# Sense, Signal and Software -

## a sensemaking analysis of meaning in early warning systems

by

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## OPSOMMING

Hierdie tesis ondersoek hoe Karl Weick se konsep van singewing ons insig teenoor swak seine, tekens, waarskuwingsanalise en sagteware binne vroeë waarskuwingstelsels verbeter. Weick se bydrae verskaf ‘n raamwerk waarbinne hierdie konsepte geanaliseer en ondersoek kan word. Die konsep van swak seine, vroeë-waarskuwing en visuele analise word binne huidige besigheidsuitgangspunte, en die formele intelligensie arena ondersoek.

Die mislukking van intelligensie is kenmerkend van gebeure soos 9/11, die onlangse finansiële krisis wat deur die ondergang van Lehman Brothers ingelei is, en die sogenaamde “Arab Spring”. Hierdie gebeure het ‘n wêreldwye opskudding op ekonomiese en politiese vlak veroorsaak. Moderne metodologieë soos vroeë waarskuwingsanalise, swaksein-analise en omgewingsaanskouing binne regerings- en besigheidsverband het duidelik in hul doelstelling misluk om voortydig te waarsku oor hierdie gebeurtenisse. Dit is juis hierdie mislukkings wat dit noodsaaklik maak om meer aandag te skenk aan hierdie konsepte, asook nuwe tegnologie wat dit kan verbeter.

Hoofstuk Een is inleidend en stel die navorsingsvraagstuk, doelwitte en afbakkening. Hoofstuk Twee lê die fondasie van die tesis deur ‘n ondersoek van die hoof konsepte. Hoofstuk Drie verskaf die teoretiese raamwerk, die van Weick se singewingsteorie, waarteen die hoof konsepte in Hoofstuk Twee ondersoek word in Hoofstuk Vier. Klem word gelê op die diepte van integrasie en die toepassing van raamwerke in die analisefase van vroeë waarskuwingstelsels en hoe dit binne die teoretiese beginsels van visuele analise geïnkorporeer word.

Die bevindinge van hierdie tesis spreek die feit aan dat Weick se konsepsualisering van singewing konseptuele helderheid rakende die begrip “swakseine” verskaf. In hierdie verband verteenwoordig Weick se “saad”- metafoor die samewerking en uitbouing van seine en “padpredikante” wat die progressiewe aard van swakseine weerspieël.

Die kernbeskouing van hierdie tesis is die belangrikheid van Weick se geloofsgedrewesingewing, veral die uitkoms van die bou van raamwerke asook die bespreking hiervan deur verskeie navorsers. Die belangrikheid van die aksie om seine op te merk, en die effek wat dit op die herbeskouing van raamwerke het, asook die raaksien daarvan in die eerste plek word beklemtoon. Laasgenoemde dui ook aan tot watter mate Weick se singewingsteorie ‘n bydrae maak tot visuele analise veral in ons begrip van die gevolg wat data of inligtingspesifikasie het op die identifisering van seine en onsinnighede in visualisering binne visuele analise-sagteware.

## SUMMARY

This thesis considers the contribution that Karl Weick's notion of sensemaking can make to an improved understanding of weak signals, cues, warning analysis, and software within early warning systems. Weick's sensemaking provides a framework through which the above mentioned concepts are discussed and analysed. The concepts of weak signals, early warning systems, and Visual Analytics are investigated from within current business and formal intelligence viewpoints.

Intelligence failure has been a characteristic of events such as 9/11, the recent financial crisis triggered by the collapse of Lehman Brothers, and the so-called Arab Spring. Popular methodologies such as early warning analysis, weak signal analysis and environmental scanning employed within both the business and government sphere failed to provide adequate early warning in many of these events. These failures warrant renewed attention as to what improvements can be made and how new technology can enhance early warning analysis.

Chapter One is introductory and states the research question, methodology, and delimits the thesis. Chapter Two sets the scene by investigating current conceptions of the main constructs. Chapter Three explores Weick's theory of sensemaking, and provides the analytical framework against which these concepts are then analysed in Chapter Four. The emphasis is directed towards the extent of integration of frames within the analysis phase of early warning systems and how frames may be incorporated within the theoretical foundation of Visual Analytics to enhance warning systems.

The findings of this thesis suggest that Weick's conceptualisation of sensemaking provide conceptual clarity to weak signal analysis in that Weick's "seed" metaphor, representing the embellishment and elaboration of cues, epitomizes the progressive nature of weak signals. The importance of Weick's notion of belief driven sensemaking, in specific the role of expectation in the elaboration of frames, and discussed and confirmed by various researchers in different study areas, is a core feature underlined in this thesis. The centrality of the act of noticing and the effect that framing and re-framing has thereon is highlighted as a primary notion in the process of not only making sense of warning signals but identifying them in the first place. This ties in to the valuable contribution Weick's sensemaking makes to understanding the effect that a specification has on identifying transients and signals in the resulting visualization in Visual Analytic software.

## ACKNOWLEDGEMENTS

I dedicate this thesis to Claire, Johan, Alexandra and my extended family. Without their support and patience, this undertaking would not have been possible. I would like to thank my friends and colleagues for their support and discussions relating to the thesis, in particular my colleague Dr. Herman van Niekerk who shares a common interest. Lastly, I thank Prof. Johann Kinghorn for his expert guidance along the path of completing this thesis.

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Cape Town

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# ABBREVIATIONS

| | |
|---|---|
| AMAN: | Directorate of Military Intelligence (Agaf ha-Modi'in), Israel Defence Force (IDF) |
| C4ISR: | Command, control, computers, communication, intelligence, surveillance, and reconnaissance |
| DCGS-A: | Distributed Common Ground System-Army |
| ELINT: | Electronic intelligence |
| EWS: | Early warning system |
| GEOINT: | Geo spatial intelligence |
| GSR: | Ground surveillance radar |
| HMI: | Human-machine interface |
| HRO: | High Reliability Organization |
| HUMINT: | Human intelligence |
| MASINT: | Measurement and signature intelligence |
| Multi-INT: | Multi source intelligence |
| NVAC: | National Visualization and Analysis Centre |
| OSINT: | Open source intelligence |
| PESTLE: | Political, Economic, Social, Technology, Legal, Environment |
| PNNL: | Pacific Northwest National Laboratory |
| RDF: | Resource Definition Framework |
| SECI: | Socialization, Externalization, Combination, Internalization (Nonaka' Knowledge creation framework) |
| SEWS: | Strategic early warning system |
| SIGINT: | Signals intelligence |
| SWOT: | Strengths, weaknesses, opportunities, threats |
| TECHINT: | Technical intelligence |
| XML: | Extensible Mark-up Language |

# *Chapter 1*
# Introduction

*It is pardonable to be defeated, but never to be surprised – Frederick the Great*[1]

## 1.1 Background

In fusing the definitions provided by Austin[2], Choo[3], Schwartz[4] and Matveeva,[5] an early warning system can be defined as: any initiative, network of actors, resources, technologies, practices, and organizational structures that focus on the systematic collection, analysis, and formulation of recommendations relating to the monitoring of an environment. The purpose of this is to detect opportunities, threats, discontinuities or strategic surprises. An early warning system is a key component in the functioning of an efficient intelligence capability.

Within management literature, early warning has received considerable attention since the publication of Francis Aguilar's[6] *Scanning the Business Environment* in 1967 and H. Igor Ansoff's[7], *Managing Strategic Surprise by Response to Weak Signals* in 1975. In particular, the notion of scanning the business environment for weak signals to provide forewarning of discontinuities, threats and opportunities became the focal point in contemporary organisations.[8]

Early warning and intelligence failure in business and government, is normally purported to be the failure to notice disparate cues or signals within the environment. This failure centres

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[1] Green, R 2006. *The 33 Strategies of War*. Viking Penguin

[2] Austin, A 2004. Early Warning and the Field: A cargo Cult Science? Berghof handbook for conflict transformation, Berghof Research Centre for Constructive Conflict Management, Berlin, August http://www.berghof-handbook.net/documents/publications/austin_handbook.pdf , accessed 2010-06-08

[3] Choo, CW 1999. The art of scanning the environment

[4] Swartz, JO 2005. Pitfalls in implementing a strategic early warning system (23)

[5] Matveeva, A 2006. Early Warning and Early Response: Conceptual and Empirical Dilemmas. Global Partnership for the prevention of armed conflict. Issue Paper 1, European Centre for Conflict Prevention. http://www.gppac.net , accessed 2010-08-07

[6] Aguilar, FJ 1967. *Scanning the Business Environment*

[7] Ansoff, HI 1975. Managing Strategic Surprise…

[8] Seidl, D 2004. The Concept of "Weak Signals" Revisited… (151)

around human ability to make sense of available information in time to provide adequate warning. Research into the surprise attack at Pearl Harbour 1941,[9] Russian surprise with Operation Barbarossa in 1941,[10] Israeli surprise of the Yom Kippur war 1973,[11] the fall of the Soviet Union 1989,[12] the Iraqi invasion of Kuwait 1990[13] and the failure to foresee the 9/11[14] attack all precluded a lack of information as reason. Rather, as Bar-Joseph and Kruglanski argue, the dominant reason for strategic surprise is: "[The] incorrect comprehension of the meaning of available information before the attack – rather than the lack of such information *per se*." [15]

This inability to comprehend the correct meaning of available information and make sense of it, is further compounded by paradoxes evident in the emergence of the knowledge society. As Tsoukas[16] states, the growth and development of information and communication technology has created a knowledge society that is fundamentally dependent on knowledge for its functioning. The irony is that this dependency on, and availability of information, has increased uncertainty and unpredictability, and contributes to the complex environment within which early warning systems function. Consequently, new software technology such as Visual Analytics has been developed to deal with the growth of information and data availability in early warning system analysis. Visual Analytics[17] may be defined as "the science of analytical reasoning facilitated by interactive visual interfaces."

Within the perspective of making sense of information and signals, Karl Weick[18] has contributed a large body of knowledge to the study of sensemaking in organisations. Weick has proposed a framework of seven properties of sensemaking to explain how sensemaking

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[9] Wohlstetter, R 1962. *Pearl Harbour*…; Marrin, S 2004. Preventing intelligence failures…

[10] Stine, R 1974. Codeword Barbarossa; Kenez, P 1999. *The History of the Soviet Union from Beginning to the End*; Marrin, S. 2004. Preventing intelligence failure…

[11] Bar-Joseph, U 2005. *The Watchman Fell Asleep: The surprise of Yom Kippur and its sources*

[12] Xenakis, CI 2002. *What happened in the Soviet Union?*

[13] Allen, CE 1998. Warning and Iraq's Invasion of Kuwait; O'Learly, J 1994. Surprise and Intelligence…; Unknown Author, 2002, Intelligence Failures: Some Historical Lessons, Part 2. *The Estimate*. Volume XV, No 12, http://www.theestimate.com/public/062802.html , accessed 2010-10-10

[14] Byman, D 2005. Strategic Surprise and the September 11 Attacks; Posner, RA 2005. *Preventing Surprise Attacks*

[15] Bar-Joseph, U & Kruglanski, AW 2003. Intelligence Failure and the Need… (77)

[16] Tsoukas, H 2005. *Complex Knowledge* (21, 31-34)

[17] Thomas, JJ & Cook, KA 2005. Illuminating the Path (4)

[18] Weick, KE 1995. *Sensemaking in Organizations*; Weick, KE 2001. *Making Sense of the Organization*

works. In particular, Weick[19] argues that sensemaking is "focused on and by Extracted cues" and that when a cue is connected to a frame a unit of meaning is established.

The main premise of this thesis is that Karl Weick's theory of sensemaking, in particular his theory of frames and framing, can make a contribution to a more sophisticated and effective weak signal analysis in warning systems. Therefore, noticing of weak signals, environmental scanning, Visual Analytics, and sensemaking within early warning systems are concepts that provide the cornerstones around which this thesis is built.

## 1.2 Research proposition

In the current discourse pertaining to weak signal analysis, environmental scanning, warning system analysis, and Visual Analytics there is a mutually enriching theoretical overlap with the concept of sensemaking. Sensemaking can be viewed as a critical component, as without it the value and contribution of these concepts in helping organisations recognize opportunities and threats are diminished.

### 1.2.1 Research objective

The aim of this thesis is to investigate how the incorporation of Weick's frames theory of sensemaking in the early warning process, may improve cue and weak signal recognition; and how it can be incorporated into the theoretical underpinnings of Visual Analytics in support of early warning systems. The investigation may provide an improved model of early warning systems analysis, which may pave the way for an intervention on a practical level.

The application of Weick's frames theory of sensemaking may not necessarily solve all the conceptual problems associated with weak signals, cues, Visual Analytics and warning analysis. However, the intended outcome of this research, is to demonstrate, that the application of Weick's concepts of "frames" and "cues," as an analytical framework, facilitates and promotes a higher level of insight and understanding of the meaning of these concepts.

### 1.2.2 Methodology and assumptions

In order to attain the stated research objective, that of building and expanding on current early warning theory and models, a conceptual approach is followed. The research strategy adopted was to evaluate the current literature on weak signal analysis, environmental scanning, Visual

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[19] Weick, KE 1995. *Sensemaking in Organizations* (50)

Analytics, and early warning systems by using a Weickian sensemaking framework as an interpretive lens. Weick's[20] theory of sensemaking is used as a point of departure to compare and critically review the conceptual foundations of weak signal analysis, environmental scanning and Visual Analytics in early warning analysis.

Conceptual analysis seeks to increase our understanding of concept usage by reducing complex concepts to more fundamental and simple levels. This is achieved by explication which reveals these concepts' constituent elements and parts. The goal of submitting constructs such as weak signals, environmental scanning, early warning system analysis, and Visual Analytics to conceptual analysis is "to increase conceptual clarity of a theory through careful clarifications and specifications of meaning"[21] ultimately comparing and clearly delimiting them.

A critical review from a sensemaking perspective may force a re-evaluation of these concepts and improve organisational early warning and decision making capabilities in particular, and the use and implementation of analytical visualisation software in general. It is against this background, characterized by constructs such as information overload, the inability to comprehend the correct meaning, uncertainty, unpredictability, complexity and software tools developed in an attempt to solve some of these challenges in early warning systems that this thesis makes a contribution to building and expanding current theory, models, and existing knowledge.

Making sense of warning information in an early warning system requires a "crystal ball" like gaze into some possible future state. Bodnar defines warning as "a prediction of the future." [22] In this regard Tsoukas[23] and Narayanan and Fahley[24] posit that the future, from an ontological perspective, is non-existent, open-ended and un-knowable. Therefore, the assumption is made that the future potentiality of weak signals and cues have to be determined from within a constructivist epistemological grounding. However, it is accepted in this thesis that from within a sensemaking perspective humans and reality can be both ordered and chaotic, which require very different epistemological approaches. Weick simultaneously propagates a realist

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[20] Weick, KE 1995. *Sensemaking in Organizations*

[21] Machado, A & Silva, FJ 2007. Towards a richer view… (671) quoting Lauden, L 1977. *Progress and its problems: Towards a theory of scientific growth.* Berkley. University of California Press

[22] Bodnar, JM 2003. Warning analysis for the information age… (11)

[23] Tsoukas, H 2005. *Complex Knowledge* (276)

[24] Narayanan, VK & Fahey, L 2004. Invention and navigation as contrasting metaphors… (39)

and idealist ontology, "that something is out there to be sensed" and "that something out there needs to be agreed on and constructed plausibly." [25] Consequently, a pluralist epistemological grounding is accepted in evaluating Weick's sensemaking relative to the constructs investigated in this thesis.

### 1.2.3 Delimitation

The scope of this study is limited to literature on early warning systems as are found in the formal intelligence, Futures Studies and business early warning sectors. Warning systems where the collection and interpretation of telemetric data is the central focus of the warning system, are excluded. Examples in this regard are earth quake, tsunami, extreme weather warning systems and geological hazards. Weak signals literature as part of the attenuation of signals in physical, engineering, and electronic communication systems are also excluded.

Within Futures Studies, extensive literature regarding weak signals are available in Nordic countries such as Finland. In this regard only English text were used and where possible references to non-English texts were used as referenced and quoted in other English texts.

Similarly, an investigation into the epistemological foundations of current and past research relating to weak signals analysis, environmental scanning, and Visual Analytics fall outside the scope of this thesis as a pluralist epistemological assumption is assumed.

