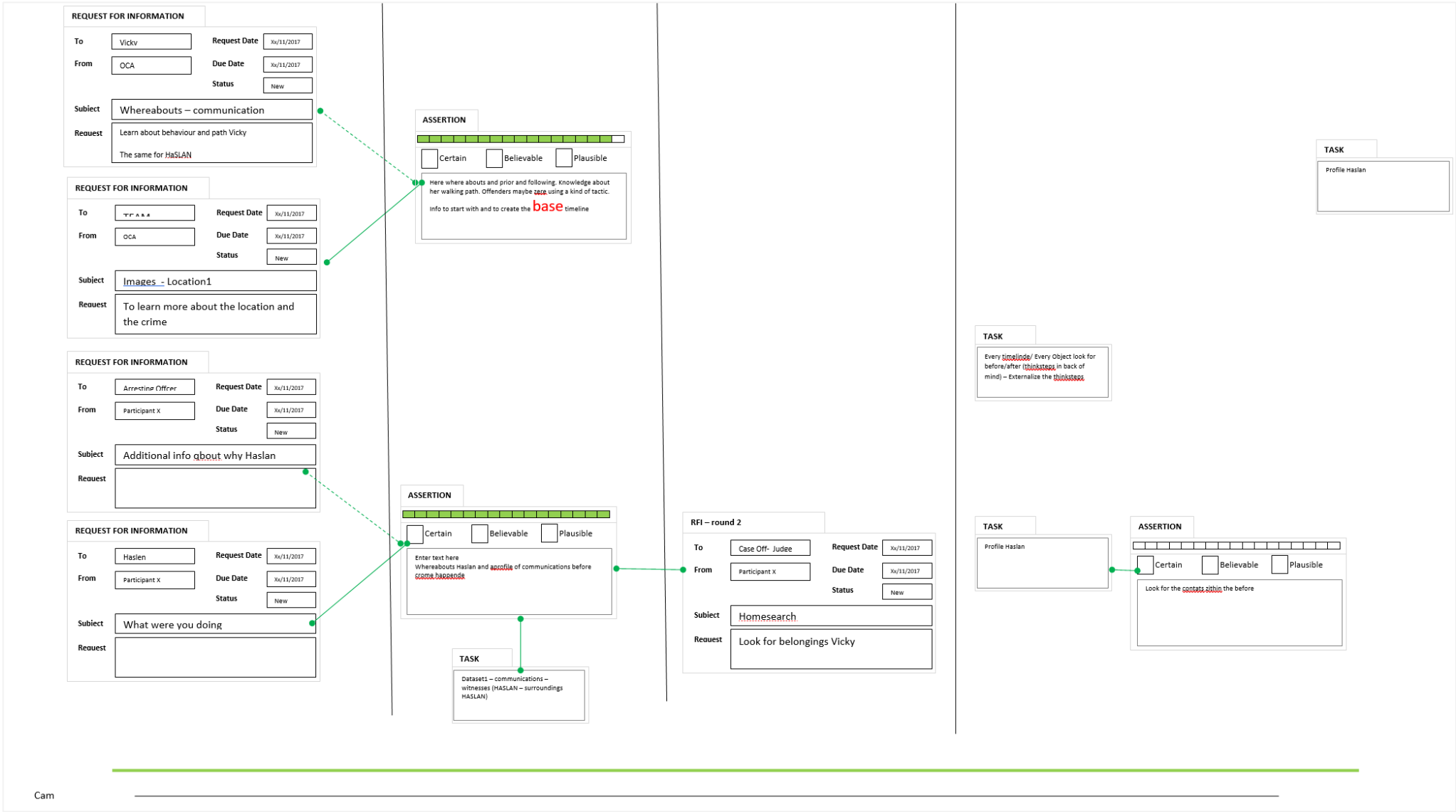


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Figure 106 - Chapter 5: Depiction of Participant's 2 rationale using the framework's concepts

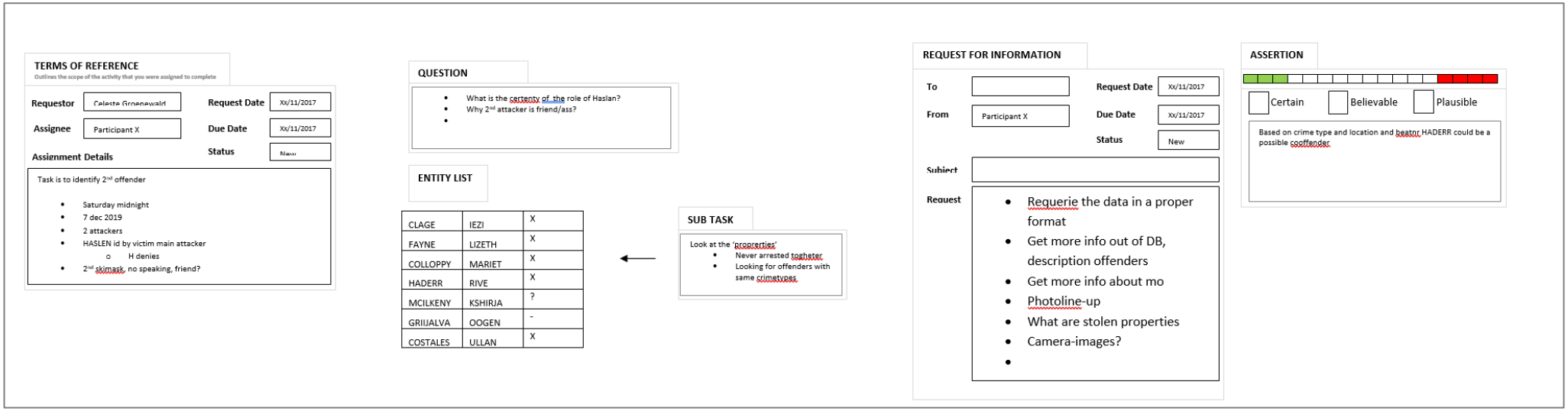


Figure 107 - Chapter 5: Depiction of Participant's 8 rationale using the framework's concepts

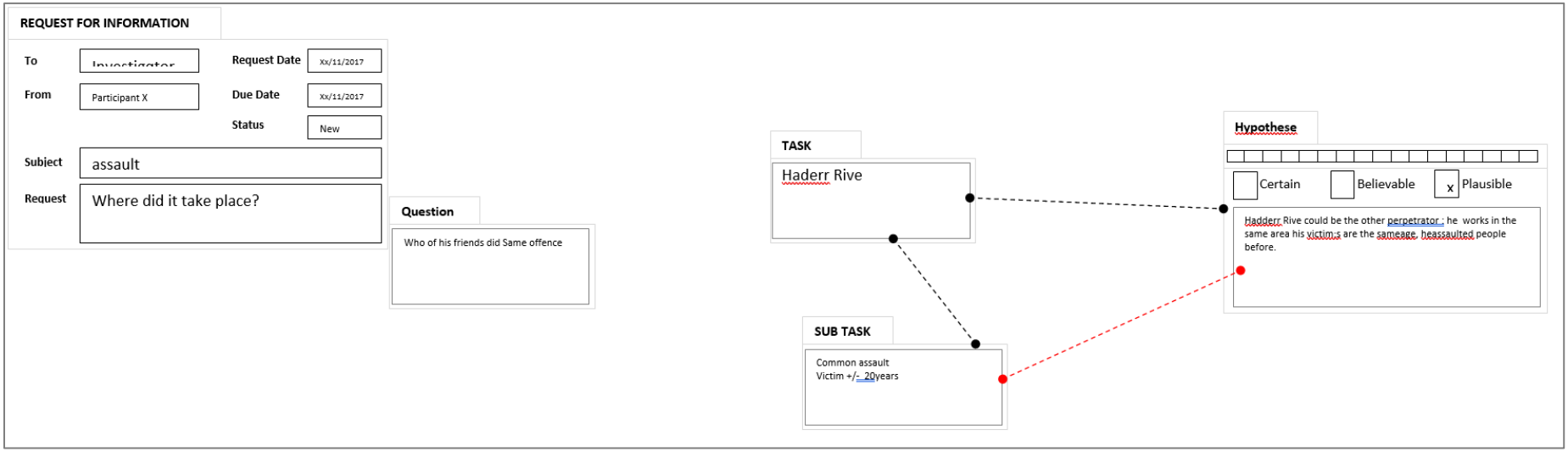


Figure 108 - Chapter 5: Depiction of Participant's 3 rationale using the framework's concepts

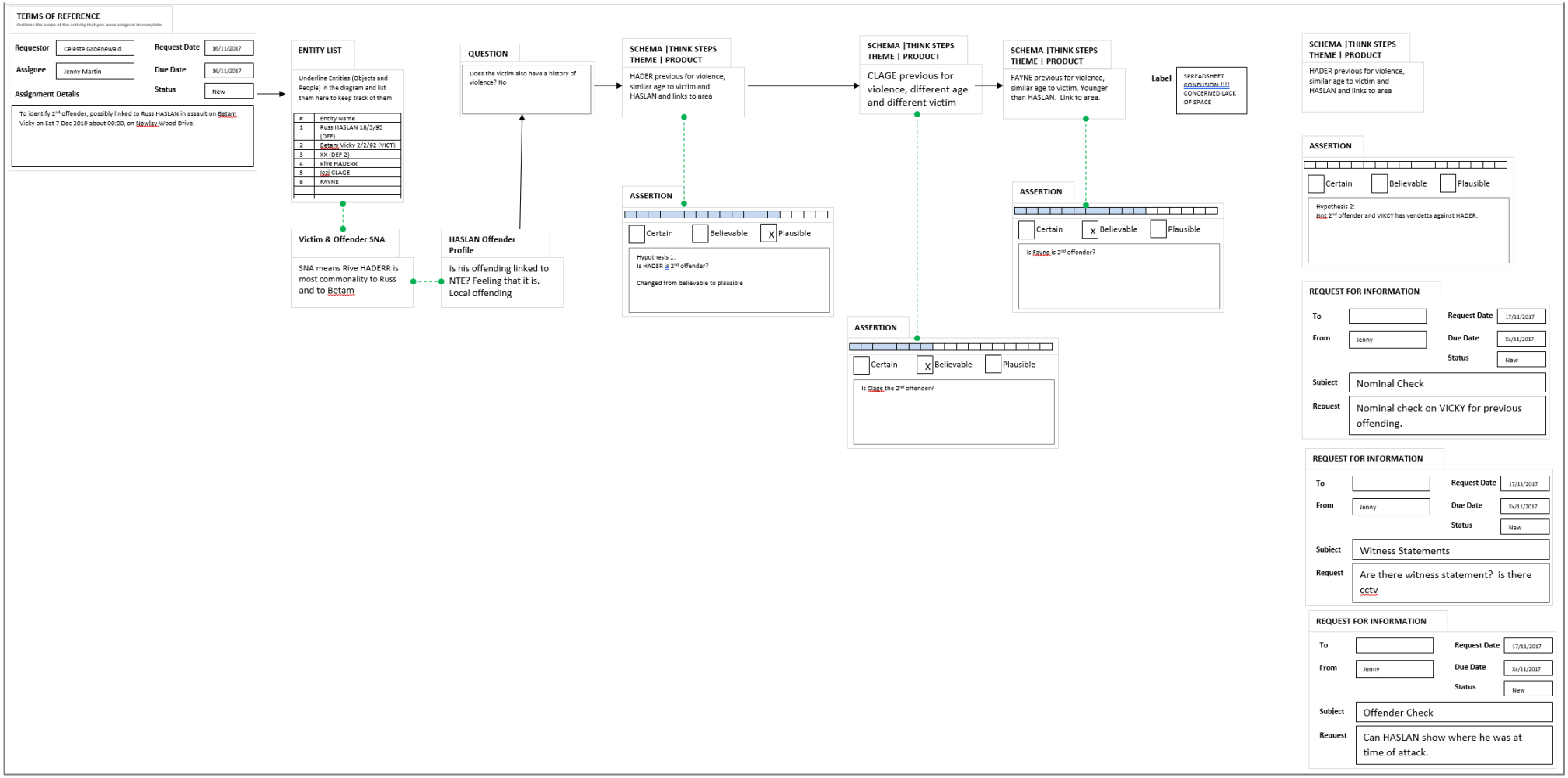


Figure 109 - Chapter 5: Depiction of Participant's 4 rationale using the framework's concepts

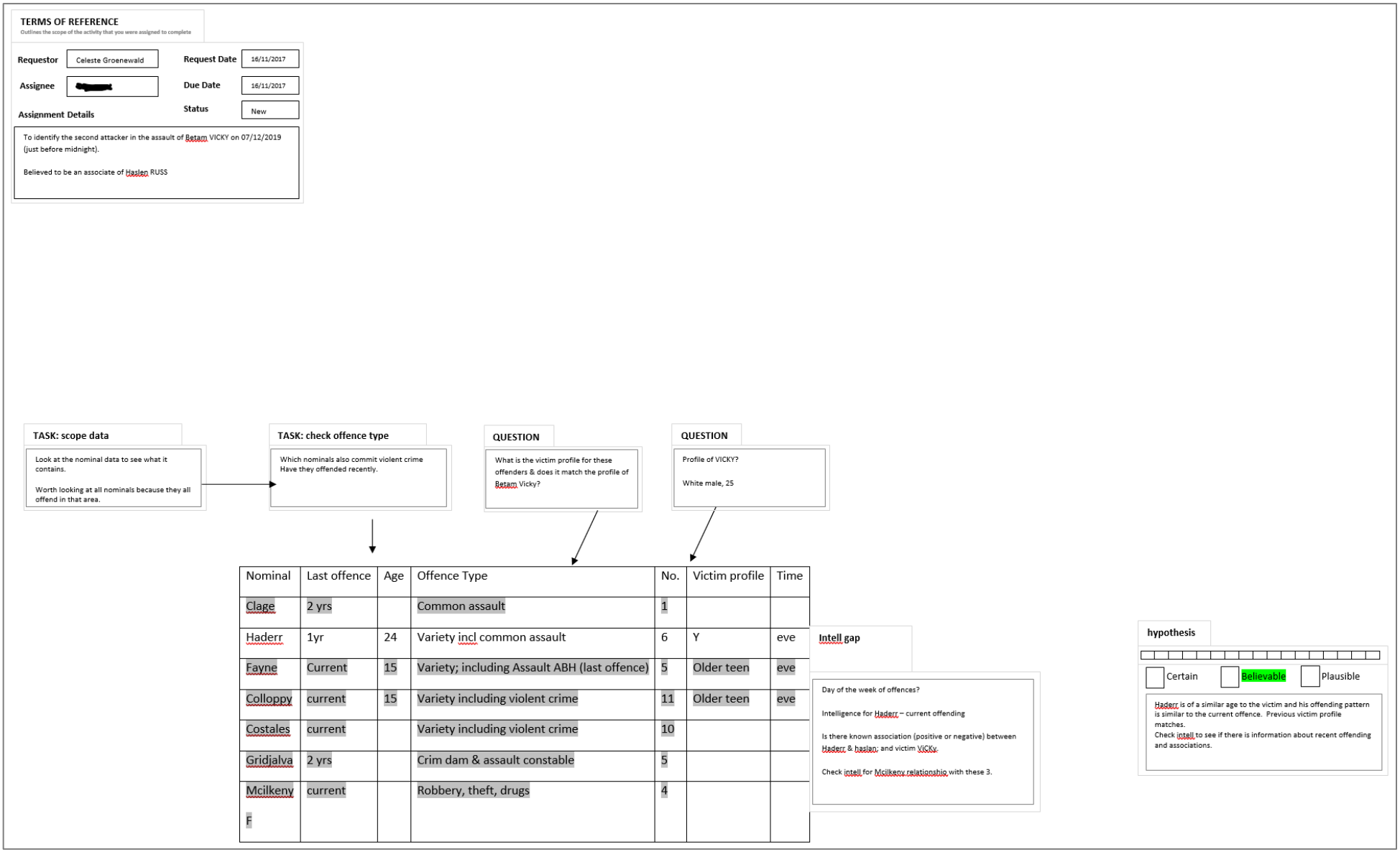
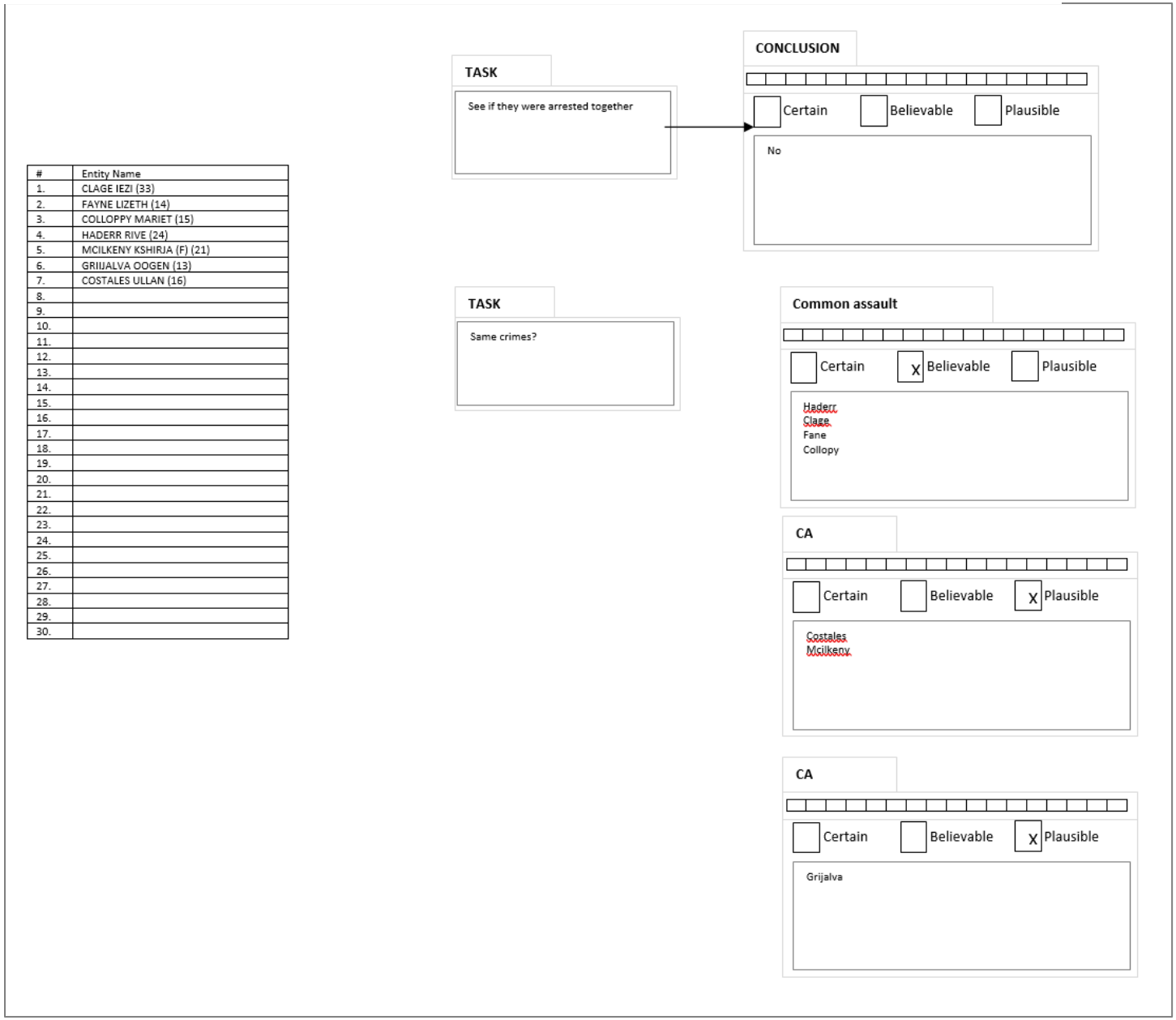


Figure 110 - Chapter 5: Depiction of Participant's 5 rationale using the framework's concepts



#	Entity Name
1.	CLAGE IEZI (33)
2.	FAYNE LIZETH (14)
3.	COLLOPPY MARIET (15)
4.	HADERR RIVE (24)
5.	MCILKENY KSHIRJA (F) (21)
6.	GRIIJALVA OOGEN (13)
7.	COSTALES ULLAN (16)
8.	
9.	
10.	
11.	
12.	
13.	
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Figure 111 - Chapter 5: Depiction of Participant's 6 rationale using the framework's concepts