Analytical and psychological bias has featured prominently in discourses relating to intelligence failure, warning and surprise. Although the influence of these biases is recognized, they fall outside of the scope of this thesis.

The sensemaking theory of Weick is the point of departure and other frameworks such as that of Dervin,[26] Aaltonen[27] and Kurtz and Snowden[28] are not included. However, the work of Gary Klein is referenced in part where deemed applicable due to the close association and similarities on an individual level of sensemaking. So-called "sensemaking" frameworks are discussed relating to Visual Analytics, but they refer to representation construction models and referred to where necessary in the thesis as "sense-making."

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[25] Weick, KE 1995. *Sensemaking in Organizations* (55)

[26] Dervin *Et al.* 2003. *Sense-Making Methodology Reader*

[27] Aaltonen, M 2007. Strategic Decision-making

[28] Kurtz, CF & Snowden, DJ 2003. The new dynamics of strategy

Furthermore, framing is a highly abstract concept. Because of its abstract nature, an artificial delimitation is necessary during analysis in terms of looking at framing as a snapshot or singularity when in fact it is a continuous cycle or process. The on-going nature of framing operations is acknowledged explicitly throughout this thesis. However, in some instances it is viewed as a singular event allowing a logical "window" to investigate instances of where a cue is placed within a frame to establish meaning.[29]

## 1.3 Structure of thesis

In order to use Weick's theory of sensemaking as a framework to evaluate weak signals, warning systems and Visual Analytics as set out in the research objective, the thesis is structured according to the following chapters:

Chapter One is the introduction to the thesis and provides a general background, problem statement, methodology to be followed, and delimitation.

Chapter Two sets the foundation of the thesis by exploring the key concepts of warning, early warning analysis models, Visual Analytics and weak signals in three distinct sub-sections.

Chapter Three reviews Karl Weick's theory of sensemaking in specific the role of framing in noticing cues. The seven properties of sensemaking are briefly discussed to provide background. This chapter provides the framework through which the constructs discussed in Chapter Two will be analysed.

Chapter Four is an analysis of the constructs discussed in Chapter Two relative to the framework provided by Weick's sensemaking in Chapter Three. The initial focus is on weak signals. Secondly, the addition of frames theory of sensemaking in warning systems is evaluated. The concept of Warning Event Bridging (WEB) is introduced, after which Weick's contribution is assessed relative to software and Visual Analytics in particular.

Chapter Five, the final chapter, concludes the thesis by a discussion of the implications that Weick's framework holds for the weak signals, early warning analysis, and Visual Analytics.

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[29] Weick, KE 1995. *Sensemaking in Organizations* (111)

# *Chapter 2*

# Cues, weak signals, and Visual Analytics in early warning systems

*Control people's perception of reality and you control them – Robert Green* [30]

## 2.1 Introduction

Chapter Two sets the foundation of the thesis by exploring key concepts such as Warning, Early Warning Analysis Models, Visual Analytics[31] and Weak Signals in three specific sections. The first section includes perspectives relating to early warning analysis models within both the formal intelligence and business environment. Warning as a concept is briefly explored within: (1) the formal intelligence environment, focusing on how it fits within the intelligence cycle, and issues relating to analytical processes and (2) the business environment.

Section two is a synopsis of Visual Analytics models, which has a specific function of trying to create opportunity in the large and overwhelming amount of information available to warning analysts. In specific, its supporting role of helping analysts to make sense of large datasets in providing interactive visualisations to facilitate analysis is reviewed.

The third section investigates conceptualisations of weak signals. It focuses on the signals and cues that provide individuals with forewarning of possible surprise, in specific the notion of weak signals that supposedly provide forewarning of impending change. Different perspectives relating to weak signals are discussed, as well as the contributions made from a constructivist stance by authors such as Seidl, Rossel, and Narayanan and Farley.

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[30] Green, R 2006. *The 33 Strategies of War* (299)

[31] The term Visual Analytics (Analytics in plural form) refers to a specific science and will be used in this format throughout this thesis to denote the science.

## 2.2 Section One – Warning and intelligence

The experienced US Defence Intelligence Agency (DIA) analyst Cynthia Grabo has provided insights into analysis for strategic warning and anticipating surprise within the field of warning intelligence.[32] Grabo recognises warning intelligence as a distinct function of intelligence, rather than a definable type of intelligence product, which is distinguished by its purpose or function. Grabo describes warning as intangible, an abstraction, a theory, perception, belief or product of reasoning or logic, "a hypothesis whose validity cannot be confirmed or refuted until it is too late."[33] Bodnar, building on Grabo's work, states that:

> Warning is a prediction of the future that matches past and current indicators with a model of the future. Therefore, warning depends very heavily on models or mental images of what the world is and how it works.[34]

Warning is an assessment of probabilities, lacks absolute certainty, and does not exist until it has been conveyed to policy or decision-makers. Grabo maintains that warning produces a conviction that results in action and that most crises have roots deep in the past. In this regard the best warning analysis does not flow from the "most methodical and diligent review of current information" but rather all possible information.[35]

Of importance is Grabo's distinction between "indication" and "indicator." An indicator is defined as something which we anticipate or expect to occur, and can be incorporated into a list of things that have to be monitored. An indication is a development of any sort or kind, a confirmed or possible fact, or an absence of something or fragment thereof, and uncertain by nature. The distinction is made between an expectation and actuality or between a theory and a current development – "Information that any step is actually being implemented constitutes an indication."[36] This distinction is an important one from a sensemaking perspective, and from this thesis's point of view, as the identification of an indicator triggers an expectation on the side of the analyst monitoring a situation for indications. The importance of *expectation* as a belief-driven form of sensemaking will become clearer in the chapters to follow.

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[32] Grabo, CM 2004. *Anticipating Surprise: Analysis for Strategic Warning*. University Press of America. New York. The book is an abridged version of a trilogy of three volumes spanning 800 pages. It took Grabo three years to write and 30 years before it was declassified and made available for public release.

[33] Grabo, CM 2004. *Anticipating Surprise* (3-4)

[34] Bodnar, JW 2003. Warning Analysis for the information Age… (11)

[35] Grabo, CM 2004. *Anticipating Surprise* (6-7)

[36] Grabo, CM 2004. *Anticipating Surprise* (3)

Warning from within the intelligence community is understood within a broad sense in that it encompasses activities that provide support to policy and decision makers in attaining their strategic goals. This, according to Cooper,[37] includes making sense of the strategic environment, assessment of alternatives and, above all, protecting against consequential surprise. However, due to the increased globally networked society as a consequence of the knowledge economy, transnational issues such as terrorism, organized crime, money laundering, narcotics, human organ trafficking, illicit copper and weapons trade have increased the complexity and scope of the monitoring brief of intelligence services. Cavelty and Mauer state that this new spectrum of threats is subject to characteristics such as complexity, uncertainty and a diminishing impact of geographical space.[38]

### 2.2.1 The intelligence cycle and analysis process

Intelligence is produced within an intelligence-tasked organisation via what is commonly known as the intelligence cycle. This cycle has been described by Marrin[39] as:

> …[a] heuristic device to portray the flow of information between intelligence agencies and policymakers – provides a descriptive theory of intelligence that is a good starting point for the interaction between information (facts), knowledge, and decision…[and] this cyclic process provides both scholars and practitioners with a framework for understanding the processes that underlie analytic production.

The cycle is a five-step process that starts with *Planning and Direction* where decision and policy makers provide their information requirements which then directs the *Collection* process. Collected information either from human, signals, technical or geographical based sources[40] are *Processed* and passed on to intelligence analysts for analytical evaluation. Analysts *Disseminate* the analysed intelligence back to the decision or policymakers. This process is normally depicted as a cyclic flow as illustrated in figure 1 on page 10:

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[37] Cooper, JR 2005. *Curing Analytical Pathologies* (16)

[38] Cavelty, MD & Mauer, V 2009. Postmodern Intelligence: Strategic warning… (128)

[39] Marrin, S 2009. Intelligence Analysis and decision-making (131)

[40] This is not a complete list of sources of intelligence. Sources of intelligence are normally classified as per information source or sensor type: HUMINT - Human Intelligence, SIGINT- Signals Intelligence, OSINT – Open Source Intelligence, GEOINT – Geospatial Intelligence, TECHINT – Technical Intelligence.


**Figure 1 - The Intelligence Cycle**[41]

There is considerable debate as to whether this cycle is an accurate depiction of intelligence production. This traditional view gives the impression, according to Johnson,[42] that all inputs into the cycle are constant and have a mechanical-like flow. Johnson examined the traditional cycle from a systematic and systemic perspective. He states that this traditional model does not accurately represent the differences in cognitive complexity involved in producing different kinds of intelligence products such as long-range assessments or national intelligence estimates.[43] A comprehensive discussion relating to the efficacy of the traditional intelligence cycle is provided by Duvenage,[44] Johnson[45] and Marrin.[46] For the purposes of this thesis it is accepted as a heuristic in the similar manner as intended earlier by Marrin.

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[41] CIA Intelligence Cycle. Diagram source: http://www.fas.org/irp/cia/product/facttell/intcycle.htm

[42] Johnson, R 2005. Analytical Culture in the US Intelligence Community – An Ethnographic Study. The Center for Intelligence Study, Washington. Available at, http://www.au.af.mil/au/awc/awcgate/cia/analytic culture.pdf , accessed 2011-05-22

[43] Johnson, R 2005. Analytical Culture in the US Intelligence Community (45-51)

[44] Duvenage, MA 2010. Intelligence Analysis in the Knowledge Age. An analysis of the Challenges facing the Practice of Intelligence. M.Phil Thesis, Stellenbosch University. Available at http://scholar.sun.ac.za/ bitstream/handle/10019.1/3087/duvenage-m-a-2010.pdf?sequence=3 , accessed 2012-12-20

[45] Johnson, R 2005. Analytical Culture in the US Intelligence Community – An Ethnographic Study. The Center for Intelligence Study, Washington. Available at: http://www.au.af.mil/au/awc/awcgate/cia/analytic culture.pdf , accessed 2011-05-22

The effectiveness of structured versus intuitive analytical techniques is also a subject of intense debate in the intelligence analysis community since the publishing of Richards J. Heuer's book, *The Psychology of Intelligence Analysis*.[47] Sundry Khalsa[48] has provided a good summation of this debate, detailing arguments from proponents within the intuitive and structured analytical camps. Khalsa argues for a combination of structured analytical techniques and intuition in early warning analysis - a systematic analytical process. She proposes seven distinct phases within the warning analysis process that is set out in table 1 on page 12. Indicators form a central theme in these phases and a list thereof drives information collection requirements to help analysts forecast identified indicators. There are similarities between Khalsa's proposed framework and that of Bodnar's discussed below, as well as that of Pirolli and Card's notional model of intelligence analysis. The core of these similarities also centre on an "information foraging" phase and a "sensemaking" phase. Khalsa's framework, however, ties into Grabo's emphasis on indicators, which again highlights the concept of creating expectations.

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[46] Marrin, S 2009. Intelligence analysis and decision-making: methodological challenges. In Gill, P Marrin, S and Phythian, M (eds.) *Intelligence Theory. Key questions and debates*. Studies in Intelligence series. Routledge. London. (Kindle edition)

[47] Heuer, RJ 1999. *The Psychology of Intelligence Analysis*. Centre for the Study of Intelligence: Central Intelligence Agency.

[48] Khalsa, S 2009. The Intelligence Community Debate over Intuition versus Structured Technique (75-86)

**Table 1- Seven Phases of the Intelligence-Warning Process with Corresponding Essential Elements**[49]

| The Seven Phases of the Intelligence Warning Process | Seven Essential Elements with Analogy to Constructing a Building | Structured Techniques |
|---|---|---|
| **I. Identify the Key Elements of Information Required to Forecast a Topic** | **1. Indicators and Indicator Question Sets**<br>The Building Blocks of a Warning Assessment | - Lists<br>- Indicators<br>- Question sets/trees<br>- Organized brainstorming<br>- Thinking backwards<br>- Causal flow diagramming<br>- Case studies<br>- Trend analysis<br>- Sorting<br>- Chronologies<br>- Prioritization |
| **II. Publish an Intelligence Collection Plan** | **2. Collection Requirements**<br>The Purchase Order for the Building Blocks | - Indicators<br>- Question sets/trees<br>- Lists<br>- Prioritization<br>- Numerical associations<br>- Utility matrix logic |
| **III. Consolidate Information** | **3. "Master Database"**<br>The Foundation to Lay All the Building Blocks | - Consolidating |
| **IV. Sort Information** | **4. Hypothesis Matrices**<br>The Blueprint of a Warning Assessment | - Indicator filtering<br>- Sorting (key word)<br>- Data mining<br>- Matrices |
| **V. Draw Conclusions** | **5. Systematic Process that Combines Intuitive and Structured Techniques**<br>The Tools to Build the Blocks | - Hypothesis testing<br>- Red teams<br>- Devil's advocacy<br>- Indicator filtering<br>- Question sets/trees<br>- Numerical associations<br>- Levels of confidence<br>- Standardized language (combining words and numbers)<br>- Color coding<br>- Matrices<br>- Utility matrix logic<br>- Simple averaging<br>- Weighted ranking in averaging<br>- Bayesian theorem<br>- Other mathematical formula (to combine multiple factors)<br>- Trend analysis<br>- Comparative analysis |
| **VI. Focus Collectors on Intelligence Gaps to Refine/Update Conclusions** | **6. Re-Prioritized Collection Requirements**<br>Repair and Maintenance Requirements | - Prioritization<br>- Numerical associations<br>- Standardized language (combining words and numbers)<br>- Utility matrix logic<br>- Indicators<br>- Question sets/trees<br>- Lists |
| **VII. Communicate Conclusions/Give Warning** | **7. The Warning Assessment Templates that Combine Narratives and Color -Coded Warning Level Graphics**<br>The Building | - Standardized language (combining words and numbers)<br>- Numerical associations<br>- Levels of confidence<br>- Color coding<br>- Matrices<br>- Prioritization<br>- Lists |

[49] Khalsa, S 2009. The Intelligence Community Debate over Intuition versus Structured Technique (75-86)

### 2.2.2 Boshoff's differences between early warning and intelligence

Concurrent with the intelligence cycle and analysis debates is a discussion involving the differences between early warning and traditional intelligence systems. Boshoff[50] has outlined the differences between early warning and traditional intelligence systems as depicted in the table 2 below:

**Table 2 - Boshoff's Differences between Early Warning and Traditional Intelligence[51]**

| **Early Warning** | **Traditional Intelligence Systems** |
|---|---|
| Depends on the collection and analysis of information, scenario-building and the presentation of recommendations to decision-makers | Depends also on the collection and analysis of information, scenario-building and the presentation of recommendations to decision-makers |
| Focuses on human security | Focuses on state security |
| Seeks to serve larger objectives than those of the state *stricto sensu* | Seeks to serve state interest |
| Depends on transparent methods and sharing of information | Rely on secrecy, situation rooms and encrypted communications of classified information |
| Transparency in information and analysis | Closed system |
| Decentralized and dependent upon other sources of information and analysis | Centralized and dependent on in-house information and analysis |

However, Boshoff's differentiation is from within a conflict early warning perspective where there are sovereignty concerns and various non-governmental organisations providing early warning monitoring services. Perry[52] is critical of the perception of proponents of the conflict-based view of early warning that intelligence involves only secrecy and national interest. He views this misperception as troubling as it seriously damages the universality of intelligence's utility. Perry emphasises the interdisciplinary nature of warning intelligence

[50] Boshoff, H 2003. Meeting the challenge of conflict prevention in Africa… (6)

[51] Boshoff, H 2003. Meeting the challenge of conflict prevention in Africa… (6)

[52] Perry, BE 2008. Fast and Frugal Conflict Early Warning in Sub-Saharan Africa: The role of Intelligence Analysis (5-11)

and cites Laur[53] in that the primary role of warning intelligence is "to aid the decision maker in avoiding surprise." In concurrence with Perry's view, is the fact that various sources of information are at play within the intelligence cycle. Not all sources are necessarily covert in nature. The separation is artificial as covert sources are merely a different type of information source not necessarily available to non-state actors.

### 2.2.3 Models of early warning

In terms of expanding on the various sub-sections of the intelligence flow, Peter Pirolli and Stuart Card[54] have devised a model by employing cognitive task analyses[55] to map out the process intelligence analysts follow during the analytical phase of the cycle. See below.

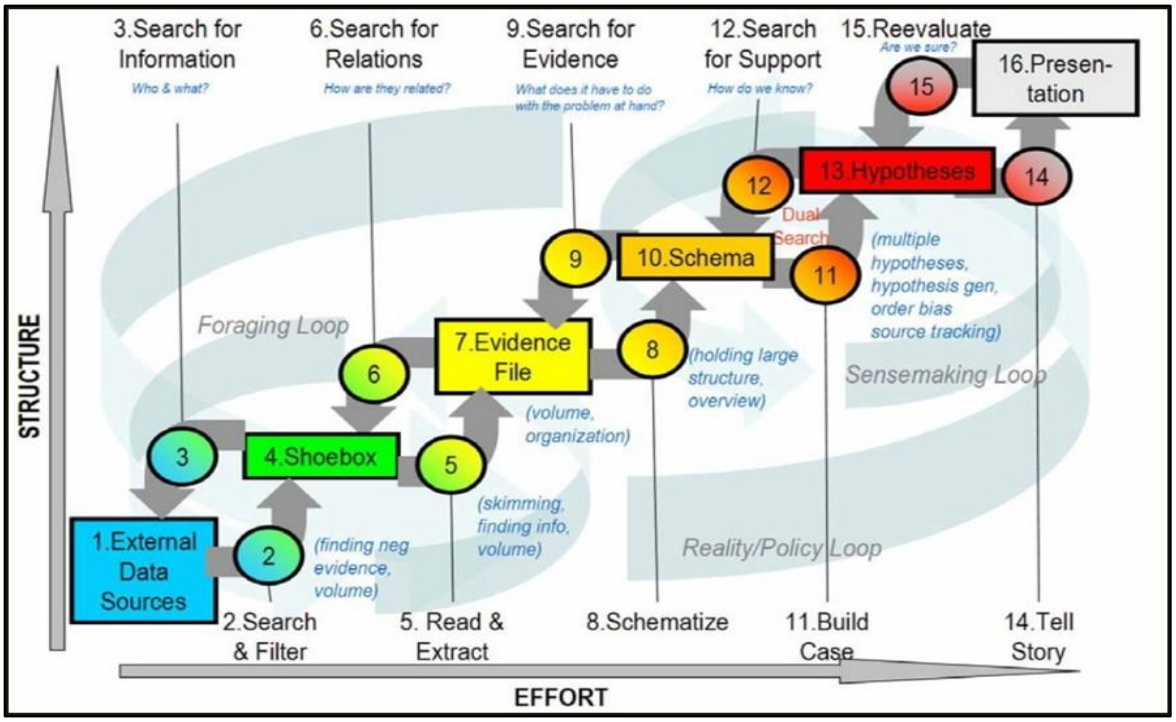


**Figure 2 – Pirolli & Cards' notional model of intelligence analysis[56]**

They found evidence that intelligence analysts use schemata in order to represent information "coming in" to the analysis environment. Their model specifically emphasises the role of

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[53] Laur, TM 1986. Principles of Warning Intelligence. (151) as cited in Perry, BE. 2008 Fast and Frugal Conflict Early Warning in Sub-Saharan Africa: The role of Intelligence Analysis. (6)

[54] Pirolli, P & Card, S 2005. Sensemaking processes and leverage points… (1-6)

[55] Mitello & Hutton (1998: 1618) define cognitive task analysis as a "set of methods for identifying cognitive skills, or mental demands, needed to perform a task proficiently." It is a technique to gather information about knowledge, thought processes and goal structures by studying and capturing information about both the overt observable behaviour and covert cognitive functions of individuals whilst executing of a task (Chipman *Et al.* 2000: 3)

[56] Pirolli, P & Card, S 2005. Sensemaking processes and leverage points… (2)

"schematic knowledge structures built for expertise and experience" which allows an analyst to make sense of a situation and determine adequate courses of action.[57]

Pirolli and Russell[58] have recently categorised sensemaking into three perspectives or groups: (1) the representation construction model of sensemaking, (2) the data/frame perspective of sensemaking, and (3) the collaborative sensemaking perspective. The representation construction model is central to the field of human computer interaction (HCI). In essence, it represents a model that explains the formational process and the working of external knowledge representations facilitating insight and action. Pirolli and Card's notional model of analyst sensemaking depicted in figure 2 on page 14, falls under this perspective. Sensemaking is seen as a "process of shaping representations [that may] be understood in terms of its effects on changing the knowledge *available* to humans interacting with computers." The data flow is transformational in that: (1) the information from its "raw" state is transformed via "expertise" and then (2) it is transformed again into a form that is appropriate for communication. Russell *Et al.*[59] recognise four main processes, (1) searching for representational structures or schemata that can organise information, (2) creating instances of these representations, (3) modification of the representations, and (4) use of representations in performing tasks. There is a sense of linearity implied although Pirolli and Russell highlight iterative loops in the process.

Going forward in this thesis the representation construction model of sensemaking will be referred to as "sense-making" and it is not compared to Weick's theory of sensemaking which is closer to the data/frame and collaborative perspective and represented by the term "sensemaking."

The model as depicted in figure 2, contains two loops, a foraging loop and a sense-making loop. The foraging loop defines processes centred on information seeking, filtering, extraction and reading. The sense-making loop involves iterative development of a "mental model from the schema that best fits the evidence"[60] or a representational schema.[61] Information processing as depicted in figure 2 can be driven as a top-down hypothesis testing

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[57] Pirolli, P & Card, S 2005. Sensemaking processes and leverage points… (1-6)

[58] Pirolli, R Russell, DM 2011. Introduction to Special issue… (3-5)

[59] Russell *Et al.* 1993. The cost structure of sensemaking (1-9)

[60] Pirolli, P & Card, S 2005. Sensemaking processes and leverage points… (2)

[61] Pirolli, P & Russell, DM 2011. Introduction to this special issue on Sensemaking (3)

process or a bottom-up exploratory process.[62] Pirolli and Card[63] posit that their analysis suggests that top-down and bottom-up processes are invoked in an adaptable manner. Furthermore, they state that the dataflow in the model represents an information transformation from a raw state to one where know-how and expertise may be applied, as well as those formats suitable for communication.[64]

In addition, and of specific interest, is their statement that sense-making represents a process of shaping representations which can be understood "in terms of its effects on changing the knowledge available to humans interacting with computers and changing the computational cost structure of accessing and using that knowledge."[65] In the model, processes and data are arranged by degree of effort as a measurement of: (1) the amount of time required, (2) number of operations or overall cost of processing, and (3) the degree of structure. In development of this model, Pirolli and Card were interested in intelligence analysis involving massive amounts of data. Taking a massive amount of data into account, they identified various time based leverage points concerning the foraging loop in particular:

- Thorough exploration of an information environment ensures that the missing of salient elements of the data is limited, but working through it has a temporal cost.
- Analysts spend considerable time scanning data as well as seeking and assessing the relevance of entities.
- The time taken in shifting attentional control to a new information domain is usually costly.
- Additional time is spent on follow-up searches as extracted information generates new questions.

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[62] An argument can be made that the two loops of Pirolli and Card's model (foraging and sense-making) has its roots in Wallace's "Wheel of Science" (Wallace: 1971; Babbie: 2013). This is in essence a cycle between deductive and inductive reasoning from an analyst's perspective. The top down approach in the Pirolli and Card model would be akin to an experienced analyst being able to posit hypotheses regarding a problem situation and then search for information to either refute or support postulated hypotheses. A bottom up approach would reign when an analyst first has to investigate a problem statement before being able to posit hypotheses about a situation. Seasoned analysts would most likely follow a top down approach and novices a bottom-up. This is due to the reason that a senior analyst can draw on more elaborate frames and a larger repertoire of frames.

[63] Pirolli, P & Card, S 2005. Sensemaking processes and leverage points… (2)

[64] Pirolli, P & Russell, DM 2011. Introduction to this special issue on Sensemaking (4)

[65] Pirolli, P & Russell, DM 2011. Introduction to this special issue on Sensemaking (4)

In terms of the sense-making loop, leverage points are associated with problem structuring, which according to Pirolli and Card[66] encompass hypothesis generation, evidentiary reasoning and decision making. These leverage points are affected by cognitive biases such as the inherent capacity limits of human working memory, human perceptional biases towards interpretation of information into existing schemata, as well as expectations and confirmation bias. Human analytical biases[67] such as availability, hindsight bias, black swans and anchoring are well documented and a full description thereof falls outside of the scope of this thesis.

Similarly, John Bodnar[68] proposed an equivalent to Pirolli and Card's model regarding how a warning analyst builds an assessment. The essence of Bodnar's model (from the analyst's point of view) is a collection and information cycle which he places within Boyd's Observation – Orientation – Decision – Action cycle (OODA loop).[69] The effect of the knowledge economy and its accompanying complexity is a central feature in Bodnar's efforts to provide a model for analysis in the intelligence warning environment and to argue for a shift away from the deterministic paradigm. Bodnar's model is depicted in figure 3 on page 18.

[66] Pirolli, P & Card, S 2005. Sensemaking processes and leverage points… (4-5)

[67] Yudkowsky, E 2008. Cognitive Biases Potentially Affecting Judgements of Global Risks (91-119)

[68] Bodnar, J 2003. Warning Analysis for the information Age… (132)

[69] Bodnar, J 2003. Warning Analysis for the information Age… (51 - 71)

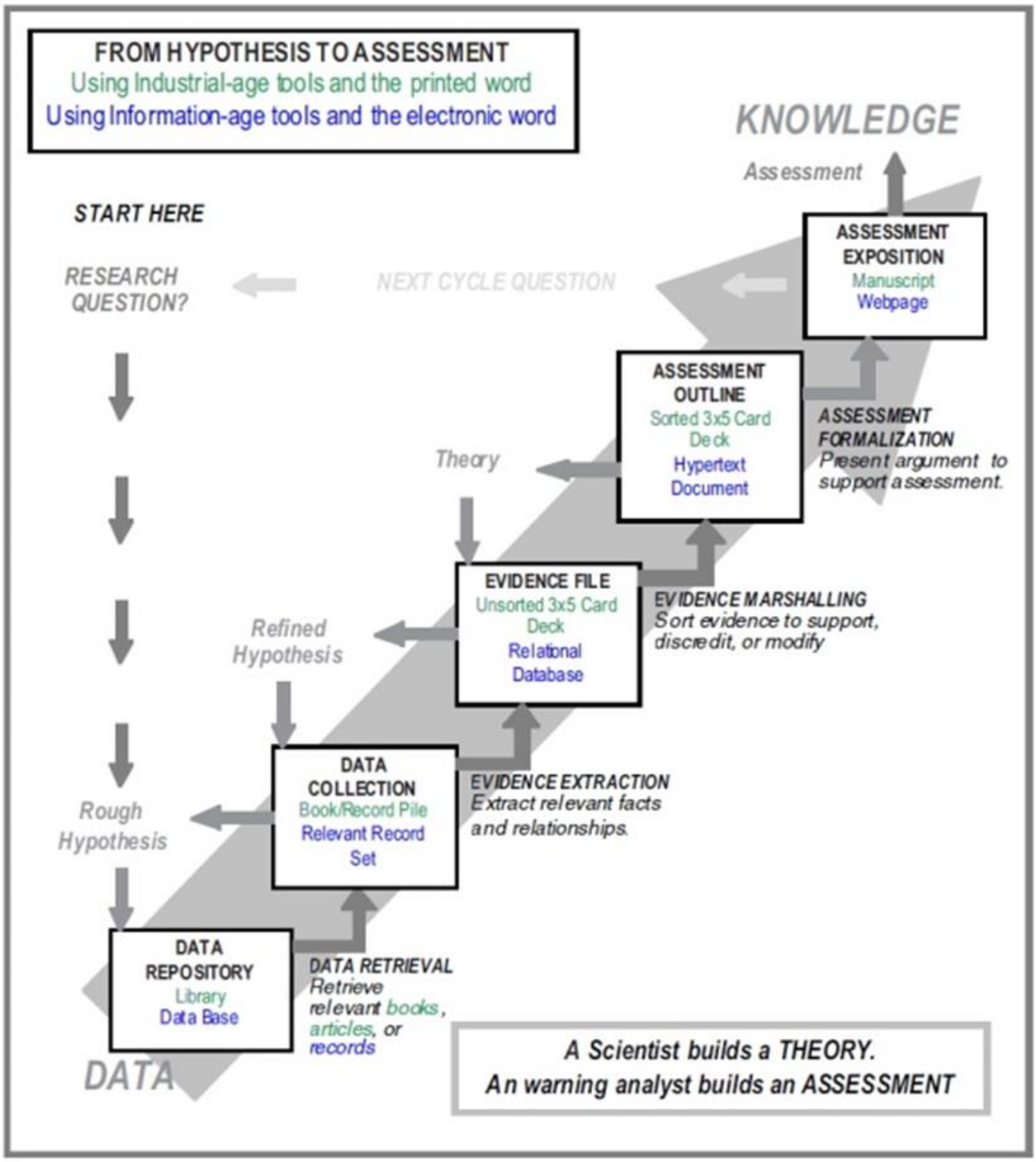


**Figure 3 - Bodnar's Model - From Hypotheses to Assessment**[70]

The massive availability of data in the analysis process of early warning systems, as well as the characteristics of big data, that of volume, variety and velocity is problematic.[71] Big data is beyond the ability of legacy database software tools to manage, store and analyse - specific new software tools are necessary to deal with it.

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[70] Bodnar, J 2003. Warning Analysis for the information Age… (132)

[71] Manyika *Et al.* 2011. *Big data: the next frontier for innovation, competition, and productivity*, McKinsey Global Institute Report, New York, NY

## 2.3 Section Two – Software within warning analysis: Visual Analytics

Thomas and Cook,[72] taking Bodnar and Pirolli and Card's models into account, affirm that processes such as gathering, finding and extracting information, and re-representing it for analysis has a cost. This cost may be considered in terms of time investment, level of difficulty, and resource requirements. Hence, they argue that Visual Analytics, in particular the capabilities of information visualisation and computational data analysis as applied to analytical reasoning, can support the so called "sense-making loop" within these models. Specifically how information visualisation augments human cognitive capabilities in the following ways:

- It increases cognitive resources by using visualization of data to expand memory.
- It reduces searching by representing a large amount of information in a small space.
- By enhancing the recognition of patterns in time and space.
- It supports the easy perceptual interpretation of relationships.
- By perceptual monitoring of numerous potential events.
- By provisioning of a workspace that may be manipulated interactively enables the exploration of parameter values.

Visual Analytics could thus facilitate the process points along Pirolli and Card's model (figure 2) and enhance the scale and effectiveness of analyst schemata. The cost structures associated with this notional model of intelligence analysis can be reduced through Visual Analytics by, (1) transforming information into forms that allow for more effective cognitive processing, and (2) enabling software to help with filtering, representation translation and interpretation of information.

### 2.3.1 Visual Analytics – dealing with large datasets in early warning analysis

In the aftermath of 9/11 the founding of the National Visualization and Analysis Centre (NVAC™) of the US Department of Homeland Security in 2004 had a profound effect on the establishment of Visual Analytics as a scientific discipline.[73] This was followed in 2005 with

[72] Thomas, JJ & Cook, KA 2005. *Illuminating the Path* (46-47)

[73] Kielman *Et al.* 2009. Foundations and frontiers in Visual Analytics (239)

the release of *Illuminating the Path*[74] that served as a roadmap of sorts for the development of Visual Analytics as a science.

Visual Analytics is defined in *Illuminating the Path* as the "science of analytical reasoning facilitated by interactive visual interfaces."[75] It was largely a response to the challenges of analysing overwhelming amounts of disparate, conflicting and dynamic information to prevent and respond to emerging terror threats and attacks and to protect the United States border. Visual Analytics is a multi-disciplinary field that includes:

- Analytical reasoning techniques
- Visual representations and interaction techniques
- Data representations and transformation
- Techniques supporting the production, presentation and dissemination of the results.

According to Thomas and Cook[76] the science of analytical reasoning provides the framework upon which to develop visual analytic technologies for the goal of:

> [Facilitating] this analytical reasoning process through the creation of software that maximizes human capacity to perceive, understand, and reason about complex and dynamic data and situations. It must build upon an understanding of the reasoning process, as well as an understanding of underlying cognitive and perceptual principles, to provide mission-appropriate interactions that allow analysts to have a true discourse with their information. The goal is to facilitate high-quality human judgment with a limited investment of the analysts' time.