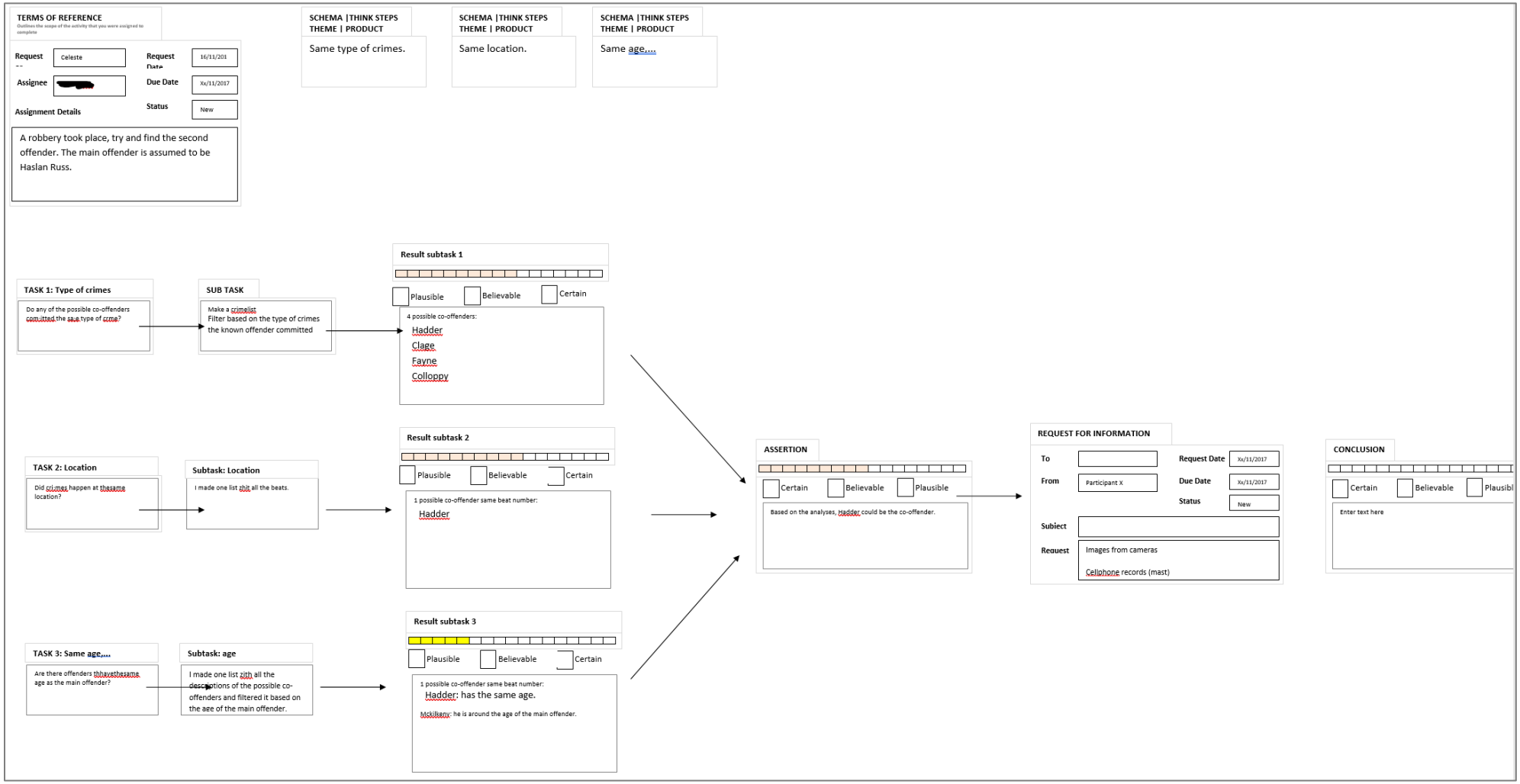
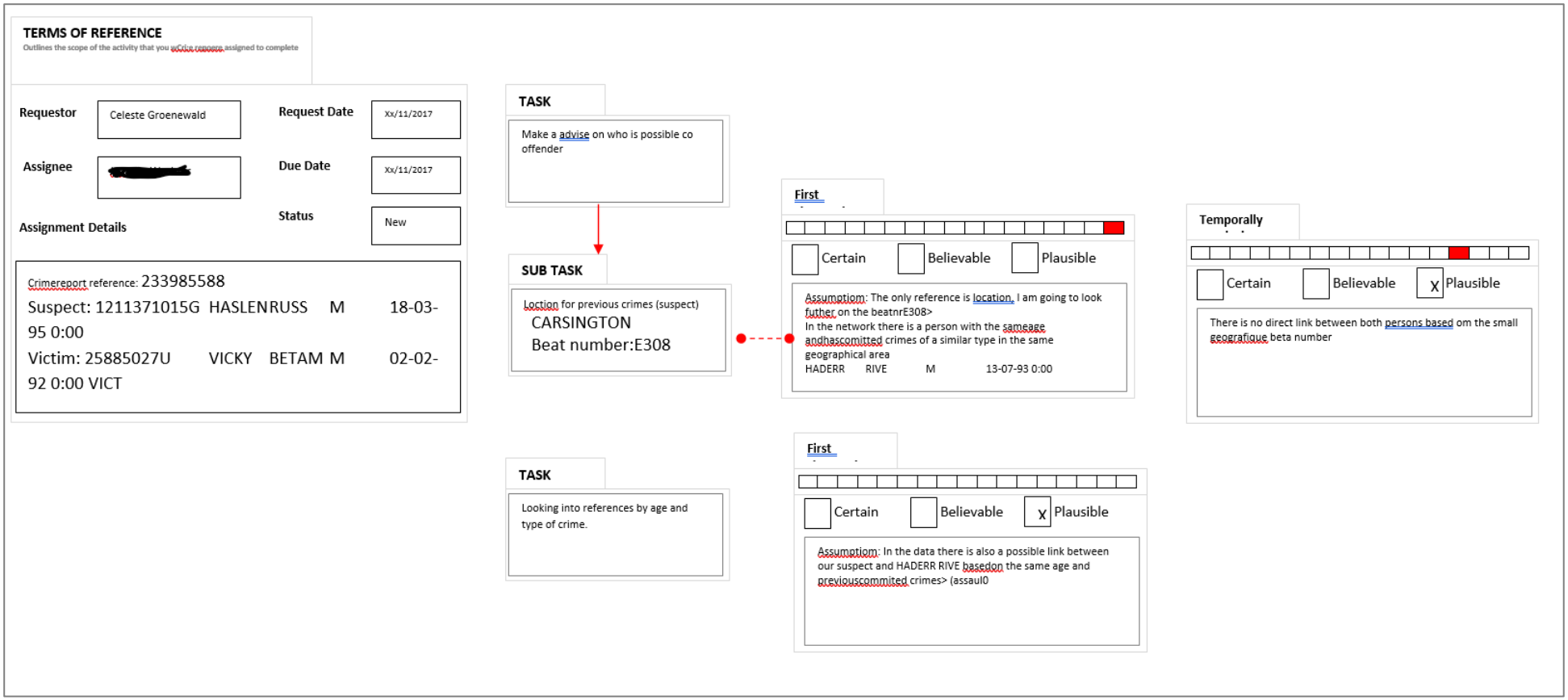


Figure 112 - Chapter 5: Depiction of Participant's 7 rationale using the framework's concepts



3.2.2. Section A: About each participant

This section was used to capture the experience and job function of the participants. The eight participants had a combined experience of 97.5 years on the police force and 74 years of combined experience as criminal intelligence analysts. Of the eight participants, two were in managerial roles with no experience as criminal intelligence analysts. By having two participants in managerial roles, the study was able to consider the different perceptions on perceived value of her prototype. Table 58 below provides a summary of the participant's roles and expertise.

Table 58 - Chapter 5: Questionnaire Results - Section A - About each participant

Question	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
Main Job Function	Operational Crime Analyst	Chief of Analyst Service	Higher Analyst	Strategic / Performance Analyst	Deputy Chief of Department	Strategic Analyst	Head of Department	Operational Crime Analyst
Experience in main job function (in years)	24	15	15	4	0.5	1	38	24
Experience as an analyst (in years)	12	15	23	11	0	1	0	24

3.2.3. Section B: General Details

This section was used to determine if criminal intelligence analysts normally record their analytical rationale (argument) and if so, do they do it from the onset or after the analysis? The study used the term 'rationale' as opposed to 'argument' to fit in with the vocabulary that the participants understand and use. The main focus was to understand if the participants normally record their rationale and how. This ties in with the day-book concepts as reported in Chapter 3.

The questions presented to the participants were:

1. I normally record most of my task procedures during my analysis task
2. I normally record most of my questions during an analysis task
3. I normally construct an argument (rationale) from the onset (beginning) of the analysis task
4. I normally construct an argument (rationale) at the end of the analysis task
5. I normally find it easy to know what I've rationalised and what the justification for the rationale was
6. I can normally return to an analysis task after period of absence (e.g., weekend, weeks) and easily resume the activities without much effort in understanding what I've rationalised previously

Table 59 below summarises the results of section B.

Table 59 - Chapter 5: Questionnaire Results - Section B – General Details (in Groenewald et al., 2018)

Q #	P1	P2	P3	P4	P5	P6	P7	P8
1	D	D	D	SD	SD	A	A	SD
2	D	-	D	SD	SD	-	SA	D
3	A	A	A	D	SD	D	-	-
4	SA	A	A	A	SD	A	A	A
5	SA	-	A	A	SD	A	-	-
6	D	-	A	A	SD	-	-	SA

3.2.4. Section C: Concept Applicability

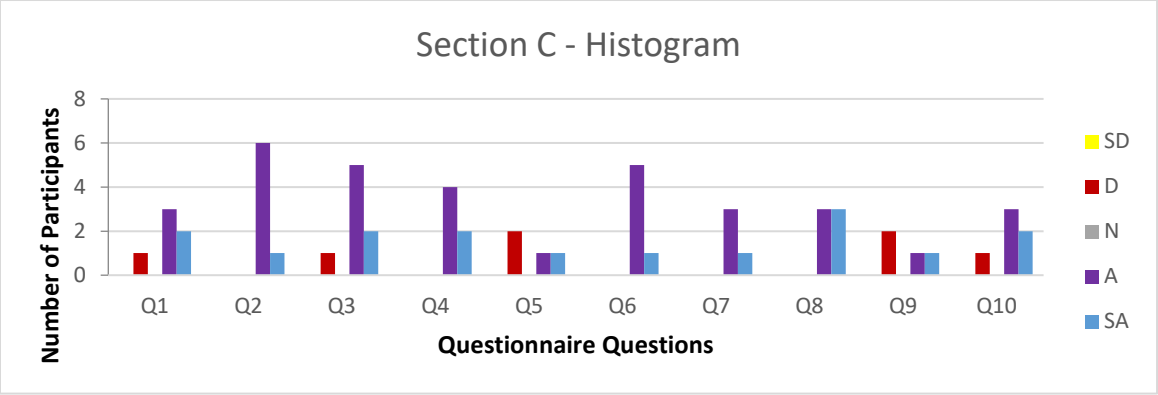
3.2.4.1. Introduction

This section is to determine if the framework's concepts are applicable to the participants. This assists with the justification of the validity of the framework's concepts that were created through the research represented in this thesis.

The research question for this section is: How is the framework's concepts applicable to criminal intelligence analysts sensemaking and reasoning activities?