Similarly, Keim *Et al.*[77] confirm the central role that the concept of the "information overload problem" has played in the development of Visual Analytics as a science. They refer to this problem as "getting lost" in data that is irrelevant to the task at hand and inappropriately processed and presented. Accordingly, they see the overarching driving vision of Visual Analytics as turning information overload[78] into an opportunity and its goal to make data and

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[74] Thomas, JJ & Cook, KA (eds.) 2005. *Illuminating the Path -The Research and Development Agenda for Visual Analytics*. IEEE. http://nvac.pnl.gov/docs/RD_Agenda_VisualAnalytics.pdf, accessed 2010-09-23

[75] Thomas, JJ & Cook, KA 2005. *Illuminating the Path* (4)

[76] Thomas, JJ & Cook, KA 2005. *Illuminating the Path* (6)

[77] Keim *Et al.* 2008. Visual Analytics: Definition, Process, and Challenges (154-154)

[78] Information load is most often referred to in management literature as "information overload." Li & Li (2011: 49) and Speier *Et al.* (1999:337) refer to information overload as the anxiety and fatigue that a person experiences while not having the capacity to deal with the information and state that the concept has its roots

information processing "transparent for an analytical discourse". Central to this idea is: (1) the management and difficulties associated with very large data sets, (2) the ability to combine individual data handling steps into the visual analytic "pipeline," and (3) creating interactive visualisations optimized for efficient human perception.

Keim *Et al.*[79] also provide an important distinction between Visual Analytics and information visualisation. Whilst they are closely related and there is some overlap, visualisation does not necessarily deal with analytical tasks or advanced data analysis algorithms. Where information visualisation focuses on the process of producing views and creating interaction techniques for a specific class of data, Visual Analytics focuses on data analytics from the start - an approach combining decision-making, visualisation, human factors and data analysis.

Recently, Kohlhammer *Et al.*[80] provided a slightly updated definition of Visual Analytics, in that it "combines automated analysis techniques with interactive visualizations for an effective understanding, reasoning and decision making on the basis of very large and complex datasets." They expand on this by stating that Visual Analytics is the creation of tools and techniques to:

- Synthesise information and derive understanding from massive, dynamic, ambiguous, and conflicting data.
- Detect the expected and discover the unexpected.
- Provide timely, sound, and understandable assessments.
- Communicate these assessments effectively for action.

The emphasis in the process, as illustrated by figure 4 on page 22, is a combination of automatic and visual analysis methods fused by human interaction to derive knowledge from

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in cognitive psychology. Eppler & Mengis (2003: 7-15) have argued that everyday use of the term information overload has led to additional constructs such as cognitive overload, sensory overload and information fatigue syndrome. In addition, they provide five key contributors to information overload; (1) information processing capacity, (2) organizational design, (3) the nature of the information, (4) the person processing the information, and (5) information technology. Eppler and Mengis (2003) provide a detailed literature study of information overload and the reader is directed to this paper for a detailed review. However, it should be noted that some researchers, such as Schwartz *Et al.* (1986:227-303), posit that the term information overload is a myth in the sense that individuals "satisfice" and make do with what they can to make a decision. They state that when "choice [or information]sets become large or choice tasks complex relative to consumers' time or skill, consumers satisfice rather than optimize" (Schwartz *Et al.*, 1986:301).

[79] Keim *Et al.* 2008. Visual Analytics: Definition, Process, and Challenges (158)

[80] Kohlhammer *Et al.* 2011. Solving problems with Visual Analytics (118)

the given data. The authors posit that Shneiderman's[81] adage for information visualisation "Overview first, zoom/filter, details on demand" is replaced with the Visual Analytics adage "Analyse first, show the important, zoom/filter, analyse further, details on demand."

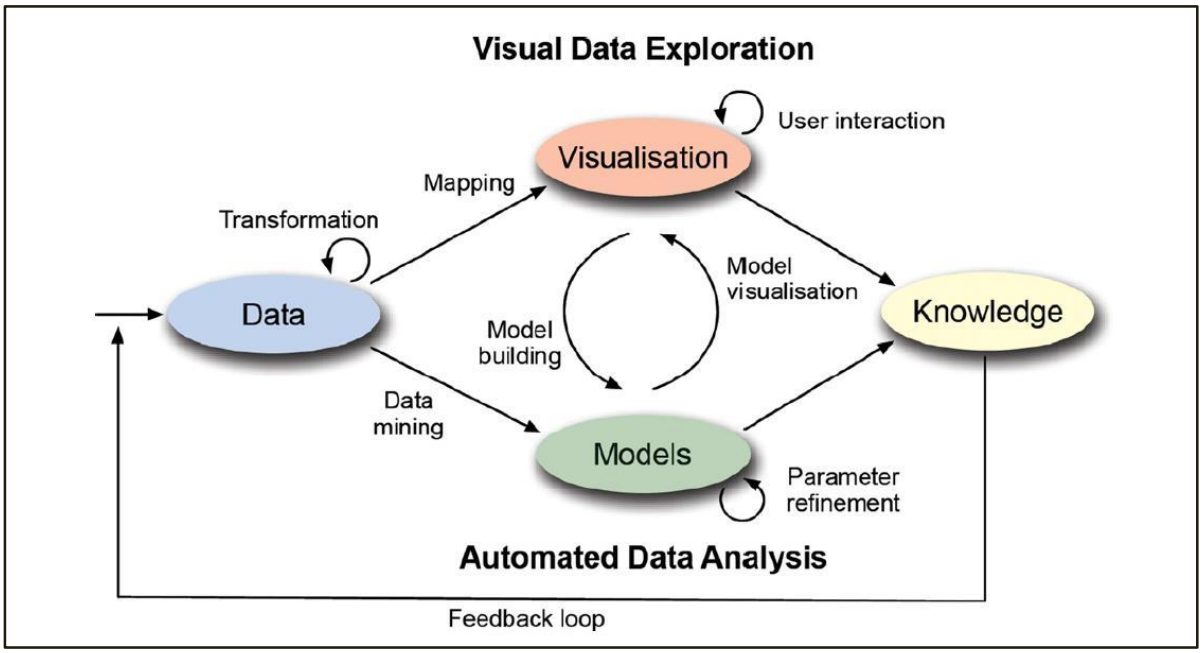


**Figure 4 - Visual Analytics Process**[82]

The essence here is that it is not sufficient to just retrieve and display data using visualisations. Apart from the visualisation, it is necessary to analyse the data according to its value of interest, relevance and to provide interaction models to get details of the data on demand. It is from within this perspective that Keim *Et al.* state that "the user has to be the ultimate authority in giving direction of the analysis along his or her specific task." [83]

### 2.3.2 Analytical models in Visual Analytics

In order to advance the science of analytical reasoning in support of Visual Analytics, Thomas and Cook recommend that it has to "build upon theoretical foundations of reasoning, sense-making, cognition, and perception to create visually enabled tools to support collaborative analytic reasoning about complex and dynamic problems."[84] However, Ribarsky, Fisher and Pottenger[85] stated in 2009 that there has been a relative lack of inquiry

[81] Shneiderman, B 1996. The Eyes have it: A task by data type taxonomy… (336–343)

[82] Kohlhammer *Et al.* 2011. Solving problems with Visual Analytics (118)

[83] Keim *Et al.* 2008. Visual Analytics: Definition, Process, and Challenges (156)

[84] Thomas, JJ & Cook, KA 2005. *Illuminating the Path* (63)

[85] Ribarsky, W Fisher, B Pottenger, WM 2009. Science of analytical reasoning (255)

into the design and evaluation of systems that assist human cognitive processing from within a Visual Analytics perspective. This may be due to a lack of communication between visualisation researchers and cognitive scientists whose methods may elucidate analytic cognition in complex visual environments. Apart from Pirolli and Card's model, there are a number of models proposed by various authors such as Van Wijk,[86] as to how analysts make sense of data through the interactive visualisations provided by Visual Analytics.

#### 2.3.2.1 Van Wijk's model of visualisation

Authors like Keim *Et al.*[87] however, warn about a naïve assumption that visualisation can offer a "first seen" or "virgin" view on data. They state that it is inevitable that any representation will favour an interpretation over other possibilities. Accordingly, in their view, Visual Analytics provides a solution to this by enabling the user to "enter into a loop where data can be interactively manipulated to help gain insight both on the data and the representation itself." They base this on the sense-making loop for Visual Analytics derived from Van Wijk's[88] simple model of visualisation illustrated in figure 5 on page 24.

Van Wijk[89] proposes that *data* are transformed according to a *specification* into a time varying *image*. The *data* may be both structured and unstructured. The *specification* includes a hardware specification, applied algorithms and specific application parameters. The *image* is *perceived* by the user resulting in a *new insight* or increase in *knowledge*. The amount of knowledge acquired is dependent on (1) the *image*, (2) the current knowledge of the user, and (3) the particular properties of perception and cognition of the user. *Knowledge* influences the process in a sense that an engineer or subject matter expert will extract more information than a layperson or novice. In terms of *perception*, some individuals are more adept at spotting trends and patterns. For instance, a colour-blind person will be less effective in extracting knowledge out of a colourful visualisation. The interactive *exploration and analyses* of the *image* results in adaptation of the *specification*, which has the effect of updating the initial knowledge.

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[86] Van Wijk, JJ 2005. The Value of Visualization (80)

[87] Keim *Et al.* 2008. Visual Analytics: Definition, Process, and Challenges (164)

[88] Van Wijk, JJ 2005. The Value of Visualization (80)

[89] Van Wijk, JJ 2005. The Value of Visualization (80)

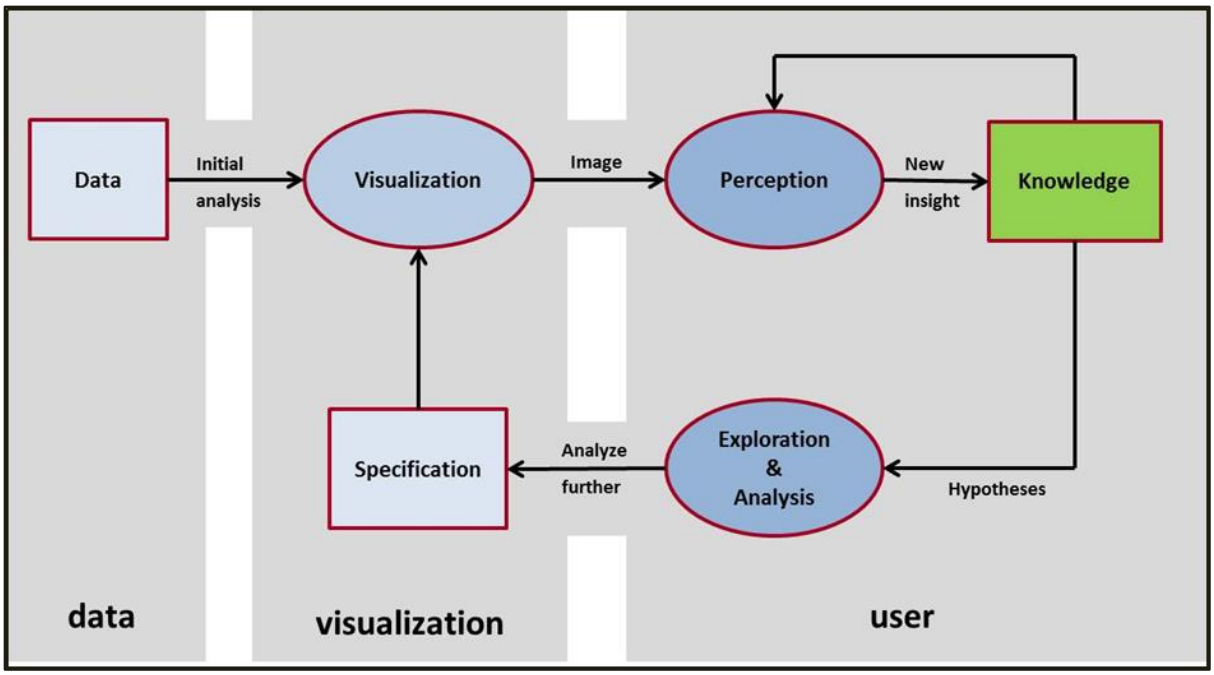


**Figure 5 - Van Wijk's model**[90]

The choice of the initial representation will be dependent on statistical or mathematical techniques such a link analysis or spatio-temporal analysis. The process then enters a cycle where the user can gain knowledge of the data. By interacting and "drilling down" into the visual representation a better understanding of the visualisation itself is gained. This enables a flow of iterations that occur through various representations, which ultimately results in the confirmation or refutation of hypotheses built from previous iterations.[91]

Illustrated in the diagram on page 25 is Van Wijk's process in conjunction with the use process of the Starlight®[92] Visual Analytics software suite. It illustrates how the product's software process conforms to Van Wijk's visualisation model.

[90] Keim *Et al.* 2008. Visual Analytics: Definition, Process, and Challenges (165)

[91] Keim *Et al.* 2008. Visual Analytics: Definition, Process, and Challenges (165)

[92] Starlight VIS – Future Points Systems, http://www.futurepointsystems.com

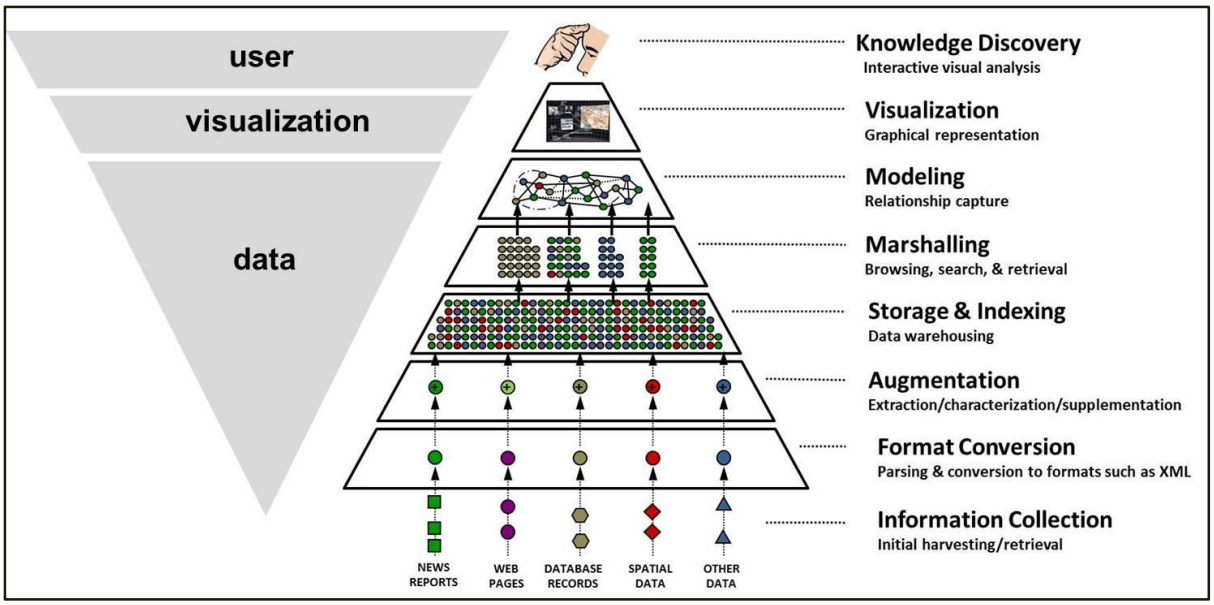


**Figure 6 - Van Wijk's process relative to Starlight® Visual Analytics Software's use process[93]**

It is important to note that Van Wijk[94] is clear in his position that extraction of knowledge from data is a subjective process. Increasing knowledge using visualisation depends on the data, the specification used, and the perceptual skills and prior knowledge of the user. Based on knowledge gained from the image (representation) the user can thus change the specification of the visualisation in order to explore the data further.