To answer this research question, the following sub-research questions were considered:

1. The 'Terms of Reference' concept was applicable to the participant?
2. The 'Request for Information' concept was applicable to participant?
3. The 'Question' concept was applicable to participant?
4. The 'Task/Sub-Task' concept was applicable to participant?
5. The 'Visualisation / Source' concept was applicable to me participant
6. The 'Assertion' concept was applicable to participant?
7. The 'Conclusion' concept was applicable to participant?
8. The 'Schema/Think-Steps/Theme' concept was applicable to participant?
9. The 'Product' concept was applicable to participant?
10. The 'Entity List' concept was applicable to participant?



Abbreviations:
SD: Strongly Disagree, **D**: Disagree, **N**: Neither Agree nor Disagree, **A**: Agree, **SA**: Strongly Agree

Table 60 – Chapter 5: Section C - Participant Responses and Statistical Outputs / Data

Table 61 - Chapter 5: Section C - Participant Responses

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
P1	-	A	A	A	SA	SA	SA	SA	SA	SA
P2	A	A	A	-	D	A	A	A	-	A
P3	SA	A	A	SA	-	-	-	SA	-	SA
P4	A	-	SA	SA	-	A	-	-	D	D
P5	D	A	A	A	D	A	A	A	D	A
P6	A	A	D	A	-	A	A	SA	-	-
P7	SA	SA	SA	A	A	A	-	A	A	A
P8	-	A	A	-	-	-	-	-	-	-

Table 62 - Chapter 5: Response / Score mapping

SD	D	N	A	SA
1	**2**	**3**	**4**	**5**

Table 63 - Chapter 5: Section C - Frequencies

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
SD	0	0	0	0	0	0	0	0	0	0
D	1	0	1	0	2	0	0	0	2	1
N	0	0	0	0	0	0	0	0	0	0
A	3	6	5	4	1	5	3	3	1	3
SA	2	1	2	2	1	1	1	3	1	2

3.2.4.2. Results

Table 64 presents the questionnaire questions as presented to the participants along with the statistical results in relation to the participant's responses.

Table 64 - Chapter 5: Section C - Statistical Results

Questionnaire question	**Hypotheses** (3 represents the hypothetical value for neutral, α=0.05)	**Results**	**Conclusion**
1. The 'Terms of Reference' concept was applicable to me?	H_0: μ <= 3. H_0 states that the 'Terms of Reference' concept is not applicable. H_1: μ > 3. H_1 states that the 'Terms of Reference' is applicable. n=6	The questionnaire data was shown to be significant (p<0.0378)	H_0 is rejected **H_1 is accepted**
2. The 'Request for Information' concept was applicable to me?	H_0: μ <= 3. H_0 states that the 'Request for Information' concept is not applicable. H_1: μ > 3. H_1 states that the 'Request for Information' concept is applicable. n=7	The questionnaire data was shown to be significant (p<0.0001)	H_0 is rejected **H_1 is accepted**
3. The 'Question' concept was applicable to me?	H_0: μ <= 3. H_0 states that the 'Question' concept is not applicable. H_1: μ > 3. H_1 states that the 'Question' concept is applicable. n=8	The questionnaire data was shown to be significant (p<0.0011)	H_0 is rejected **H_1 is accepted**
4. The 'Task/Sub-Task' concept was applicable to me?	H_0: μ <= 3. H_0 states that the 'Task/Sub-Task' concept is not applicable. H_1: μ > 3. H_1 states that the 'Task/Sub-Task' concept is applicable. n=6	The questionnaire data was shown to be significant (p<0.0001)	H_0 is rejected **H_1 is accepted**
5. The 'Visualisation / Source' concept was applicable to me?	H_0: μ <= 3. H_0 states that the 'Visualisation/Source' concept is not applicable. H_1: μ > 3. H_1 states that the 'Visualisation/Source' concept is applicable.	The questionnaire data was shown to be non-significant (p>0.3804)	**H_0 is accepted** H_1 is rejected

	n=4		
6. The 'Assertion' concept was applicable to me?	H_0: μ <= 3. H_0 states that the 'Assertion' concept is not applicable. H_1: μ > 3. H_1 states that the 'Assertion' concept is applicable. n=6	The questionnaire data was shown to be significant (*p*<0.0001)	H_0 is rejected **H_1 is accepted**
7. The 'Conclusion' concept was applicable to me?	H_0: μ <= 3. H_0 states that the 'Conclusion' concept is not applicable. H_1: μ > 3. H_1 states that the 'Conclusion' concept is applicable. n=4	The questionnaire data was shown to be significant (p<0.001)	H_0 is rejected **H_1 is accepted**
8. The 'Schema/Think-Steps/Theme' concept was applicable to me?	H_0: μ <= 3. H_0 states that the 'Schema/Think - Steps/Theme' concept is not applicable. H_1: μ > 3. H_1 states that the 'Schema/Think - Steps/Theme' concept is applicable. n=6	The questionnaire data was shown to be significant (*p*<0.0001)	H_0 is rejected **H_1 is accepted**
9. The 'Product' concept was applicable to me?	H_0: μ <= 3. H_0 states that the 'Product' concept is not applicable. H_1: μ > 3. H_1 states that the 'Product' concept is applicable. n=4	The questionnaire data was shown to be non-significant (*p*>0.3804)	**H_0 is accepted** H_1 is rejected
10. The 'Entity List' concept was applicable to me?	H_0: μ <= 3. H_0 states that the 'Entity List' concept is not applicable. H_1: μ > 3. H_1 states that the 'Entity List' concept is applicable. n=6	The questionnaire data was shown to be significant (*p*<0.0378)	H_0 is rejected **H_1 is accepted**

3.2.4.3. Data

The section below outlines the statistical data.

Table 65 - Chapter 5: Section C - One-sample, one tailed Z-test against a hypothetical median of 3 (Neutral)

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
P1	-	4	4	4	5	5	5	5	5	5
P2	4	4	4	-	2	4	4	4	-	4
P3	5	4	4	5	-	-	-	5	-	5
P4	4	-	5	5	-	4	-	-	2	2
P5	2	4	4	4	2	4	4	4	2	4
P6	4	4	2	4	-	4	4	5	-	-
P7	5	5	5	4	4	4	-	4	4	4
P8	-	4	4	-	-	-	-	-	-	-
Mean	4.0000	4.1429	4.0000	4.3333	3.2500	4.1667	4.2500	4.5000	3.2500	4.0000
Mode	4	4	4	4	2	4	4	5	2	4
p	0.0127	0.0001	0.0011	0.0000	0.3694	0.0001	0.0001	0.0001	0.3694	0.0127
Significant at p<0.05	yes	yes	yes	yes	no	yes	yes	yes	no	yes

3.2.5. Section D: Sensemaking Orientation

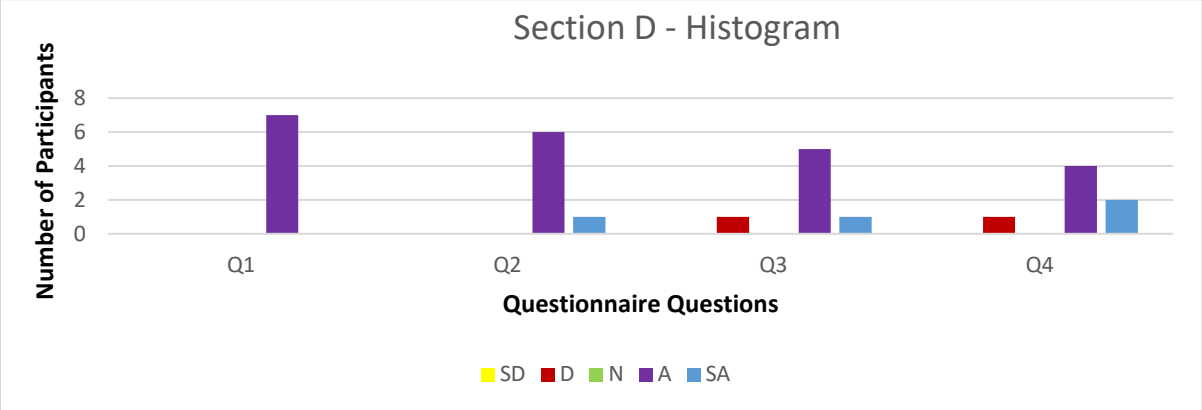
3.2.5.1. Introduction

This section was used to determine if using the framework's concepts assisted the participants with orienting themselves in the analysis process. This refers to assessing, tracking and to gain/maintain an overview of their analytical activities and the sensemaking progress they have made.

The research question for this section is: Do the Framework concepts assist criminal intelligence analysts with orienting themselves in the analytical and sensemaking process?

To answer this research question, the following sub-research questions were considered:

1. Did the ability of creating concepts assisted the participants with getting started?
2. Did the ability of creating concepts assisted the participants with dividing the analytical problem into manageable pieces?
3. Did the ability of creating concepts assisted the participants with providing an overview of their analytical process?
4. Did the ability of creating concepts assisted the participant with keeping track of where they were in their analytical process?



Abbreviations:
SD: Strongly Disagree, **D**: Disagree, **N**: Neither Agree nor Disagree, **A**: Agree, **SA**: Strongly Agree

Table 66 - Chapter 5: Section D - Participant Responses and Statistical Outputs / Data

Table 67 - Chapter 5: Section D - Participant Responses

	Q1	Q2	Q3	Q4
P1	A	A	SA	SA
P2	A	A	A	A
P3	A	A	A	D
P4	A	SA	-	SA

Table 68 - Chapter 5: Response / Score mapping

SD	D	N	A	SA
1	2	3	4	5

Table 69 - Chapter 5: Section D - Frequencies

	Q1	Q2	Q3	Q4

P5	A	A	A	A
P6	A	A	A	A
P7	A	A	D	-
P8	-	-	A	A

SD	0	0	0	0
D	0	0	1	1
N	0	0	0	0
A	7	6	5	4
SA	0	1	1	2

3.2.5.2. Results

Table 70 presents the questionnaire questions as presented to the participants along with the statistical results in relation to the participant's responses.