### 2.3.2.2 Adaptations of Van Wijk's model

Green *Et al.*[95] builds on Van Wijk's process of the user perceiving an image and utilising a specification in exploration. They posit that it is difficult to separate "knowledge" from the reasoning process that created it. Accordingly, a user or individual's knowledge is not a collection of declarative facts but also includes inferential or relational semantic meaning, perceived value, and factual reasoning in relation to these facts. This reasoning power to manipulate facts therefore leads Green *Et al.*[96] to include a "cognition" process to Van Wijk's visualisation model as illustrated in figure 7 on page 26.

[93] RJ Goosen, self-constructed based on Starlight use process

[94] Van Wijk, JJ 2005. The Value of Visualization (82)

[95] Green *Et al.* 2008. Visual Analytics for complex concepts… (94)

[96] Green *Et al.* 2008. Visual Analytics for complex concepts… (94)

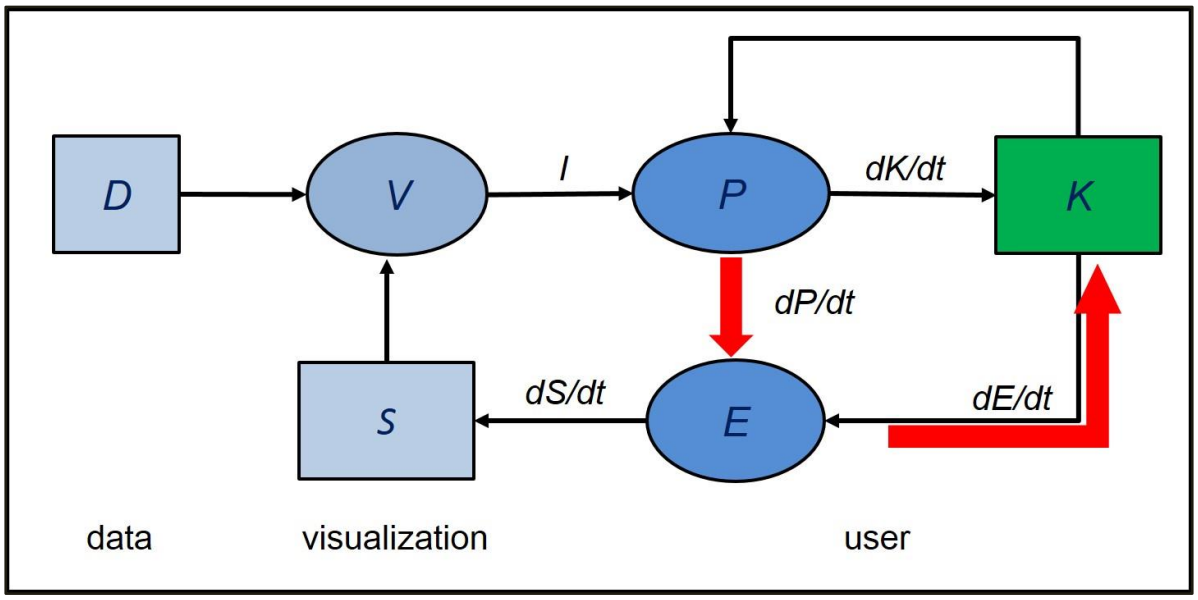


**Figure 7 - Van Wijk's Model with Green *Et al.* integrations in red**[97]

They argue that the knowledge required to determine which methods to use when integrating new knowledge with old, has to be considered within Van Wijk's process. Hence, the inclusion of a perception, knowledge and exploration cycle as illustrated in figure 7 above. In Green *Et al.'s* model the P relates to perception, K to knowledge and E to exploration and analyses as illustrated in Van Wijk's model (figure 5) above. Perception, knowledge, and exploration are thus modelled as cognitive processes informing each other. Green *Et al.*[98] see perception (P) as an early cognitive process of selective attention, categorisation, accommodation, and perceptual logic. Knowledge (K) represents meaningful knowledge utilising reasoning and problem solving in the creation thereof. Exploration (E) represents a focussed interactive cognitive process using perception (P) and knowledge (K). These additions to Van Wijk's model emphasise the important role perception and logic play in exploration as well as how a cycle of interaction fuels knowledge reasoning. This exploration and learning directs and focuses the attention of continued data exploration.

Wang *Et al.*[99] have applied Van Wijk's model as a basis to extend Nonaka and Takeuchi's[100] knowledge conversion model and applied it to interactive visualisation. From a visualisation perspective, internalisation parallels the insight discovery process in that "visually

[97] Green *Et al.* 2008. Visual Analytics for complex concepts… (94)
[98] Green *Et al.* 2008. Visual Analytics for complex concepts… (94)
[99] Wang *Et al.* 2009. Defining and applying knowledge conversion processes… (616-623)
[100] Nonaka, I & Takeuchi, H 1995. *The knowledge Creating Company*

representing explicit knowledge would support analysts in understanding and transforming the explicit knowledge into tacit (internal) knowledge." In addition, they state that tacit knowledge derived from a representation or image can also be externalized by way of visualisation and stored in a knowledge base, effectively creating explicit knowledge.[101] The authors attempt to delineate tacit and explicit knowledge as well as provide a mechanism to experience this tacit-explicit interaction through interactive visualisation. They posit that explicit knowledge is different from data or information and that tacit knowledge results from human cognitive processing. Specifically, Wang *Et al.* state that explicit knowledge exists in data and is independent from the user or his/her tacit knowledge.[102]

In terms of Visual Analytics, they state that explicit knowledge is extracted from data and information and represented in a visualisation. A user then receives this visualisation perceptually and cognitively which in turn increases the user's tacit knowledge. Accordingly, cognitive processing is responsible for understanding and an increase in tacit knowledge – thus recursively affecting subsequent perception and cognition. It is the user's tacit knowledge that directs the user's interaction and exploration of the visualisation.

Wang *Et al.*,[103] in referencing Van Wijk's model, believe that the knowledge the user gains is tacit and depends on the image and the current knowledge state of the user. Furthermore, they believe that the amount of explicit knowledge that exits in a dataset (to be visualised/represented via a specification) "could be nearly infinite [and may] be expressed and stored in a knowledge base (KB) as a collection of smaller knowledge artefacts." This knowledge base could be represented by any system that stores information or data via an "ontological knowledge structure" for example, an SQL[104] database or content management system. This is illustrated on page 28 in their representation of Van Wijk's model, where explicit knowledge elements ($K_{e1}$….$K_{en}$) are stored in a knowledge base structure for use in the visualisation process.

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[101] Wang *Et al.* 2009. Defining and applying knowledge conversion processes… (618)

[102] Wang *Et al.* 2009. Defining and applying knowledge conversion processes… (617)

[103] Wang *Et al.* 2009. Defining and applying knowledge conversion processes… (617)

[104] Structured Query Language

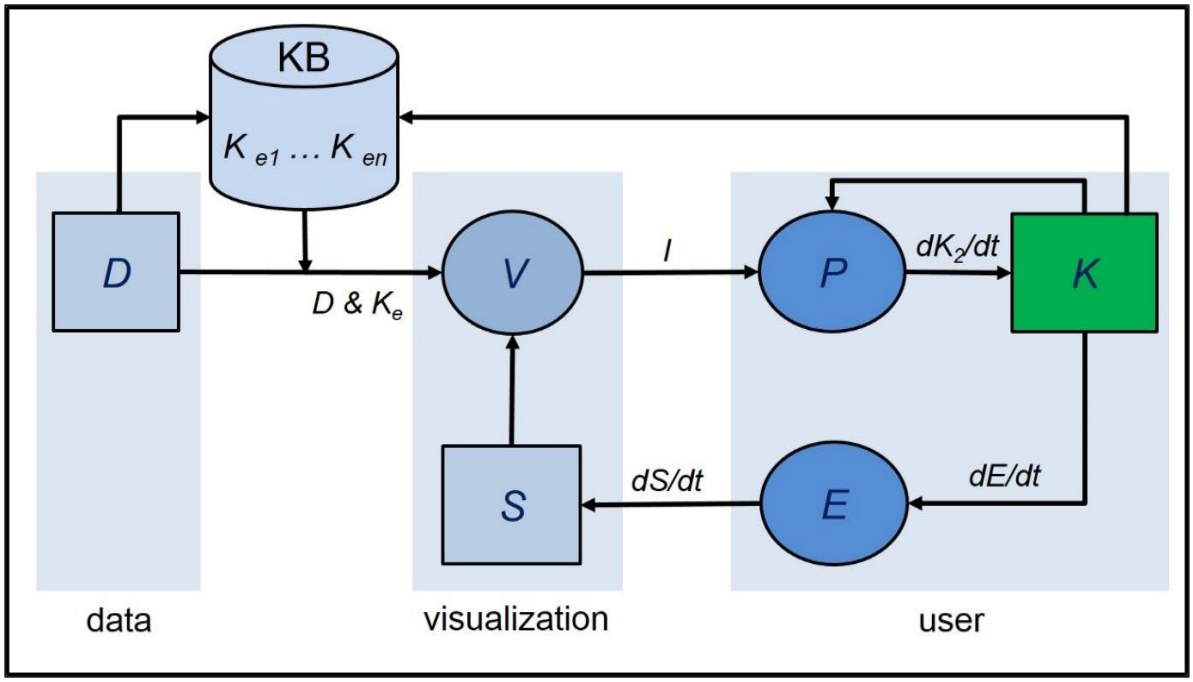


**Figure 8 - Knowledge base incorporated in Van Wijk's model[105]**

Visual Analytics is important from an early warning perspective in that warning analysts operate within a Multi-INT[106] environment where large data volumes are a reality. It is within this data and information environment that warning analysts have to notice indicators and signals that may provide clues to impending threats, opportunities and changes within the environment. Visual Analytics thus sets out to provide a software tool in support of the notional models of intelligence and warning analysis as depicted by Pirolli and Card and Bodnar. Therefore, the end goal of Visual Analytics is to enable analysts to recognise signals, cues, patterns, trends and anomalies in large datasets.

## 2.4 Section Three - Signals and cues in warning system analysis

In addition to the use of Visual Analytics as a software support tool in the warning analysis process, Cavelty and Mauer[107] have argued for a more reflexive intelligence perspective to warning in the current threat environment. They state that a growing part of the intelligence community realises that changing context "has significant consequences for strategic early warning methodologies and methods." In specific they evaluate two distinct types of warning methodology: warning and discovery. From their perspective, predicting or forecasting

[105] Wang *Et al.* 2009. Defining and applying knowledge conversion processes

[106] Multi Source Intelligence – Signals, Human, Geospatial, Imagery, Open Source, Measurement and Signature

[107] Cavelty, MD & Mauer, V 2009. Postmodern Intelligence: Strategic warning… (129-133)

methodologies encompass trends and patterns, frequency and probability. However, discovery is an altogether different domain - "strategic early warning is based on the assumption that discontinuities do not emerge without warning." They state that warning signs have been described as weak signals and the management of "unknown unknowns" makes it necessary to gather "weak signals." According to them, one approach to "maximize" weak-signal detection in a complex system is horizon scanning together with engaging in systematic probing strategies.[108]

The concept of "weak signals" provides a nexus between the business strategy and the formal intelligence environment. Schwartz in providing a theoretical model of a Strategic Early Warning System (SEWS) posits that discontinuities do not emerge without warning and these warning signs can be described as "weak signals." Detecting weak signals are achieved via environmental scanning.[109] Schwarz derives the ideal SEWS process from Liebl who describes this process in three distinct phases[110]: an information gathering phase followed by a diagnosis and strategy formulation phase. Schwarz's theoretical model is similar to Pirolli and Card's model – both have a foraging/information gathering component and a sense-making/diagnosis component. Brief overviews of the different phases are provided but not in the same level of detail as that of Bodnar or Khalsa above.

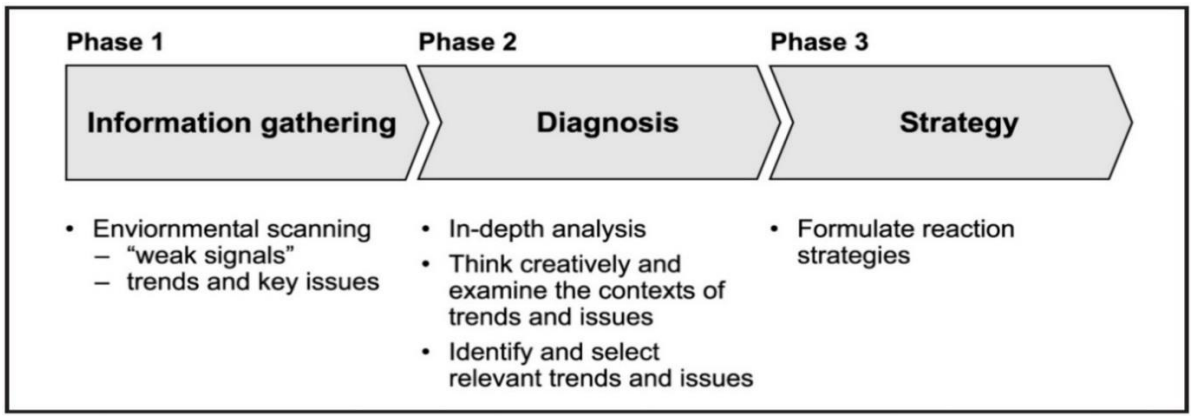


**Figure 9 - SEWS Process[111]**

This systematic scanning follows either an outside-in (a 360 degree focus) or an inside-out (management determines fields of interest) approach. Brouard defines this scanning phase as

[108] Cavelty, MD & Mauer, V 2009. Postmodern Intelligence: Strategic warning… (137)
[109] Schwarz, JO 2005. Pitfalls in implementing a strategic early warning system (22-23)
[110] Schwarz, JO 2005. Pitfalls in implementing a strategic early warning system (24)
[111] Schwarz, JO 2005. Pitfalls in implementing a strategic early warning system

informational processes through which an organization stays "attuned" to or cognisant of its environment in order to facilitate decision making and action to achieve its goals and objectives.[112] Recently, authors, such as Franco *Et al.*[113] and Ramirez *Et al.*,[114] have associated environmental scanning with competitive intelligence. Brouard also makes this association and posits that environmental scanning includes three components, that of input (needs of users), cycle and output. He equates the "cycle" with the intelligence cycle as discussed previously.

"In-depth analysis" is included in Liebl's second phase, but this is not unpacked by the author nor expanded on to provide a thorough description of what it entails. However, analytical tools such as scenario planning,[115] SWOT analysis,[116] Porter's Five Forces[117] and other structured techniques are normally utilised during the analytical phase.

Bodnar's assertion stated earlier, that warning is "[a] prediction of the future that matches past and current indicators with a model of the Future"[118] is well worth emphasising as it resonates heavily through the rest of this thesis. It reflects on recognising and noticing signals or cues in the environment and the resulting sense to be made. Consequently, it is necessary to investigate how signals and weak signals are conceptualised within the literature.

### 2.4.1 Conceptualisations of weak signals

Igor Ansoff formally introduced his concept of weak signals in his 1975 paper *Managing strategic surprise by response to weak signals*[119] and supplemented this with additional works in 1980[120] and 1984.[121] His development of the weak signals concept was a response to limitations he identified in the strategic planning approach of the 1970s, which according to Ansoff, could successfully deal with incremental developing historical trends, but not

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[112] Brouard, EF 2006. Development of an Expert System on Environmental Scanning Practices… (39-41)

[113] Franco *Et al.* 2011. Competitive intelligence: a research model tested on Portuguese firms (332-333)

[114] Ramirez *Et al.* 2013. Scenarios and early warnings as dynamic capabilities to frame… (825–838)

[115] Fink *Et al.* 2005. The future scorecard… (360-381); Wack, P 1985 Scenarios: shooting the rapids (139–150); Postma,T & Liebl, F 2005. How to improve scenarios as a strategic management tool? (161–173)

[116] Novicevic, M & Harvey, M 2004. Dual-perspective SWOT: a synthesis of marketing intelligence and planning (84-94)

[117] Porter, M 1980. *Competitive Strategy* (4)

[118] Bodnar, JM 2003. Warning analysis for the information age… (11)

[119] Ansoff, HI 1975. Managing strategic surprise by response to weak signals. *California Management Review*, 18(2), (21-33)

[120] Ansoff, HI 1980. Strategic issues management, *Strategic Management Journal*, 1, (131-148)

[121] Ansoff, HI 1984. *Implanting Strategic Management*. Prentice-Hall International, London

surprise. Ansoff also introduced the concept of a strategic discontinuity, which is a future occurrence that shows a significant departure from the past or from some expected trend or extrapolation. In some circumstances, a discontinuity invariably leads to a strategic surprise, which is a sudden or rapid change usually culminating into a significant threat in a firm's business environment.[122]

Ansoff posits that signals that are "weak" foreshadow changes in an environment. These weak signals are vague harbingers of possible future change. As more related information progressively becomes available organisations are able to develop these signals further in order to make sense of them. In particular, Ansoff refers to weak signals as "imprecise early indications about impending impactful events."[123] This progressive nature is seen as: "[a] graduated response through amplification and response to weak signals."[124]

In relation to identifying these weak signals, Ansoff proposed a model of filters through which organisations can recognise them. Clues or phenomena from an environment have to pass through: (1) an observation/surveillance filter that defines a data observation or collection area, (2) a mentality/cognitive filter used to evaluate data that passed the surveillance filter for its relevance, and (3) a power filter that engages as power structures influence the meaning ascribed to a particular clue. Ansoff implied that this filter model allows humans to convert a supposed weak signal into usable knowledge in order to prevent some future threat.[125] This conversion takes place as a graduated response to how the weak signals mature and become strong signals.[126]

The filter model is one of the most enduring insights created by Ansoff according to Holopainen and Toivonen.[127] They argue that the surveillance filter refers to the "observation" of the signal and the signal can only pass this filter if an actor or several actors have discovered the emerging signal. It has also been stated that in order to "effect the future, the signal has to traverse three filters."[128] This immediately begs the question: what about cues and signals that are not noticed (which lead to surprise and invariably affect some future

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[122] Ansoff, HI 1975. Managing strategic surprise (22)
[123] Ansoff, HI 1985. Conceptual underpinnings… (2)
[124] Ansoff, HI 1975. Managing strategic surprise (22-23)
[125] Ansoff, HI 1984. Implanting strategic management (510)
[126] Ansoff, HI 1985. Conceptual underpinnings… (12)
[127] Holopainen, M & Toivonen, M 2012. Weak signals: Ansoff today (199)
[128] Holopainen, M & Toivonen, M 2012. Weak signals: Ansoff today (199)

state of an environment)? Furthermore, they state that the mentality filter, in an environment undergoing a "discontinuous change," invalidates historical success models and acts as a barrier or blocker of novel data. Therefore they posit that the situation then arises where "several individuals or organizations notice weak signals around them, but do not understand the importance of the signals because they rely on what has been *learned in the past* [my emphasis]."[129]

Building on Ansoff's work, Coffman contributed to the discourse of weak signals analysis in a series of papers in 1997.[130] He defines weak signals as:

- An idea or trend that will affect business and the business environment;

- Something new or surprising from the signal receiver's point of view although others may also perceive it;

- Sometimes difficult to track down amid other noise and signals;

- A threat or opportunity to an organisation;

- Something that is often scoffed at by individuals who "know";

- Something that usually has a substantial lag time before it will mature and become mainstream;

- Something that represents an opportunity to learn grow and evolve.

The influence of Claude Shannon's theory of information and JM Pierce's *Symbols, Signals and Noise*[131] becomes apparent in Coffman's Part II discussion of weak signals.[132] Shannon's model of communication consists of five parts as illustrated on page 33.[133]

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[129] Holopainen, M & Toivonen, M 2012. Weak signals: Ansoff today (199)

[130] Coffman, B 1997. Weak Signal Research, Part I: Introduction, Journal of Transition Management, MG Taylor Corporation, http://www.mgtaylor.com/mgtaylor/jotm/winter97/wsrintro.htm, accessed 2011-03-22.

[131] Pierce, JM 1969. *Symbols, Signals and Noise: The nature and process of communication*. Harper and Brothers, New York

[132] Coffman, B 1997. Weak Signal Research, Part II: Information Theory, Journal of Transition Management, MG Taylor Corporation, http://www.mgtaylor.com/mgtaylor/jotm/winter97/infotheory.htm, accessed 2011-03-22

[133] Shannon, CE 1948. A mathematical theory of communication (7)

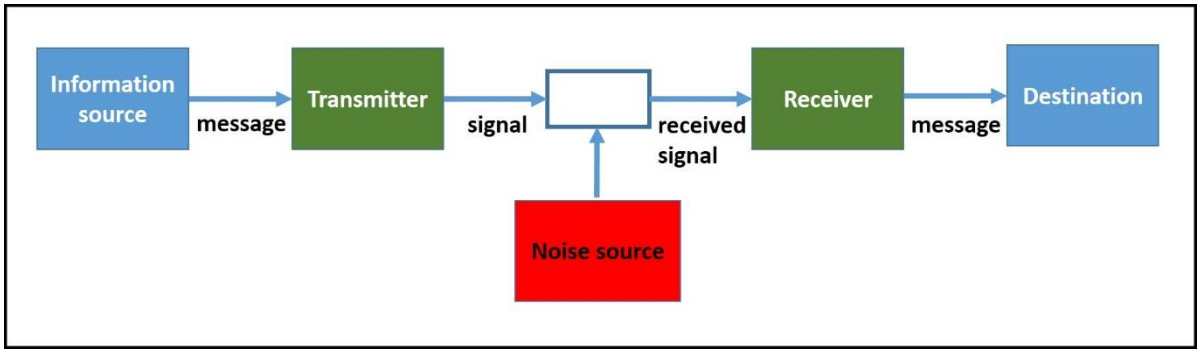


**Figure 10 - Shannon's schematic diagram of a general communication system**[134]

Coffman considers the effects that mental models have on the ability to perceive weak signals in an environment. He identifies three types of signals transmitted in our direction on a daily basis: (1) signals beyond our perception that we are incapable of receiving, (2) signals within our perception but unrecognised by our mental models, and (3) signals recognised by our mental models that we use to modify our behaviour. Drawing on Shannon and Pierce's theories, Coffman posits that in order for organizations to notice weak signals our "sensory apparatus" or "mental models" need to be changed. In effect, our ability to notice weak signals is dependent on our ability to "know" or understand the "noise" in the transmission channel. Although Coffman considers the effects of "mental models" on signal recognition, he embraces a mechanistic interpretation of Shannon's theory in applying it to weak signal recognition.[135]

As signals are passed or transmitted from source to receiver a methodology or approach to capture weak manifestations of signals effected by some arbitrary "noise source" is needed. In this regard, environmental scanning, as proposed by Francis Aguilar has provided a methodology to operationalize weak signal or early warning analysis in organisations. Aguilar defined the process of Environmental Scanning as:

> The activity of acquiring information [about] events and relationships in a company's outside environment, the knowledge of which would assist top management in its task of charting the company's future course of action.[136]

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[134] Shannon, CE 1948. A mathematical theory of communication (7)

[135] Coffman, B 1997. Weak Signal Research, Part III: Sampling, Uncertainty and Phase Shifts in Weak Signal Evolution, Journal of Transition Management, MG Taylor Corporation, http://www.mgtaylor.com/ mg tay lor /jotm/winter97/wsrsampl.htm , accessed 2011-03-22

[136] Aquilar, FJ 1967. *Scanning the business environment*. New York, Macmillian (1)

Authors such as Meredith[137] and, Kourteli[138] have discussed the merits of deploying environmental scanning as a mechanism to monitor the environment for threats. Kourteli in particular has also highlighted the empirical weaknesses of Aguilar's enunciation of environmental scanning. Kourteli states that Aguilar's work has certain conceptual and empirical weaknesses in that it does not take into account the level of dynamic characteristics within an external environment. There is no concomitant recognition that different environments would need different processes of scanning.[139] Consequently, Kourteli states that Aguilar's scanning process is mechanistic because he implies that the scanning process may be improved by looking for better sources, kinds of information and ways of scanning.[140]

This mechanistic approach as stated by Kourteli is evident in works such as that of Schultz where methodological improvements relative to the scanning process are advocated. Schultz's focus is on the clear articulation of strategies to validate both scan sources and data in order to increase acceptance and usefulness.[141] This mechanistic approach is also evident in earlier research such as that reported on by Correia and Wilson[142] who examined factors influencing environmental scanning in an organisational context. Correia and Wilson argue that research in individual scanning activity has been manager centric and focused on: (1) identification of information sources used, (2) environmental sectors scanned, (3) scanning mode and methods, and (4) their influence and tasks performed on scanning activity.

### 2.4.2 The Futures Studies view of weak signals

Weak signals and environmental scanning have also received attention in Futures Studies research, notably by Day and Schoemaker,[143] Mendonca *Et al.*,[144] Hiltunen,[145] Nikander and Eloranta[146], Harris and Zeisler,[147] and Choo.[148] Futures Studies are dedicated to examining

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[137] Meredith, L 2007. Scanning for market threats (211–219)
[138] Kourteli, L 2000. Scanning the business environment (406-413)
[139] Kourteli, L 2000. Scanning the business environment (409)
[140] Kourteli, L 2000. Scanning the business environment (409)
[141] Schultz, WL 2006. The cultural contradictions of managing change… (11)
[142] Correia, Z & Wilson, TD 2001. Factors affecting environmental… Information Research 7(1)
[143] Day, GS & Shoemaker, PJH 2004. Driving through the fog: managing at the edge (127-142)
[144] Mendonca *Et al.* 2009. Venturing into the wilderness… (23-41)
[145] Hiltunen, E 2006. Was it a wildcard or just our blindness to change… (61-74)
[146] Nikander, IO and Elorante, E 2001. Project management by early warnings (385-399)
[147] Harris, DD & Zeisler, S 2002. Weak signals detecting the next best thing (21-29)
[148] Choo, CW 1999. The Art of Scanning the Environment (13-19)

future prospects in order to facilitate creative thinking about the future. The concept of weak signals (a key element of strategic issue management) and environmental scanning (a tool to achieve the identification of weak signals) creates the feedstock or seeding material for Futures Studies to pre-empt trends or likely future scenarios.[149] However, in current Futures Studies research there are various interpretations regarding the nature and meaning of the term weak signal. As discussed previously the foundations are grounded in an Ansoffian-Aguilarian framework in identifying and acting on so-called weak signals. Authors like Holopainen and Toivonen[150] recognize that the concept of weak signals have been used "very loosely" and in a "confusing way" and have criticised the way in which "weak signals" are used in the production of reports requiring a view of up-and-coming trends in a specific environment.

Holopainen and Toivonen[151] discuss four main directions regarding the specification of the concept of weak signals:

1) A more detailed and accurate definition of Ansoff's "quite simple" definition of weak signals have been pursued by authors such as Coffman[152] (see page 32-34) and Kamppinen *Et al.*[153] Kamppinen and colleagues, according to Holopainen and Toivonen, formulated their definition along the same lines as that of Coffman. They see weak signals as individual events or a group of interrelated events. These events may not seem important or far-reaching when first noticed but may have far-reaching consequences for the future. However, it is not necessarily possible to connect the signal credibly with the upcoming event by statistical analysis.

2) Attempts by some authors to separate or discriminate between the sign or phenomenon and the phenomenon itself. In this regard, the concept of a wild card is introduced where a weak signal is a sign of a future wild card (the phenomenon). Hiltunen[154] takes this further by differentiating between situations where weak signals signpost wild cards or

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[149] Schwartz, JO 2005. Linking strategic issues… (39)

[150] Holopainen, M & Toivonen, M 2012. Weak signals: Ansoff today (204)

[151] Holopainen, M & Toivonen, M 2012. Weak signals: Ansoff today (200)

[152] Coffman, B 1997. Weak Signal Research, Part I: Introduction, Journal of Transition Management, MG Taylor Corporation, http://www.mgtaylor.com/mgtaylor/jotm/winter97/wsrintro.htm , accessed 2011-03-22.

[153] Kappinen *Et al.* 2002. Futures Studies, Foundations and Directions

[154] Hiltunen, E 2006. Was it a wild card or just our blindness to gradual change? (61-74); Hiltunen, E 2008. The future sign and its three dimensions. (247-260)

gradual future change. She expands on this by drawing from semiotics and applying the triadic model of a sign as proposed by Pierce,[155] which refers to the representamen (the form the sign takes), the object (emerging issue the sign indicates) and the interpretant (future potentiality of the sign). Furthermore, Hiltunen prefers the term "future sign" instead of weak signal.[156]

3) Some researchers, also dispute the nature of "phenomena" which weak signals represent. There is unanimity that weak signals and wild cards are characterized by a sense of improbability. The dispute arises regarding the importance of the "phenomenon if it eventually occurs."[157] In this regard Mendonca *Et al.*[158] and Mannermaa[159] emphasise the large impact of effect, positive or negative, that the phenomena must represent if the initial signal is to qualify as a weak signal.

*4)* The "managerial implication" view by Coffman[160] and Mendonca *Et al.*[161] Coffman posits that organisational strategy will include more risk and opportunity if weak signals are interpreted early and strategic action is executed based thereon. Mendonca *Et al.* scrutinise the nature of activities focused on detecting weak signals. They highlight organisational improvisation development by the use of futures orientated methods such as alternative scenarios.

In addition to these four main directions, Holopainen and Toivonen also provide a synopsis of Ansoff's thoughts and contribution to Futures Studies from a weak signal perspective, and is provided in table 3 on page 37.

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[155] Pierce, CS 1960. *Collected Papers*, Belknap Press of Harvard University Press, Cambridge

[156] Hiltunen, E 2008. The future sign and its three dimensions (247-260)

[157] Holopainen, M & Toivonen, M 2012. Weak signals: Ansoff today (200)

[158] Mendonca *Et al.* 2004. Wild cars, weak signals… (201-218)

[159] Maanermaa, M 2004. Heokoista Signaaleista Vahva Tulevaisuus, (Creating Strong Future with the Help of Weak Signals), WSOY, Porvoo as reported in, Holopainen, M & Toivonen, M 2012. Weak signals: Ansoff today (200)

[160] Coffman, B 1997. Weak Signal Research, Part I: Introduction, Journal of Transition Management, MG Taylor Corporation, http://www.mgtaylor.com/mgtaylor/jotm/winter97/wsrintro.htm, accessed 2011-03-22.

[161] Mendonca *Et al.* 2004. Wild cars, weak signals… (201-218)

**Table 3 – Adaptation of Holopainen & Toivonen's Summary of weak signal studies – Ansoff's original thoughts and the contributions of futures research[162]**

| Study Areas | Ansoff's analyses | Contributions of future studies | Authors |
|---|---|---|---|
| *Definition of weak signal* | Weak signals are first symptoms of strategic discontinuities; they are symptoms of possible change in the future | More detailed definitions - an event which may not seem important when it occurs, but may be crucial for the emergence of the future | Kamppinen *Et al.* 2002 |
| *Differentiating sign and phenomenon* | No explicit discussion, but the concepts of strategic discontinuities and strategic surprises refer to a difference between a weak signal and the phenomenon that it indicates | Some authors argue that weak signals should be separated from 'wild cards', i.e. from phenomena that they indicate | Mendonca *Et al.* 2004<br>Hiltunen,E 2006 |
| *Nature of knowledge of weak signals* | First a sense of a threat/opportunity, then gradually increasing knowledge of its source, characteristics, necessary responses, and outcomes | Adopting from semiotics the term 'interpretant' to refer to the sense made of the future potentiality of the sign | Hiltunen, E 2008 |
| *Importance of phenomena that weak signals indicate* | The concept of strategic surprises restricts the phenomena to the important ones; however, Ansoff states that a weak signal may not be realized because it is ever perceived | Some researchers restrict weak signals to important phenomena , others not | Kamppinen *Et al.* 2002<br>Mannermaa, M 2004<br>Hiltunen, E 2006<br>Kuusi *Et al.* 2000 |
| *Managerial implications* | Ansoff's main focus, including e.g. analysis of three progressive strategies: enhancing awareness, increasing flexibility, and directly attacking the threat or opportunity | Additional notions: identification of one signal often leads to perceiving others; emphasis on the management system for wild cards | Coffman, B 1997<br>Mendonca *Et al.* 2004 |

[162] Holopainen, M & Toivonen, M 2012. Weak signals: Ansoff today (202)

| | | | |
|---|---|---|---|
| *Weak signals in relation to other futures phenomena* | Discussion of differences between weak and strong signals | Positioning weak signals in the context of futures studies, analysing their relation to strong signals, trends, megatrends etc. | Kamppinen *Et al.* 2002<br>Moijanen, M 2003<br>Mannermaa, M 2004 |
| *Sources of weak signals* | Ansoff named experts outside the firm and personnel with broad contacts inside the firm as relevant sources of weak signals, but did not discuss this topic in detail | Moving outside one's own context, eliciting opinions from people of different backgrounds, unofficial discussions, Internet and other media, 'expert amateurs' | Mannermaa, M 2004;<br>Day,G & Schoemaker,P. 2004<br>Hiltunen, E 2001 |
| *Methods and tools for identifying weak signals* | Ansoff developed a systematic framework for identification of weak signals, but did not discuss in detail the methods and tools to be used in identification | Systematic environmental scanning, expert opinions, Internet-based tools that facilitate the choice of information, visual images 'in the futures window' | Decker *Et al.* 2005<br>Ilmola, L & Kuusi, O 2006<br>Hiltunen. E 2007 |
| *Skills needed in the mapping of weak signals* | Sensitivity, creativity, genuine interest and expertise are all needed | Creativity and daring are essential. But expertise is also needed | Kuusi, O 1999 |
| *Factors hindering the perception of weak signals* | The idea of 'filters': surveillance, mentality and power filters | Discussion and application of the 'filter theory'; 'paradigm blindness' as a new concept | Ilmola, L & Kuusi, O 2006<br>Mannermaa, M 2004 |
| *Empirical studies of weak signals* | Ansoff created a network of contacts to major corporations over the years to validate his research. He consulted with Philips, General Electric and IBM to name a few | Applications in many contexts, ranging from broad societal issues to the management of organizations and projects | Nikander, O 2002;<br>Geerlings, H & Rienstra, S 2003 |

These different perspectives indicate that there is a level of ambiguity and issues of clarity in Futures Studies and other managerial disciplines as to what constitutes a weak signal as well as how to classify the effect and size of the future phenomenon that it is supposed to represent. Mendonca *Et al.* rely heavily on the work of Coffman and emphasise that weak

signals are information about the likelihood of an event with a low probability estimate and high impact uncertainty.[163] In contrast, wild cards are defined as "incidents with perceived low probability of occurrence and with potentially high impacts and strategic consequences."[164] The difference lies in the certainty of high impact. Weak signals are seen as dispersed data that function as signposts to the appearance of a wild card.