Table 70 - Chapter 5: Section D - Statistical Results

Questionnaire question	**Hypotheses** (3 represents the hypothetical value for neutral, α=0.05)	**Results**	**Conclusion**
1. The ability of creating concepts assisted me with getting started?	H_0: $\mu <= 3$. H_0 states that the ability of creating framework's concepts did not assist the participants with getting started with their analytical process. H1: $\mu > 3$. H1 states that the ability of creating framework's concepts did assist the participants with getting started with their analytical process. n=7	The questionnaire data were shown to be significant (p<0.0001)	H_0 is rejected **H_1 is accepted**
2. The ability of creating concepts assisted with dividing the analytical problem into manageable pieces?	H_0: $\mu <= 3$. H_0 states that the ability of creating framework's concepts did not assist the participants with dividing the analytical problem into manageable pieces. H_1: $\mu > 3$. H_1 states that the ability of creating framework's concepts did assist the participants with dividing the analytical problem into manageable pieces. n=7	The questionnaire data were shown to be non-normally distributed and significant (p<0.0001).	H_0 is rejected **H_1 is accepted**
3. The ability of creating concepts assisted me with providing an overview of my analytical process?	H_0: $\mu <= 3$. H_0 states that the ability of creating framework's concepts did not assist the participants with providing an overview of where they were in their analytical process. H_1: $\mu > 3$. H_1 states that the ability of creating framework's concepts did assist the participants with providing an overview of where they were in their analytical process. n=7	The questionnaire data were shown to be non-normally distributed and significant (p<0.0059).	H_0 is rejected **H_1 is accepted**
4. The ability of creating concepts assisted me with keeping track of where I was in my analytical process?	H_0: $\mu <= 3$. H_0 states that the ability of creating framework's concepts did not assist the participants with keeping track of where they were in their analytical process. H_1: $\mu > 3$. H_1 states that the ability of creating framework's concepts did not assist the participants with keeping track of where they were in their analytical process. n=7	The questionnaire data were shown to be non-normally distributed and significant (p<0.0041).	H_0 is rejected **H_1 is accepted**

3.2.5.3. Data

The section below outlines the statistical data.

Table 71 - Chapter 5: Section D - One-sample, one tailed Z-test against a hypothetical median of 3 (Neutral)

	Q1	Q2	Q3	Q4
P1	-	4	4	4
P2	4	4	4	-
P3	5	4	4	5
P4	4	-	5	5
P5	2	4	4	4
P6	4	4	2	4
P7	5	5	5	4
P8	-	4	4	-
Mean	4.0000	4.1429	4.0000	4.3333
Mode	4	4	4	4
p	0.0001	0.0001	0.0057	0.0041
Significant at p<0.05	yes	yes	yes	yes

3.2.6. Section E: Sensemaking Exploration

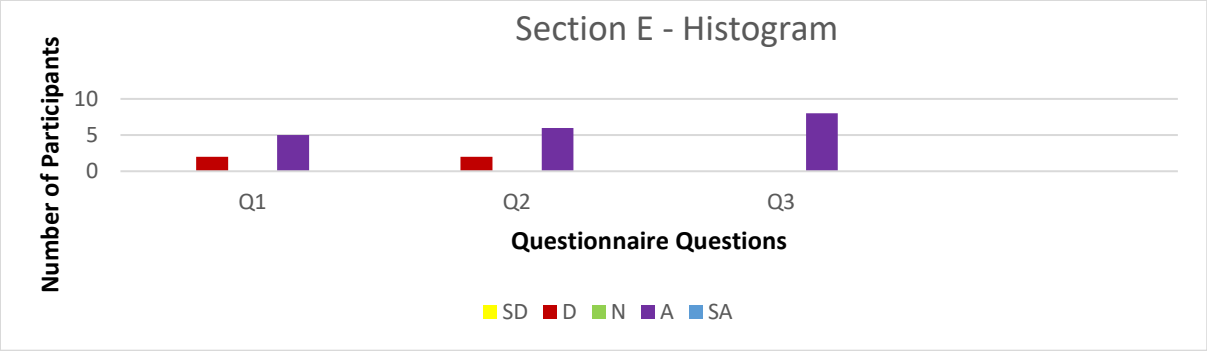
3.2.6.1. Introduction

This section was to determine if using the Framework concepts would assist the participants with exploring alternative pathways (lines of enquiry).

The research question for this section is: Do the Framework concepts assist the criminal intelligence analyst with exploring alternative pathways (lines of enquiry) during analytical and sensemaking tasks?

To answer this research question, the following sub-research questions were considered:

1. Did having the framework's concepts visible assisted the participant with identifying what the next analytical step should be e.g., delve deeper or to start a new search?
2. Did having the framework's concepts visible assisted the participant with identifying important areas?
3. Did having the framework's concepts visible assisted the participant with understanding what was going on?



Abbreviations:
SD: Strongly Disagree, **D**: Disagree, **N**: Neither Agree nor Disagree, **A**: Agree, **SA**: Strongly Agree

Table 72 - Chapter 5: Section E - Participant Responses and Statistical Outputs / Data

Table 73 - Chapter 5: Section E - Participant Responses

	Q1	Q2	Q3
P1	A	A	A
P2	A	A	A
P3	D	D	A
P4	A	A	A
P5	A	A	A
P6	A	A	A
P7	-	A	A
P8	D	D	A

Table 74 - Chapter 5: Response / Score mapping

SD	D	N	A	SA
1	2	3	4	5

Table 75 - Chapter 5: Section E - Frequencies

	Q1	Q2	Q3
SD	0	0	0
D	2	2	0
N	0	0	0
A	5	6	8
SA	0	0	0

3.2.6.2. Results

Table 76 presents the questionnaire questions as presented to the participants along with the statistical results in relation to the participant's responses.

Table 76 - Chapter 5: Section E - Statistical Results

Questionnaire question	**Hypotheses** (3 represents the hypothetical value for neutral , α=0.05)	**Results**	**Conclusion**
1. Having the concepts visible assisted me with identifying what the next analytical step should be?	H_0: μ <= 3. H_0 states that the ability of having the framework's concepts visible, did not assist the participants with identifying what the next analytical step should be. H1: μ > 3. H1 states that the ability of having the framework's concepts visible, did assist the participants with identifying what the next analytical step should be. n=7	The questionnaire data were shown to be non-significant (p>0.1226).	**H_0 is accepted** H_1 is rejected

2. Having the concepts visible assisted me with identifying important areas?	H_0: $\mu <= 3$. H_0 states that the ability of having the framework's concepts visible, did not assist the participants with identifying important areas. H_1: $\mu > 3$. H_1 states that the ability of having the framework's concepts visible, did assist the participants with identifying important areas. n=8	The questionnaire data were shown to be non-significant (p>0.0633).	**H_0 is accepted** H_1 is rejected
3. Having the concepts visible assisted me with understanding what was going on?	H_0: $\mu <= 3$. H_0 states that the ability of having the framework's concepts visible, did not assist the participants with understanding what was going on. H_1: $\mu > 3$. H_1 states that the ability of having the framework's concepts visible, did assist the participants with understanding what was going on. n=8	The questionnaire data were shown to be significant (p<0.0001) Please note that the sample was inadequate for a z-test, so a t-test was used.	H_0 is rejected **H_1 is accepted**

3.2.6.3. Data

The section below outlines the statistical data.

Table 77 - Chapter 5: Section E - One-sample, one tailed Z-test against a hypothetical median of 3 (Neutral)

	Q1	Q2	Q3
P1	4	4	4
P2	4	4	4
P3	2	2	4
P4	4	4	4
P5	4	4	4
P6	4	4	4
P7		4	4
P8	2	2	4
Mean	3.4286	3.5	4
Mode	4	4	4
p	0.1226	0.0633	0.0001
Significant at p<0.05	no	no	yes

3.2.7. Section F: Sensemaking Verification

3.2.7.1. Introduction

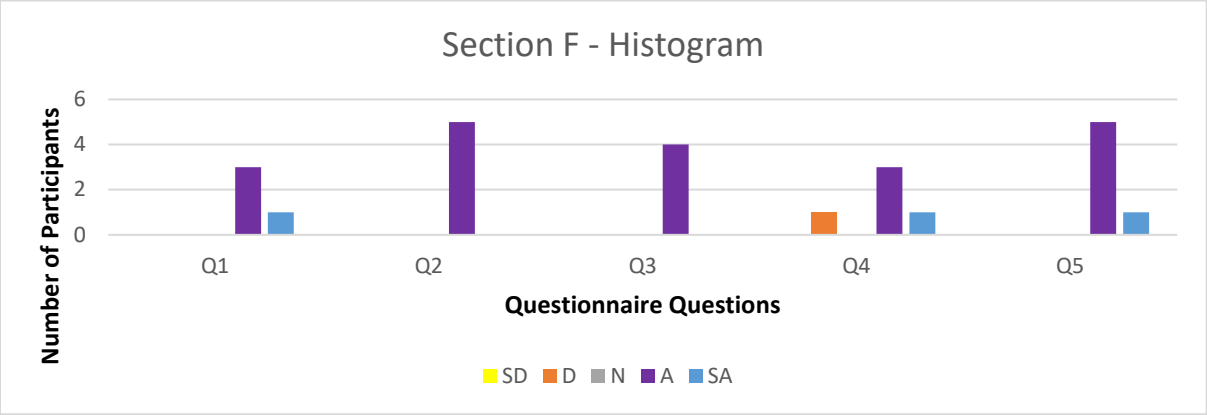
This section was to determine if using the framework's concepts assisted the participants with verifying their analytical results and sensemaking process.

The research question for this section is: How do the framework's concepts assist the criminal intelligence analyst with verifying their reasoning process?

To answer this research question, the following sub-research questions were considered:

1. Did having the framework's concepts visible assisted the participants with differentiating between certain and uncertain areas?
2. Did having the framework's concepts visible assisted the participants with identifying where the gaps in their understanding was?

3. Did having the framework's concepts visible assisted the participants with identifying where their focus should be?
4. Did having the framework's concepts visible assisted the participants with identifying the weak areas in their rationale?
5. Did having the framework's concepts visible assisted the participants with identifying the strong areas in their rationale?



Abbreviations:
SD: Strongly Disagree, **D**: Disagree, **N**: Neither Agree nor Disagree, **A**: Agree, **SA**: Strongly Agree

Table 78 - Chapter 5: Section F- Participant Responses and Statistical Outputs / Data

Table 79 - Chapter 5: Section F - Participant Responses

	Q1	Q2	Q3	Q4	Q5
P1	-	-	-	A	A
P2	A	A	-	A	A
P3	SA	A	-	-	-
P4	-	A	A	SA	SA
P5	A	-	A	-	A
P6	-	-	A	D	A
P7	A	A	A	A	A
P8	-	A	-	-	-

Table 80 - Chapter 5: Response / Score mapping

SD	D	N	A	SA
1	**2**	**3**	**4**	**5**

Table 81 - Chapter 5: Section F - Frequencies

	Q1	Q2	Q3	Q4	Q5
SD	0	0	0	0	0
D	0	0	0	1	0
N	0	0	0	0	0
A	3	5	4	3	5
SA	1	0	0	1	1

3.2.7.2. Results

Table 82 presents the questionnaire questions as presented to the participants along with the statistical results in relation to the participant's responses.