However, Mendonca *Et al.*[165] refer to "surprise" and categorise surprise into: (a) imaginable surprises that are probable or improbable, (b) unimaginable surprise, and (c) certain surprise. They posit that surprise is negatively correlated with the ability to detect weak signals accurately. Consequently, they create a taxonomy of surprise in relation to weak signals and wildcards based around a PESTLE[166] framework. The environment is divided-up into specific scanning sectors or pigeonholes. The interest here is "imaginability" of the surprise. This reference to the ability to imagine surprise would have the effect of the "imaginer" creating or altering current mental frameworks to allow for the identification of indicators to monitor for possible surprising events.

### 2.4.3 Constructivist theories on weak signal conceptualisation

The variety of different weak signal viewpoints may be linked to an attempt to define weak signals from within a nominal or reductionist perspective, consequently seeking a defined set of characteristics for the concept of a weak signal. Other avenues are being investigated in conceptualising weak signals. Authors such as Kaivo-oja[167] have recently attempted to investigate alternative theoretical frameworks in support of weak signals such Nonaka's SECI model and Boisot's Information Space model in an effort to provide a more robust theoretical framework. Constructivist perspectives, four authors in specific, David Seidl,[168] Pierre Rossel,[169] and Narayanan and Fahey,[170] are questioning the conventional conceptual grounding of weak signal theory and discourse. These constructivist perspectives provide important insights into any future based projection and the open-ended nature of the future.

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[163] Mendonca *Et al.* 2004 Wild cars, weak signals… (205-206)

[164] Mendonca *Et al.* 2004 Wild cars, weak signals… (203)

[165] Mendonca *Et al.* 2004 Wild cars, weak signals… (203)

[166] Political, Economic, Social, Technological, Legal and Environmental analysis framework

[167] Kaivo-oja, J 2012. Weak signal analysis, knowledge management… (206-217)

[168] Seidl, D 2004. The concept of Weak Signals Revisited… (151-168)

[169] Rossel, P 2009. Weak signals as a flexible framing space… (307-320)

[170] Narayanan, VK and Fahey, L 2004. Invention and navigation as contrasting metaphors… (38-57)

### 2.4.3.1 David Seidl

Seidl argues that Ansoff's concept of weak signals and the resulting literature that it sparked rests on epistemological assumptions which represent a "fairly naïve representationalist belief."[171] He argues that cognitions are conceptualised as direct representations of the outside world and that internal cognitions and reality are perceived as directly related. Weak signal literature, according to Seidl, is focused on whether signalling events in the environment are represented in the right place within the cognitive system and if they are understood as signals of impending strategic discontinuity. He views this as naïve and a contradiction in terms of what "is common knowledge about the essentially constructed nature of our cognitions." Seidl draws from Tsoukas in terms of stating that the environment around us causes us to have beliefs, but the environment cannot tell us what to believe. He states that weak signals do not exist in the external environment, but rather that they need to be conceptualised cognitively "as cognitive phenomena, determined by the structures of the cognitive system."[172]

### 2.4.3.2 Pierre Rossel

Similar to Seidl, Pierre Rossel[173] states that the notion of a weak signal does not necessarily correspond to a real event but is "only a metaphor, building upon information theory" and "what we call a weak signal is usually not a direct warning message but, at best, a series of perceptions of issues, events and processes." Rossel, in his critique of the Ansoffian tradition, poses three questions relating to weak signal analysis and early detection. The first is, "what is [the weak signal's] relationship to change? The second, "what change does a weak signal represent or carry?" and thirdly, "how can any claim of weak signal identification be verified?" These three questions lead Rossel[174] to state that current revisited neo-Ansoffian and past Ansoffian research traditions fail to take account of reflexivity.[175]

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[171] Seidl, D 2004. The concept of Weak Signals Revisited (156)

[172] Seidl, D 2004. The concept of Weak Signals Revisited (156)

[173] Rossel, P 2009. Weak signals as a flexible framing space (307-309)

[174] Rossel, P 2012. Early detection, warnings, weak signals… (234)

[175] Reflexivity according to Schwandt (2007:260), in a methodological sense, describes the process of critical self-reflection on one's biases and theoretical predispositions and indicates that the enquirer is part of the context, setting and social phenomena under investigation.[175] Schwandt (2007:260) states that reflexivity is an important procedure in establishing the validity of accounts of social phenomena.

In this light, Rossel[176] criticises the current view that weak signals are influential isolated portions of reality that may be interpreted and then incorporated in strategy. The nature of current and past research is viewed as un-reflexive in that it does not account for the habits, models and assumptions for constructing weak signals out of a larger signal environment. According to Rossel weak signals are seen as if they "are objects within their own right, waiting to be discovered, instead of considering them as an expression of the paradigmatic capacity of the analyst."[177] Articulating this from within a constructivist perspective Rossel sees all weak signals as proposed by the Ansoffian perspective as "candidate weak signals, hypotheses or starting points for exploratory reflection."

The crux for Rossel in providing the reflexivity required is "making our assumptions explicit as possible," and all these dimensions, together with the proviso that it is reflected upon, is defined as "a reflexive interrogation of one's framing choices."[178] The issue here is that Rossel is trying to bring in an element of increasing the accuracy of identified weak signals by introducing reflexivity in the framing process so that "one can be confronted by ones' own bias-producing capabilities."[179]

#### 2.4.3.3 V.K. Narayanan and Liam Fahey

Narayanan and Fahey state that "the future is a cognitive construction that must be conceived, imagined, or otherwise created as an explicit cognitive act by one or more individuals."[180] They build upon the work of Nicholas Rescher[181] and his view of epistemology, in specific his idea of conceptual idealism that offers an analytical framework to deal with how individuals construct the future. Accordingly, they state that any efforts to construct the future inevitably illicit questions of an epistemological nature. These questions are: (1) What provides confidence in our skill in scrutinising or looking into the future, and (2) if a level of confidence is attainable, what methodologies will enable us to do so? The future according to Narayan and Fahey is ontologically non-existent and thus a cognitive construction creating a situation where accuracy or assertions about the future can only be measured once the future has unfolded. The future can thus not exert any causal influence on the present. Complicating

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[176] Rossel, P 2009. Weak signals as a flexible framing space (312)

[177] Rossel, P 2009. Weak signals as a flexible framing space (312)

[178] Rossel, P 2011. Beyond the obvious: Examining ways of consolidating early detection schemes (382)

[179] Rossel. P 2012. Early detection, warnings, weak signals… (235)

[180] Narayanan, VK & Fahey, L 2004. Invention and navigation as contrasting metaphors… (38)

[181] Rescher, N 1992. *A System of Pragmatic Idealism*, Princeton, NJ. Princeton University Press

this further is that the future may be "cognitively inaccessible" due to deficient information. Visions or depictions of the future are thus not possible without the involvement of the human mind and thus will depend on our conceptual abilities, weaknesses, limitations and biases.[182]

In looking at the future, the role of conceptual innovation is a key constituent element of Rescher's framework. It emphasises the "critical need to engage in (re)conceptualisation: to continually reframe the world as we understand it." Conceptual innovation creates an impetus to accept that finding or creating new data and information forces us to make an assessment as to "whether our long held concepts are adequate to describing and explaining the word around us."[183] In addition, Narayanan and Fahey state that Rescher distinguishes between mind involving and mind invoking. Mind involving is ever present, but mind invoking is the ability or capacity of the mind to invoke visions about the future, an ability to resort to assumptions, suppositions and hypotheses about the future. Importantly Narayanan and Fahey emphasise that this mind involved/mind invoked conception of the world around us is not egocentric or self-referential and therefore "inquirers" are never in a position to realise how our current conceptions are inadequate. This realisation is only possible based on retrospect.[184]

Based on Rescher's framework, Narayanan and Fahey propose using two metaphors for looking at the future, that of invention and navigation, as alternative modes of prediction[185]:

1.) Invention sees the future as open and that it can be manipulated by human action. Mind involving is through induction and mind invoking though imagination. It is applicable in uncertain environments over long time frames. The emphasis here is strategic flexibility.
2.) Navigation sees the future as patterned evolution that can be deterministic or probabilistic. Mind involving is through induction and extrapolation of data. "Mind-invokingness" is not present. As such, applicability is in dynamic environments over a medium time-frame and the emphasis is on technical and operational flexibility.

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[182] Narayanan, VK & Fahey, L 2004. Invention and navigation as contrasting metaphors… (39-40)
[183] Narayanan, VK & Fahey, L 2004. Invention and navigation as contrasting metaphors… (42)
[184] Narayanan, VK & Fahey, L 2004. Invention and navigation as contrasting metaphors… (42)
[185] Narayanan, VK & Fahey, L 2004. Invention and navigation as contrasting metaphors… (47)

There are fundamental differences in the epistemological basis of invention and navigation. Narayanan and Fahey see these two metaphors for looking at the future as incommensurable and state that similar sounding tools such as scenario planning often mask this. They view the frequent use of "navigation" strategies in a turbulent context as misplaced, specifically "[the] capturing of signals from a diverse set of indicators, within an accepted world view." [186] The resultant effect is the superficial understanding of the drivers of change, underlying connections between these drivers and the subsequent development of a limited integrated picture of turbulence in an environment. They are not convinced by the claims of "truth hood" made by the proponents of "navigation," as the future, according to Rescher, is a cognitive construction of which the accuracy or truthfulness cannot be established.

## 2.5 Implications

Warning is an intangible abstraction that makes a prediction of the future. It is both a process and product of reasoning and logic, the validity of which can only be determined in hindsight. It is an assessment of probabilities of the future, one that matches past and current indicators with a model of the future. It is also steeped in action: the social act of conveying the warning to others such as decision makers. It is the product of an early warning process operating within an early warning system (EWS). This system is an initiative that harnesses a network of actors, resources, technologies, practices and organisational structures. The focus of which is the systematic collection, analysis and formulation of recommendations relating to the monitoring of an environment for the purpose of detecting and acting on opportunities, threats, discontinuities and preventing surprise.

In addition, early warning systems are a highly complex mix of: (1) establishing indicators that signpost possible futures, (2) the collection of vast amounts of data and information about an environment to try and find indications of the indicators, (3) the application of specialized software to deal with big data and facilitate analytical reasoning, as well as, (4) the dissemination of the end result. The complex nature of this endeavour, together with the open-ended, unknowable[187] and non-existent nature[188] of the future, effects how warning systems, signals/signs, and software are used, and applied in warning systems.

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[186] Narayanan, VK & Fahey, L 2004. Invention and navigation as contrasting metaphors… (54-55)

[187] Tsoukas, H 2005. *Complex Knowledge* (276)

[188] Narayanan, VK & Fahey, L 2004. Invention and navigation as contrasting metaphors… (54-55)

Analytical models, such as Pirolli and Card's notional model of analysis, centre around the shaping and construction of representations during a "waterfall like" transformational dataflow. This model represents the so-called representation construction model of sensemaking and is represented as "sense-making" in the rest of this thesis. In actuality this refers to the sense an analyst makes by inductive and deductive analysis while processing and analysing collected data. The nature of this model suggests a mechanistic description of the analysis process without really addressing the actual sensemaking process the analyst undergoes from a cognitive perspective.

The cost structures associated with the notional model of analysis as well as 9/11 provided the impetus for Visual Analytics. As demonstrated earlier, reasoning models in Visual Analytics also focus on schematic knowledge structures or representational schemata that underlie interactive visualisations of large datasets. Variations on these models such as that of Van Wijk are based on the perspective or view of the researchers regarding the role of explicit and tacit knowledge. In essence, a large dataset is visualised based on a specification determined by algorithms, entity extraction, manipulation, and filtering – a significant amount of pre-structuring. In effect, Visual Analytics is a tool facilitating the sense-making of an warning analyst.

There are very different interpretations relating to what constitutes a weak signal. The imprecise, nebulous, or vague state of the signal or sign when first noticed, is a common aspect of weak signals within the Ansoffian and neo-Ansoffian tradition. Interpretations vary between the "representationalist" paradigm and the "constructivist" paradigm. The representationalists see weak signals as cognitions that directly represent the environment, whilst constructivists see them as mere cognitive constructions determined by structures of our cognition. This conceptual variation effects the methodologies and processes in place to notice signals and cues in a warning environment, and adds an additional layer of complexity.

Futures Studies has made a considerable contribution, but at the same time added its own issues. This is especially evident, as an example, in statements relating to Ansoff's filter model, where Holopainen and Toivonen[189] posit that in order to effect the future a signal has to traverse Ansoff's three filters. On the contrary, not noticing a sign, cue or weak signal certainly does not mean it won't affect the future, it only means it was not noticed by the

[189] Holopainen, M & Toivonen, M 2012. Weak signals: Ansoff today (199)

analyst. In addition they propose that in some instances weak signals are noticed but not understood because of what has been learned in the past. The complex nature of predicting these "futures" and validating these predictions is by implication steeped in the past and only confirmable in hindsight.

The ambiguity in research attempting to define weak signals may be linked to an attempt to define weak signals from within a nominal or reductionist perspective, consequently seeking a defined set of characteristics for the concept of a weak signal. Furthermore, warning systems do not only operate at the level of the individual. As soon as attempts are made to move from an individual level of analysis to that of the organisation, conceptual clarity becomes hazy.

The constructivist paradigm represented by authors such as Seidl, Rossel and Narayanan and Fahey provide a bridgehead to Karl Weick's theory of sensemaking, in particular the contribution the concept of framing can make to weak signal analysis and Visual Analytics. Elements of the sensemaking process are evident in these authors' work: Seidl more so from an organisational perspective and Rossel focusing more on framing on the level of the individual. The notion of invention, by Narayanan and Fahey, also alludes to the belief-driven aspects of sensemaking as proposed by Weick. It is this overlapping between the individual and organisational level that makes Weick's position different and compelling.

# *Chapter 3*

# The Sensemaking Theory of Karl Weick

*What we wish, we readily believe, and what we ourselves think, we imagine others think also. – Julius Caesar (100-44B.C.)*[190]

## 3.1 Introduction

This chapter provides a synopsis of Weick's theory of sensemaking which is used as a guiding framework to compare and critically review the conceptual foundations of weak signal and early warning analysis, environmental scanning, and Visual Analytics. Whilst the essence of Weick's theory is discussed it will zero in on Weick's view of frames and framing and the role this plays in the process of sensemaking.