Table 82 - Chapter 5: Section F- Statistical Results

Questionnaire question	**Hypotheses** (3 represents the hypothetical value for neutral, α=0.05)	**Results**	**Conclusion**
1. Having the concepts visible assisted me with differentiating between certain and uncertain areas?	H_0: $\mu <= 3$. H_0 states that the ability of creating framework's concepts did not assist the participants with differentiating between certain and uncertain areas. H1: $\mu > 3$. H1 states that the ability of creating framework's concepts did assist the participants with differentiating between certain and uncertain areas. n=4	The questionnaire data were shown to be significant (p<0.0001).	H_0 is rejected **H_1 is accepted**
2. Having the concepts visible assisted me with identifying where the gaps in my understanding was?	H_0: $\mu <= 3$. H_0 states that the ability of creating framework's concepts did not assist the participants with identifying where the gaps in their understanding was. H_1: $\mu > 3$. H_1 states that the ability of creating framework's concepts did assist the participants with identifying where the gaps in their understanding was. n=5	The questionnaire data were shown to be significant (p<0.0001). Please note that the sample was inadequate for a z-test, so a t-test was used.	H_0 is rejected **H_1 is accepted**
3. Having the concepts visible assisted me with identifying where my focus should be?	H_0: $\mu <= 3$. H_0 states that the ability of creating framework's concepts did not assist the participants with identifying where their focus should be. H_1: $\mu > 3$. H_1 states that the ability of creating framework's concepts did assist the participants with identifying where their focus should be. n=4	The sample size is too small for a t-test and not adequate for a z-test. The results are therefore inconclusive and so H_0 is accepted.	**H_0 is accepted** H_1 is rejected
4. Having the concepts visible assisted me with identifying the weak areas in my rationale?	H_0: $\mu <= 3$. H_0 states that the ability of creating framework's concepts did not assist the participants with identifying the weak areas in their rationale. H_1: $\mu > 3$. H_1 states that the ability of creating framework's concepts did assist the participants with identifying the weak areas in their rationale. n=5	The questionnaire data were shown to be non-significant (p>0.0512).	**H_0 is accepted** H_1 is rejected
5. Having the concepts visible assisted me with identifying the strong areas in my rationale?	H_0: $\mu <= 3$. H_0 states that the ability of creating framework's concepts did not assist the participants with identifying the strong areas in their rationale. H_1: $\mu > 3$. H_1 states that the ability of creating framework's concepts did assist the participants with identifying the strong areas in their rationale. n=6	The questionnaire data were shown to be significant (p<0.0001).	H_0 is rejected **H_1 is accepted**

3.2.7.3. Data

The section below outlines the statistical data.

Table 83 - Chapter 5: Section F - One-sample, one tailed Z-test against a hypothetical median of 3 (Neutral)

	Q1	Q2	Q3	Q4	Q5
P1	-	-	-	4	4
P2	4	4	-	4	4
P3	5	4	-	-	-
P4	-	4	4	5	5
P5	4	-	4	-	4
P6	-	-	4	2	4
P7	4	4	4	4	4
P8	-	4	-	-	-
Mean	4.2500	4	4	3.800	4.16667
Mode	4	4	4	4	4
p	0.0001	0.0001	Sample not adequate	0.0512	0.0001
Significant at p<0.05	yes	yes	-	no	yes

3.2.8. Section G: Practical Use

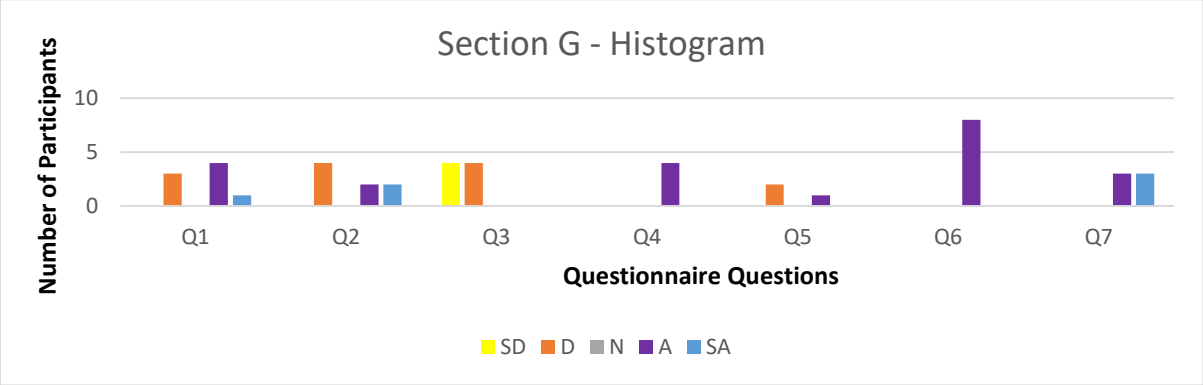
3.2.8.1. Introduction

This section was to determine if using the Framework concepts would be of practical use in criminal intelligence analysis.

The research question for this section is: How is the framework's concepts of practical use to criminal intelligence analysts? To answer this research question, the following sub-research questions were considered:

1. Would participants use all of the framework's concepts if they were available as part of an application?
2. Would participants only ever use some of the framework's concepts, if they were available as part of an application?
3. Would participants not use any of the framework's concepts, if they were available as part of an application?
4. Would participants prefer to use the framework's concepts from the onset (beginning) of their analytical process, if they were available as part of an application?
5. Would participants prefer to use the framework's concepts at the end of the analytical process, if they were available as part of an application?
6. Would using the framework's concepts assist participants with remembering what their rationale was and the justifications for each rationale, if they were part of an application?

7. Would using the framework's concepts assist participants with easily resuming their activities after a period of absence (e.g. weekend/weeks) without much effort in understanding what their rationale was?



Abbreviations:
SD: Strongly Disagree, **D**: Disagree, **N**: Neither Agree nor Disagree, **A**: Agree, **SA**: Strongly Agree

Table 84 - Chapter 5: Section G - Participant Responses and Statistical Outputs / Data

Table 85 - Chapter 5: Section G - Participant Responses

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
P1	A	SA	D	A	D	A	SA
P2	A	D	SD	A	A	A	SA
P3	A	D	D	A	D	A	A
P4	A	D	SD	-	-	A	SA
P5	D	D	SD	-	-	A	A
P6	D	A	D	-	-	A	-
P7	SA	SA	SD	A	-	A	A
P8	D	A	D	-	-	A	-

Table 86 - Chapter 5: Response / Score mapping

SD	D	N	A	SA
1	**2**	**3**	**4**	**5**

Table 87 - Chapter 5: Section G - Frequencies

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
SD	0	0	4	0	0	0	0
D	3	4	4	0	2	0	0
N	0	0	0	0	0	0	0
A	4	2	0	4	1	8	3
SA	1	2	0	0	0	0	3

3.2.8.2. Results

Table 88 presents the questionnaire questions as presented to the participants along with the statistical results in relation to the participant's responses.

Table 88 - Chapter 5: Section G - Statistical Results

Questionnaire question	**Hypotheses** (3 represents the hypothetical value for neutral, α=0.05)	**Results**	**Conclusion**
1. I would use all of the concepts if they were available as part of an application?	H_0: μ <= 3. H_0 states that participants would not use all the concepts if they were part of an application. H1: μ > 3. H1 states that participants would use all the concepts if they were part of an application. n=8	The questionnaire data were shown to be non-significant (p>0.1860).	**H_0 is accepted** H_1 is rejected
2. I would only ever use some of the concepts, if they were available as part of an application?	H_0: μ <= 3. H_0 states that participants would only ever use some of the concepts if they were part of an application. H_1: μ > 3. H_1 states that participants would never only just use some of the concepts if they were part of an application. n=7	The questionnaire data were shown to be non-significant (p>0.3053).	**H_0 is accepted** H_1 is rejected
3. I would not use any of the concepts, if they were available as part of an application?	H_0: μ <= 3. H_0 states that participants would not use any of the framework's concepts if they were part of an application. H_1: μ > 3. H_1 states that participants would use the framework's concepts if they were part of an application. n=7	The questionnaire data were shown to be (p<0.0001) The sample was inadequate for a z-test so the t-test results were used.	H_0 is rejected **H_1 is accepted**
4. I would prefer to use the concepts from the onset (beginning) of the analytical process, if they were available as part of an application?	H_0: μ <= 3. H_0 states that participants would prefer not use the framework's concepts from the onset of analysis if they were part of an application. H_1: μ > 3. H_1 states that participants would prefer to use the framework's concepts from the onset of analysis if they were part of an application. n=4	The sample size is too small for a t-test and not adequate for a z-test. The results are therefore inconclusive and so H_0 is accepted.	**H_0 is accepted** H_1 is rejected
5. I would prefer to use the concepts at the end of the analytical process, if they were available as part of an application?	H_0: μ <= 3. H_0 states that participants would prefer not use the framework's concepts at the end of analysis if they were part of an application. H_1: μ > 3. H_1 states that participants would use the framework's concepts from the onset if they were part of an application. n=3	The questionnaire data were shown to be non-significant (p>0.6914).	**H_0 is accepted** H_1 is rejected
6. Using the concepts would assist me with remembering what my rationale was and the justifications for each rationale, if they were part of an application?	H_0: μ <= 3. H_0 states that the framework's concepts would not assist the participants with remembering what their rationale was and the justifications for each rationale, if the concepts were part of an application. H_1: μ > 3. H_1 states that the framework's concepts would assist the participants with remembering what their rationale was and the justifications for each rationale, if the concepts were part of an application. N=7	The questionnaire data were shown to be significant (p<0.0001). The sample size is not adequate for a z-test, so the t-test was used.	H_0 is rejected **H_1 is accepted**
7. Using the concepts would assist me with easily resuming my activities after a period of absence (e.g weekend/weeks) without much effort in understanding what my rationale was?	H_0: μ <= 3. H_0 states that the framework's concepts would not assist the participants with easily remembering what their rationale was after a period of absence, if the concepts were part of an application. H_1: μ > 3. states that the framework's concepts would assist the participants with easily remembering what their rationale was after a period of absence, if the concepts were part of an application. N=7	The questionnaire data were shown to be significant (p<0.0001).	H_0 is rejected **H_1 is accepted**

3.2.8.3. Data

The section below outlines the statistical data.

Table 89 - Chapter 5: Section G -Shapiro-Wilk Test to determine normal vs non-normal distribution

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
P1	4	5	2	4	2	4	5
P2	4	2	1	4	4	4	5
P3	4	2	2	4	2	4	4
P4	4	2	1	-	-	4	5
P5	2	2	1	-	-	4	4
P6	2	4	2	-	-	4	-
P7	5	5	1	4	-	4	4
P8	2	4	2	-	-	4	-
Mean	3.375	3.2500	1.5000	4	2.6667	4	4.5000
Mode	4	2	2	4	2	4	5
p	0.1860	0.3053	0.0001	sample not adequate	0.6915	0.0001	0.0001
Significant at p<0.05	no	no	yes	-	no	yes	yes

4. Discussion

The sections that follow discusses the research questions for this chapter. It references the statistical results for example, (SectionD-Q1, p<0.0001) implies Section D, sub-research question 1 and the statistical result was significant. The discussion also references the relevant interview snippets from participants which can be found in Table 90.

Table 90 - Chapter 5: Open-ended feedback from participants who evaluated the framework's concepts

Section	Reference	Questionnaire open-ended responses
Rationale Process	B1	(P2): The answers from above depend on the sort of analysis task we have. Going from more strategic to more tactical and the degree of difficulty of the question.
	B2	(P4): Too time consuming to record rationale at each stage of analysis.
Applicability of the framework's concepts	C1	(P7): Entity list and Schema/ThinkSteps I missed, but would use them probably the most.
	C2	(P4): Entity List needs more options.
	C3	(P4): Terms of Reference (TOR) and Request for Information (RFI) one similar. Assertion and Conclusion is similar.
Maintaining a view of what is going on with their rationale	D1	(P3): I was in a circular process and getting tired, so I started to shortcut. However, mapping thoughts is an interesting methodology.
	D2	(P4): I didn't use this to 'project plan' the task, but with something more complex, I think this would be really useful in the scoping phase.
	D3	(P7): Because my lack of experience it was difficult to maintain the overview.
Exploring alternative lines of enquiry	E1	(P2): I'm not used to work in this kind of detail in describing think-steps, tasks and subtasks, but it is helpful to do it in this kind of detail.
	E2	(P3): I think having the chart/graph to colour as well as the certain/plausible/believable checkboxes as really helpful. I could change it as more information came in.
	E3	(P4): Helped me identify which parts of the task I had missed. It provides useful prompts for lines of enquiry / methods of dissemination

Tracking level of confidence in their rationale	F1	(P4): Particularly the idea of how certain I was about my hypothesis
	F2	(P3): I think once I'd exhausted the data, I could then think freely at end. I didn't feel like I did this in the given task - putting steps down felt too logical / not playful."
Practical use of the framework's concepts	G1	(P4): I would probably use in different ways depending on the task
	G2	(P2): Interesting exercise where I learned something I will use in the future.
	G3	(P3): I like this and it is similar to business modelling, so it is an interesting exercise. I would like to reuse this in the office.
	G4	(P7): The concepts are a very interesting 'concept', which could be a winner when fine-tuned.
Other	H1	(P4): New for me to provide such rationale. I think it would be very useful for investigation / evidential analysis for disclosure at court

Q1: Which of the framework's concepts are applicable to criminal intelligence analysts sensemaking and reasoning activities?

H1 was accepted for 8/10 framework's concepts that were included in the low-fidelity prototype. The Visualisation and Intelligence-Product concepts were deemed by participants as non-applicable (H_0 was accepted). The researcher reckons that this is due to how the experiment was designed due to the limitations that are outlined in section 3.1.2.6. Due to these limitations, it was expected that the Visualisation concept would score low ($p>0.3804$) due to the absence of maps, graphs and other visual analytical aids. The analytical task that was given to the participants did not indicate that they were required to create a report, so the participants did not have a need to group different analytical results together in order to create intelligence products, which explains why the Intelligence-Product concept was found to be non-applicable ($p>0.3804$).

There is however room for improvement as it was outlined that some of the frameworks' concepts were identically designed (C3) such as TOR and RFI and similarly Assertion and Conclusion. The research purpose was not to evaluate the design of the components, but rather their utility and contribution to the rationale-formulation process. It is however good feedback to take into account for when the next prototype is designed. This answers RQ1 of this chapter.

Q2: How do the framework's concepts assist criminal intelligence analysts with orienting themselves in the analytical and sensemaking process?

The degree to which criminal intelligence analysts need to externalise their rationale, is dependent on the nature and difficulty of the analytical task that they are asked to solve (B1, G1). Criminal intelligence analysts can perceive the externalisation process of their rationale as a too-time-consuming-process, if they are required to do so at each stage of the analysis process (B2). The externalisation process can also be perceived as being too rigid (F2) if the design is not flexible enough to accommodate criminal intelligence analyst's needs. This strengthens the recommendation (Wong, 2018) that the process of creating and externalising a rationale should be a fluid process that can adapt to the needs of criminal intelligence analysts.

The notion of externalising one's rationale as a time-consuming process, could be why only three of the participants indicated that they normally construct their rationale from the onset of the analysis process (SectionB-Q3). However, participants found that the framework's concepts assisted them with; getting started with their rationale (SectionD-Q1, $p<0.0001$); dividing the analytical task into manageable pieces (SectionD-Q2, $p<0.0001$); providing the participants with an overview of their rationale (SectionD-Q3, $p<0.0059$) and; keeping track of their progress and rationale (SectionD-Q4, $p<0.0041$).

When criminal intelligence analysts have difficulty with the analysis and enter into a circular process, then they risk opting for analytical shortcuts (D1). Working within a flexible 'methodology' (D1) might help in these situations where the investigative work is complex, especially during the scoping phase (D2). Inexperienced criminal intelligence analysts may also experience difficulties to maintain an overview of their rationale-formulation process (D3).

Most of participants were not sure about how easy it normally is for them to remember what their rationale was (SectionB-Q5) or how easily they can pick up their rationale after a long period of absence, for example a weekend or a holiday (SectionB-Q6). However, they did indicate that the framework's concepts would assist them with remembering their rationale (SectionG-Q6, $p<0.0001$) and resuming their rationale after periods of absence (SectionG-Q7, $p<0.0001$). This indicates that the framework's concepts address the limitations from Chapter 3, where it was found that the disjointed and lengthy nature of investigations contribute to criminal intelligence analysts experiencing a delay in recovering their rationale after absences. Absences can also be in the form of when criminal intelligence analysts have to wait for information they requested to be supplied (Chapter 3 and Chapter 4).

Q3: How do the framework's concepts assist the criminal intelligence analyst with exploring alternative pathways (lines of enquiry) during analytical and sensemaking tasks?

Chapter 4 outlines how criminal intelligence analysts could make use of LoE as part of a schema to keep track of relevant information. In the framework, 'entity list' was an example of a LoE. Multiple participants made use of the 'entity list' component (see Figure 106, Figure 108, Figure 109 and Figure 110). Participants agreed that having the frameworks' concepts visible assisted them with understanding what was going on (Section E-Q3, $p<0.0001$). Even though participants mostly agreed that the framework's concepts assisted them with identifying next steps in the analytical process (Section E-Q1) and with identifying the important areas in their rationale, the statistics made it non-significant. However, it was found that the framework's concepts assisted with identifying LoE and for spotting which tasks were missed (E3). It was also stressed that the LoE concept needed more work to utilise it's intended function (C2) and that it would be a useful component (C1).

Q4: How do the framework's concepts assist the criminal intelligence analyst with verifying their reasoning process?

Chapter 4 outlines how criminal intelligence analysts progress their confidence in what they believe to be happening within the crime scenario, by using the task-justification-outcome combination. The framework's components included a confidence indicator that consisted of three checkboxes (certain, believable and plausible) and a line of blocks that participants could colour code in any way they deem fit. Participants made use of these visual cues without being instructed to do so as a requirement. This indicates that understanding their own confidence-level of the outputs they produce is an important part of their rationale-formulation process. As participants utilised it in many different ways (see Figure 105 to Figure 112) it can be a source for 'Expression of Uncertainty Bias' (Heuer, 1999) (see Table 4). It showed how confidence-levels of their rationale changed as the investigation progressed (E2, F1). The framework's concepts assisted the participants with; differentiating between certain and uncertain areas (SectionF-Q1, $p<0.0001$); knowing where the gaps in their understanding was (SectionF-Q2, $p<0.0001$) and; being aware how strong their rationale was (SectionF-Q5, $p<0.0001$).

Q5: How is the framework's concepts of practical use to criminal intelligence analysts?

Participants found the framework's concepts helpful to provide this level of detail (E1), and interesting for future use (G2, G3) when finetuned (G4), especially for investigative work that requires disclosure of evidence for court proceedings (G5). Participants indicated that they would use a subset of the framework's components if it were included in an application (SectionG-Q3, $p<0.0001$). They also indicated that the framework's components would assist them with remembering what their rationale was and the justifications for their rationale (SectionG-Q6, $p<0.0001$) and that they would be able to easily resume their rationale after a period of absence (SectionG-Q7, $p<0.0001$).

This chapter answered Research Question 5 (as described in Chapter 1) in the following ways:

Research Question 5: Which areas of criminal intelligence analysts' analytical reasoning process can be supported in software and how?

Answer*:* The results from this chapter indicate that the rationale-formulation process can co-exist alongside the sensemaking process. It also indicates that the framework's concepts address the affordances that the day-book offers, but as an electronic version. Some of the affordances are: the ability to recap the rationale-formulation process; finding gaps or unexplored LoE; collation of everything in one place and; assistance with rationale delay recovery (see Figure 31 and Figure 33). Wong and Varga (2012) outlined design problems within visual analytical systems that hinders sensemaking and they categorised it into a data, analysis and hypothesis space. This chapter contributes to their design spaces by specifying which practical components should exist

in each space to allow for the rationale-formulation process to take place alongside the sensemaking process (see Figure 102). Furthermore, the practical components are not high-level concepts, but tangible concepts that can be implemented in a software design such as illustrated with the design of the low-fidelity prototype in this chapter. The results of this chapter illustrated that the components contribute to the rationale-formulation process and that criminal intelligence analysts find them practical and useful.

Wong and Varga (2012) further outlined various data-space problems namely; the keyhole problem where criminal intelligence analysts see a large data set through a limited lens; the blackhole problem where criminal intelligence analysts are unaware of which data is missing; and the brown worm problem where criminal intelligence analysts need to build their understanding from deceptive information. These problems can also exist within the analysis space and the hypothesis space. In the analysis space the black-hole problem can be where criminal intelligence analysts miss performing tasks or fail to investigate unexplored LoE. The results in this chapter outlined how criminal intelligence analysts reckoned that the framework's concepts could assist them with these types of black-hole problems. In the hypothesis space, brown worms can present itself as different levels of confidence in task outcomes. Deceptive information could contribute to low confidence. But so can task outcomes that do not meet the task's justification and can lead to 'deceptive confidence levels', which contributes to cognitive anchoring biases. The research results showed that the framework's concepts contributed to criminal intelligence analysts being aware of their confidence levels.

Ya'acob et al. (2021) developed a conceptual framework that "describes analytical reasoning features from three parts of visual analytics representation which are higher-level structure, interconnection and lower-level structure." The framework's components (from this thesis) contribute to Ya'acob et al. (2021) research by providing tangible components that can exist in the higher-level structure. For the higher-level structure (Ya'acob et al., 2021) the framework in this thesis offers practical components such as TOR, tasks and outcomes (segmentation, structure and overview of the analytical reasoning development) and the LoE as an argumentation component (segmentation, structure and overview of the development of relevance).

The results from Chapter 4's study 1, provides 33 self-contained templates where each template holds information on:

1. Example of the analytical task along with how the task-justification-outcome combination contributes to analytical proof and confidence.
2. Example of how the task-justification-outcome combination (as analytical rationale) can be expressed in a format that resembles formal argumentation notation
3. Example of how the analytical rationale can be used to infer the equivalent formal implicit argument
4. Listing of possible relevant analytical techniques to support the analytical rationale formulation process
5. Listing of possible relevant cognitive biases that can arise as a result of the analytical rationale

6. Listing of possible critical questions to assist with improving the analytical rationale
7. Listing of possible critical questions to verify the soundness of the implicit formal argument

The results from Chapter 4's study 2, provides practical information on how LoE serve and operate as a schematisation solution to track and manage relevance. It further indicates how the relevance states change and how it fits in with broader Think-Steps and Crime Schemas. The results in this chapter illustrated that criminal intelligence analysts would use LoE if properly designed for fluid interaction.

The next chapter concludes this research and outlines future research work that can follow on from the results in this chapter.

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Chapter Six
Conclusion and Future Work

1. Overview

This thesis provides an in-depth analysis of criminal intelligence analysts' analytical reasoning process and how to practically support that process within software systems.

Researchers have done a wonderful job in researching specific areas of criminal intelligence analysts' sensemaking and reasoning process (see Chapter two, section 2). However, there has not yet been an attempt to offer researchers and developers a complete toolkit or framework on how to accomplish such an enthusiastic endeavour, such as supporting criminal intelligence analysts reasoning process. I must admit that I have fallen short on the 'complete' part, but the research in this thesis offers a 'good starting point' in compiling and offering such a framework/toolkit.

With initiatives such as the National Policing Digital Strategy:2020–2030 (NPDS) (APCC/NPCC, 2020) who is going to spend an estimated £7bn-£9bn on technology by 2030, it is becoming more relevant to understand how to support criminal intelligence analysts' reasoning process in such a rapidly growing digital space.

The literature section outlines how NIM (ACPO/Centrex, 2005,2007) contributes to unifying the working practices of the policing community and how APP (College of Policing, 2013c) is contributing to the personal development of analytical and working skills of those who serve on the police force, such as criminal intelligence analysts. Both of these are massive contributions in their own right, but both omits descriptions of how the rationale of criminal intelligence analysts develop alongside the sensemaking process. A simplistic way to address this shortcoming, is to investigate how criminal intelligence currently externalise their analytical rationale using the old-fashioned, but dependable, pen and paper method (known as a day-book). This led to the research outlined in Chapter 3, as a first attempt to understand criminal intelligence rationale-formulation process, by investigating how they currently externalise their rationale. This also answers the first research question on extending NIM to include details on how criminal intelligence analysts formulate their rationale.

Figure 31, Figure 33 and Figure 34 provide details on how the pen and paper method assist criminal intelligence analysts with formulating and externalising their analytical rationale. Even if researchers and developers ignore everything in this thesis except Figure 34, then they would still be in a position to digitise the process of providing support for criminal intelligence analysts' reasoning process. So, why not stop there and end the research? The answer lies in Wong's (2018) Fluidity and Rigour model (see Figure 14). Wong's (2018) model dictates that the software tools on the fluid side should support the variability of one's thinking processes (which includes reasoning). The rigour side should include tools to support interrogation of results such found in formal argumentation. On top of that, the existing pen and paper method will not be solely

working in a stand-alone application, but it will likely be integrated as part of a suite of visual analytical tools. So, the challenge is how to make it work alongside various sensemaking tools, in a fluid workspace that supports tentative constructs, yet should have the ability to evolve into a rigorous construct, that can withstand interrogation in a rigorous work space? The research in this thesis tries to address this challenge and offers an argumentation theory-based framework alongside:

- The un-packing of Pirolli and Card's (2005) Notional Model of sensemaking to illustrate the typical analytical tasks that exist within each area of their model (see Figure 100) and how their top-level approach includes argumentation questions that support relevance, proof and confidence in support of criminal intelligence analysts' rationale-formulation process, as part of the bottom-up approach (see Figure 97). It was shown how proof and confidence develops as the criminal intelligence analyst progress their rationale through the task-justification-outcome combination as outlined in chapters 3 and 4. This serves to answer research question 2.
- 33 self-contained templates describing typical analytical tasks and how each contributes to criminal intelligence analysts' rationale-formulating process (see chapter 4's section 3.2). Each template falls within the unpacked areas of Pirolli and Card's (2005) model as described in the previous point. Each template contains: relevant analytical techniques to assist with the formulation of the analytical rationale; relevant cognitive biases that could present itself during that particular analytical rationale-formulation process; critical questions to assist with the analytical rationale-formulation process and; critical questions for the formal implicit argument to assist with determining soundness.
- In-depth depiction on how Lines of Enquiry (LoE) serve as a schematisation container and how LoE fit into broader ThinkStep (Selvaraj et al., 2016) containers and crime schemas (see Figure 98). LoE offers a method of determining and tracking relevance of information and the rationale surrounding the analysis of the information (see Figure 99). This serves to answer research question 3.
- In-depth depiction of how the task-justification-outcome combination (see chapter 3) can be used to express the analytical rationale in a format that resembles formal argumentation linked-notation constructs and how the task-justification-outcome combination can be used to infer the equivalent formal implicit argument construct (See chapter 4's section 3.2). This point and the 33 templates serves to answer research question 4.
- In-depth depiction of how LoE can be expressed in a format that resembles formal argumentation convergent-notation and how it can be used to infer the equivalent formal implicit argument construct (see chapter 4's section 4.2). Figure 96 depicts how fluid analytical rationale constructs can evolve into rigorous constructs that can be interrogated. This contributes to answering research question 4.

The argumentation theory-based framework is constructed from the concepts based on the result findings of chapters 3 and 4 that elicited knowledge from experienced criminal intelligence analysts. The argumentation theory-based framework incorporates the design spaces (data, analysis and hypothesis) as designed by Wong and Varga (2012). Each of the design spaces include the relevant components that assist with the rationale-formulation process and that can be expressed as tangible components in a software interface. This contributes to the greater understanding of how the analytical rationale presents itself in each of the spaces and an opportunity for the 33 templates to be applied inside the respective analytical and hypothesis spaces, along with the affordances that the templates offer such as highlighting applicable cognitive biases for that task.

The argumentation theory-based framework was evaluated as a low-fidelity prototype with eight experienced criminal intelligence analysts. The statistical results and the feedback that were received from the criminal intelligence analysts confirm that the frameworks' components are applicable, practical, useful and provides similar affordances as outlined in Figure 31 and Figure 33 (pen and paper method). This serves to answer research question 5.

2. Future Research

As time did not allow to test all the research outcomes, I would like to continue doing so going forward. In particular, I would like to:

- Create a fully operable software prototype which incorporates all the frameworks' components for further evaluation. The prototype in this thesis was a low-fidelity prototype which had usability issues.
- Evaluate the fluid task-justification-outcome combinations along with the LoE and see how it scales up to the rigour formal argument constructs.
- Evaluate the 33 templates to determine their applicability and impact as templates
- Make the research outputs available to other researches through publications, so that they can elaborate on these research concepts and hopefully use it as part of their own research projects.

3. Lessons Learned

I am grateful that I have had the opportunity to learn how to conduct research and that I was able to be part of a large research team (VALCRI project).

Time management formed an essential part of the research process. The transcription of audio interview files took much longer than expected. Planning for the submission of papers to conferences also took careful planning, especially to allow enough time for co-authors to review and add their own insights. The planning of research studies also required ample preparation

time. I learned to test the study multiple times beforehand to allow enough time for the actual study.

I have learned to have ample backups and backup plans. In my evaluation study, some of the equipment did not arrive on site and luckily, I had a backup plan to use spreadsheets with crime data in case something happened. Equipment can fail, so it was useful that the 'perfectionists' in the group had packed additional cables, batteries, dictators and video cameras. In the future, I will also make additional independent backups of data before leaving the evaluation site, as I have lost an entire research study's data due to a robbery en route home.

The analysis of transcript data using different coding techniques took a while to learn. I learned that I had to take a step back and to consider what was really going on in the data. I also learned to ask myself the question on if I am being impartial or if I am imposing the results that I want on the data. Similarly, I learned how to conduct interviews using the Critical Decision Method and how to keep the participant on-topic, without leading them or suggesting a specific answer. Authoring papers for conferences took some time to get used to, especially conveying the results in such a way that the reader had enough information to make their own conclusion on whether they agree or not.

I learned how to work as part of a group on a research project. Being a new researcher, I initially found it difficult to understand where the balance was between what I considered to be important for research and what the project defined as required research outputs. It is therefore important to do the research to the best of one's ability, but it is also important not to be too attached to the outcomes.

I consider that part of the PhD process, is to learn about yourself and to understand where one fits in with the research material that already exist out there. I am happy that I persisted with the research on understanding how criminal intelligence analysts formulate their reasoning and how it fitted in with other researcher's already established work. It was a difficult area to research as it touched on so many tacit concepts of the thinking and reasoning processes of a person. Researching argumentation in the evidential reasoning space alone would not have been enough to have produced the same results as I have outlined in this thesis.

I am looking forward to continuing this research.

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Appendix

Critical Decision Method (CDM):

Below is a subset of the first 10 pages of 104 pages of Google Scholar search results for "Critical Decision Method" for period "2021 – 2022". The papers are peer-reviewed and made use of the CDM method to elicit knowledge from SMEs:

- Clinical / Healthcare / Pharmaceutical research: 14 studies
- HCI / Visualisations / Game research: 3 studies
- Intelligence / Crime / Criminal Analysis: 3 studies
- Management / Organisation / Business / Sales research: 3 studies
- Risk / Threat / Accident / Crisis research: 6 studies
- Manufacturing / Mining Research: 4 studies
- Maritime / Pilot / Control Rooms / Sonar: 7 studies

This suggests that CDM has become a popular research method and used in a variety of studies including intelligence analysis.

Domain	Citation
Clinical / Healthcare / Pharmaceutical / Medical research	Janzen, S., Arnetz, J., Radcliffe, S., Fitzpatrick, L., Eden, J., & Wright, M. C. (2022). Preventing patient violence in hospitals: Applying critical decision method interviews to understand how skilled staff think and act differently. Applied nursing research, 63, 151544.
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Intelligence / Crime / Criminal Analysis	Hepenstal, S., Zhang, L., & Wong, B. W. (2021, October). An analysis of expertise in intelligence analysis to support the design of Human-Centered Artificial Intelligence. In 2021 IEEE International Conference on Systems, Man, and Cybernetics (SMC) (pp. 107-112). IEEE.
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