## 3.2 Weick's sensemaking

Karl Weick has contributed to the study of organizational science with three works in particular, *The Social Psychology of Organizing*[191], *Sensemaking in Organizations*[192] and, *Making Sense of the Organization*[193]. In his book *Sensemaking in Organizations* Weick describes and conceptualises sensemaking in terms of seven distinguishing characteristics that set it apart from interpretation and understanding. These characteristics are applied to organisational sensemaking and serve as a guide to sensemaking and how it works.[194] His work relating to the seven properties of sensemaking has fostered a wealth of literature by researchers applying these seven properties as a framework in understanding organisational

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[190] Gaius Julius Caesar Quotes. (n.d.). Quotes.net. Retrieved at http://www.quotes.net/quote/22393, accessed 2013-07-21

[191] Weick, KE 1969. *The social psychology of organizing*. Reading, MA: Addison-Wesley; Weick, KE 1979. *The social psychology of organizing*, Reading, MA: Addison-Wesley 2nd edition.

[192] Weick, KE 1995. *Sensemaking in Organizations*. Sage, California

[193] Weick, KE 2001. *Making sense of the organization*. Blackwell Publishing

[194] Weick, KE 1995. *Sensemaking in Organizations* (17-18)

events and crises.[195] Scott and Barret[196] have investigated strategic risk positioning as a sensemaking method in financial crises. Weick's sensemaking has received attention in the investigation of environmental crises,[197] mass shootings such as the Columbine school incident[198] and the mapping of subjective risk in venture capital risk taking.[199]

Sensemaking is about placing cues into frameworks to derive meaning. It is about noticing something in an on-going flow of events, a transient, or something out of the ordinary, something surprising. That "something" which is noticed (a cue), is noticed when a person looks back in time. It is retrospective in that plausible explanations are sought in past experiences to explain the noticed cues.[200] Weick states that sensemaking "is about such things as placement of items into frameworks, comprehending, redressing surprise, constructing meaning, interacting in pursuit of mutual understanding, and patterning."[201] Weick refines this description by contrasting sensemaking with interpretation to show what sensemaking is not. He refers to interpretation as "a rendering in which one word in explained by another," a "focus on some kind of text," and it "points towards a text to be interpreted" and an "audience presumed to be in need of the interpretation."[202] For Weick, sensemaking is not only about the reading of the text but also about the authoring of it. He sees authoring and interpretation intertwined in the sensemaking process. Action and "creating" lay down the material that needs to be interpreted and reinterpreted.[203] Weick states that to engage in sensemaking is to "construct, filter, frame, create facticity, and render the subjective into something more tangible."[204] In making sense of an event, it is implied that "something" must have existed to be noticed. It is only after this "something" was noticed that sense is then constructed to render that which is noticed into something sensible.

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[195] Parry, J 2003. Making sense of executive sensemaking (240-263); Nathan, ML 2004. How the past becomes prologue (181-199)

[196] Scott, SV & Barrett, MI 2005. Strategic risk positioning… (45-68)

[197] Mullen, J, Vladi, N & Mills, AJ 2006. Making sense of the Walkerton Crises… (207-220)

[198] Nathan, N 2004. How the past becomes prologue… (181-199)

[199] Moessell, DD, Fiet, JO & Busenitz, JW 2001. Embedded fitness landscapes… (91-106)

[200] Weick, KE 1995. *Sensemaking in Organizations* (2-3)

[201] Weick, KE 1995. *Sensemaking in Organizations* (6)

[202] Weick, KE 1995. *Sensemaking in Organizations* (8)

[203] Weick, K.E. 1995. *Sensemaking in Organizations* (12)

[204] Weick, K.E. 1995. *Sensemaking in Organizations* (14)

Building on this differentiation of Weick between interpretation and sensemaking, Kinghorn states that there is a fundamental difference between meaning and sense. Sense is not inherent in meaning but rather the fusing together of a set of meanings and that meaning is derived from interpreting what our senses notice around us.[205] Sense for Kinghorn, is a "holistic construction of our own making as we weld different meanings into a coherent understanding of their purpose and base our actions upon this understanding."[206]

## 3.3 Weick's seven properties of sensemaking

Sensemaking as described by Weick should be understood as a process characterised by the following seven properties:

### 3.3.1 Grounded in identity construction

Identity construction is one of the core elements of sensemaking. Weick states, "the sensemaker is an on-going puzzle undergoing continual redefinition."[207] The sensemaker's sense of who he or she is will affect how that person defines a situation, but the situation will also affect the person's definition of self. Weick cites Knorr-Cetina[208] to assert that identities are established out of a process of construction – "a typified discursive construction." Weick provides the phrase: "how can I know what I think until I see what I say?", emphasizing the importance of the sense of self in assigning meaning to a situation. Identity has to be established as well as maintained for a consistent and positive conception of self.[209] Browne confirms that this failure to maintain and confirm a sense of self triggers episodes of sensemaking.[210]

Accordingly, the sense maker has to decide what implications an event will have on the sense of self and that the meaning of an event or situation will be determined by the identity adopted in handling the situation. The re-affirmation of self-concept reduces the discomfort an individual feels when confronted by a situation that is out of the ordinary or inconsistent with the norm.[211] In other words, our identity shapes how we interpret a situation and what

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[205] Kinghorn, J 2005. Understanding organizational sensemaking… (320)
[206] Kinghorn, J 2005. Understanding organizational sensemaking… (319)
[207] Weick, KE 1995. *Sensemaking in Organizations*. (20)
[208] Knorr-Cetina, KD 1981. The microsociological challenge… (10)
[209] Weick, KE 1995. *Sensemaking in Organizations* (23)
[210] Brown, AD 2000. Making sense of inquiry sensemaking (46)
[211] Weick, KE 1995. *Sensemaking in Organizations* (23)

actions we will take in that situation. Weick's re-interpretation of the Mann Gulch Disaster provides a good example of the role of identity in making sense in crises situations. The supervisor of a smokejumper team commanded his team members to drop their tools, and lit an escape fire in the face of an oncoming and out of control forest fire. Of the fifteen team members, only two survived. Dodge, the team supervisor, survived the firestorm by lying down in the ashes of his escape fire. Apart from problems such as structure, the order to throw away their tools, and the lighting of a fire in the face of the oncoming firestorm, had a profound effect on the identity of the smokejumpers as fire fighters, and ultimately on their survival. As Weick states, "If I am no longer a fire fighter then who am I?"[212]

### 3.3.2 Retrospective

The retrospective nature of sensemaking is one of its most distinguishing features for Weick.[213] He derives retrospective sensemaking from Schutz's[214] analysis of "meaningful lived experience." The emphasis here being on the verb "lived." Individuals only know what they have done after they have done it. Reflection focuses on lived experience, which according to Schutz,[215] as cited in Weick,[216] is singular and implies distinct separate episodes within a "stream of experience." In order to direct attention to this experience of ours implies that it must exist and has already previously passed in the "stream of experience."[217]

Consequently, Weick[218] argues that creation of meaning is an attentional process to what has already occurred in the past and is directed backward from a specific point in time. However, meaning is not attached to the highlighted experience, but rather the kind of attention directed to it. Sensemaking is an evaluation of historic or past experience in order to comprehend elements of a current situation.[219] The following statement of Weick drives the importance of retrospect home[220]:

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[212] Weick, KE 1993. The Mann Gulch disaster (629-631, 636-637)

[213] Weick, KE 1995. *Sensemaking in Organizations* (24)

[214] Schutz, A 1967. *The phenomenology of the social world*. Evanston, IL., Northwestern University Press

[215] Schutz, A 1967. *The phenomenology of the social world* (47)

[216] Weick, KE 1995. *Sensemaking in Organizations* (25)

[217] Weick, KE 1995. *Sensemaking in Organizations* (25)

[218] Weick, KE 1995. *Sensemaking in Organizations* (26)

[219] Nathan, N 2004. How the past becomes prologue… (3)

[220] Weick. KE1995. *Sensemaking in Organizations* (30)

> The Dominance of retrospect in sensemaking is a major reason why students of sensemaking find forecasting, contingency planning, strategic planning, and other magical probes into the future wasteful and misleading if they are decoupled from reflective action and history.

### 3.3.3 Enactive of sensible environments

Action is a crucial element of sensemaking for Weick. He draws on the work of Follett[221] whose main notion is the idea that individuals "receive stimuli as a result of their own activity."[222] Weick prefers the word *enactment* and states that people create a portion of the environment they deal with. This enactment is circular in the sense that individuals construct their own environment as the environment creates them – "people create and find what they expect to find."[223] To Weick sensemaking embodies a process that "creates objects for sensing or the structures of structuration."[224]

### 3.3.4 Social

Sensemaking is essentially a social process. The conduct of individuals is reliant on the conduct of imagined or present conduct of others.[225] Weick places emphasis on concepts such as "network," "intersubjectively shared meanings," "common language," and "social interaction," to drive home the importance of the social nature of sensemaking. Sensemaking is thus never separated from others because what we think and do is dependent on others and this social contact is mediated through discourse and conversation.[226]

### 3.3.5 Ongoing

Sensemaking is a continuous process and may be seen as a constant flow with no beginning or end. Sensemaking never starts because it never stops. People select moments out of this continuous flow and extract cues based on past experience. It is only when this flow is interrupted that people become aware of it, which in turn causes an arousal or "discharge of

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[221] Follett, MP 1924. *Creative Experience*. New York: Longmans, Green

[222] Weick, KE 1995. *Sensemaking in Organizations* (32)

[223] Weick, KE 1995. *Sensemaking in Organizations* (34-35)

[224] Weick, KE 1995. *Sensemaking in Organizations* (36)

[225] Weick, KE 1995 *Sensemaking in Organizations* (39)

[226] Weick, KE 1995. Sensemaking in Organization (40-41)

the autonomic nervous system."[227] According to Weick it is this arousal that triggers an act of sensemaking alerting an individual that there is something in need of attention.

### 3.3.6 Focused on and by extracted cues

Weick defines cues as "simple, familiar structures that are seeds from which people develop a larger sense of what is taking place."[228] The metaphor of a 'seed' is used to highlight the open-ended quality of sensemaking when extracted cues are used. Context is an important dependency on what extracted cues will ultimately become: it affects what is extracted as a cue and how the cue is interpreted. Cues become noteworthy because of context and play an important role in taking action or launching into a course of action.[229]

### 3.3.7 Driven by plausibility rather than accuracy

Sensemaking does not rely on accuracy, but rather plausibility, pragmatism and reasonableness. Weick argues that it is about the embellishment and elaboration of cues and that "accuracy is meaningless when used to describe a filtered sense of present, linked with a reconstruction of the past that has been edited in hindsight."[230] It is not so much about the truth, but rather the continuous redrafting of a story so that it becomes more sensible over time.[231] Accuracy is not as important as sufficiency and plausibility in the enhancement and elaboration of extracted cues in the sensemaking process.

Apart from Weick's seven properties, there are supplementary features or properties that have a bearing on the sensemaking process but do not fall within the scope of this thesis. These supplementary issues are categorised into two areas namely, multi-ontological frameworks[232] and power relationships[233] in organisations.

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[227] Weick, KE 1995. *Sensemaking in Organizations* (34, 45)

[228] Weick, KE 1995. *Sensemaking in Organizations* (50)

[229] Weick, KE 1995. *Sensemaking in Organizations* (52-53)

[230] Weick, KE 1995. *Sensemaking in Organizations* (57)

[231] Weick, KE, Sutcliff, KM & Obstfeld, D 2005. Organizing and the process of sensemaking (451)

[232] After the publication by Weick of *Sensemaking in Organizations* in 1995, authors such as Mika Aaltonen (Aaltonen, M 2007. The Third Lens p.xvii) levelled criticism against "the almost canonical position" of the seven characteristics of sensemaking in the literature. Aaltonen proposes a multi ontological sensemaking framework that recognises ordered, complex and chaotic ontologies and posits that they require different epistemological approaches – in essence a pluralist epistemology (Aaltonen, M. 2007. The Third Lens p. xxiii). There are similarities between Aaltonen's framework and the Cynefin framework developed by Dave Snowden (Kurtz, CF & Snowden, DJ 2003. The New Dynamics of Strategy p.470) in relation to how sensemaking works within ordered, complicated and complex environments. Aaltonen goes further to say that Brenda Dervin's work rather than Weick has fostered his approach, in particular that: (1) Sensemaking assumes that both humans and reality can be both orderly and chaotic, (2) humans have a need to create

In summary, these seven properties or "guiding principles" provide us with a foundation or rough guideline to explore sensemaking. However, sensemaking is applicable to both individual and organisational levels. Consequently, it is necessary to discuss sensemaking within an individual and a group perspective in organisations.

### 3.4 Sensemaking: individual and organisational level

Apart from sensemaking on the level of the individual, Weick recognizes three distinct levels of sensemaking from an organisation's perspective: intersubjective, generic subjective and extrasubjective.[234] Intersubjective sensemaking emerges as a consequence of interaction between individuals, when meaning is derived and synthesised during discussions that transform the "I" into the "we." Generic subjectivity operates at the level of social structure. Individuals are no longer present, rather a "generic self" that fulfils roles and follows rules. Weick illustrates this by reference to times of stability where generic subjectivity takes on the form of scripts, interlocking routines and habituated action patterns where people can substitute for one another. In times of uncertainty these scripts and generic subjectivity no longer work. Focus has to shift to intersubjectivity in order for individuals to interact and synthesise new meaning. The old scripts do not completely disappear during management of uncertainty but rather a mixing of the intersubjective and generic subjective.[235] To paraphrase Weick:

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meaning, and (3) there are differences in experience and observation (Aaltonen, M 2007. The Third Lens pp.xviii – xix). The latter three points are areas that Weick covers in some detail in *Sensemaking in Organizations*, in specific the occasions (Weick, KE 1995, pp.85-105) and substance of sensemaking (Weick, KE 1995, pp. 106-132). Furthermore, Weick is acutely aware that the seven characteristics serve merely as a rough guideline for inquiry into sensemaking; he views it more as "a set of raw materials for disciplined imagination" than a "tacit set of propositions to be refined and tested."

[233] Mills *Et al.* argue for a critical sensemaking approach and that any analysis of sensemaking needs to take into account "the contextual factors of structure and discourse" (Mills, JH Thurlow, A Mills, AJ. 2010. Making sense of sensemaking pp.188-191). Drawing from interpretism, post-structuralism and critical theory they set out to show that sensemaking also takes place within a broader context of organizational power and social experience. That some individuals who hold more power in an organization may exert more influence on how meaning is derived. Powerful individuals may also exert more power on the sensemaking of others in the organization. However, Weick does not discount the role of power relationships and structures in the process of sensemaking and is cognizant of the influence that power carries in the construction of social reality (Weick, KE Sutcliff, KM and Obstfeld, D 2005. Organizing and the process of sensemaking p.418).

[234] Weick, KE 1995. *Sensemaking in Organizations* (70)

[235] Weick, KE 1995. *Sensemaking in Organizations* (71,80)

> What varies during times of convergence and stability and times of divergence and turbulence is the relative emphasis on the generic subjectivity and scripts that ratify and intersubjectivity and scripts that modify.[236]

More importantly when people substitute for one another, (intersubjective to generic subjective) there is "always some loss of joint understanding" and a tension between innovation (intersubjective) and control (generic subjective). Excessive control frustrates innovation and when dominant in an organisation, prevents the reframing of generic subjectivity in the face of uncertainty. Lastly, on the extrasubjective level, the generic self is replaced by pure meaning "without a knowing subject" such as mathematics, algebra, feminism, and capitalism - an "abstract idealized framework derived from prior interaction."[237] The circularity of the framing processes at various levels of sensemaking is illustrated in figure 11 on page 54.

The seven attributes of sensemaking operate at both an individual and organisational level and organisational forms are the bridging operations between the intersubjective and generic subjective levels.[238] Furthermore, separating individual sensemaking from organisational sensemaking may be an artificial undertaking given the social nature of sensemaking in particular.

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[236] Weick, KE 1995. *Sensemaking in Organizations* (72)

[237] Weick, KE 1995. *Sensemaking in Organizations* (72)

[238] Weick, KE 1995. *Sensemaking in Organizations* (73)

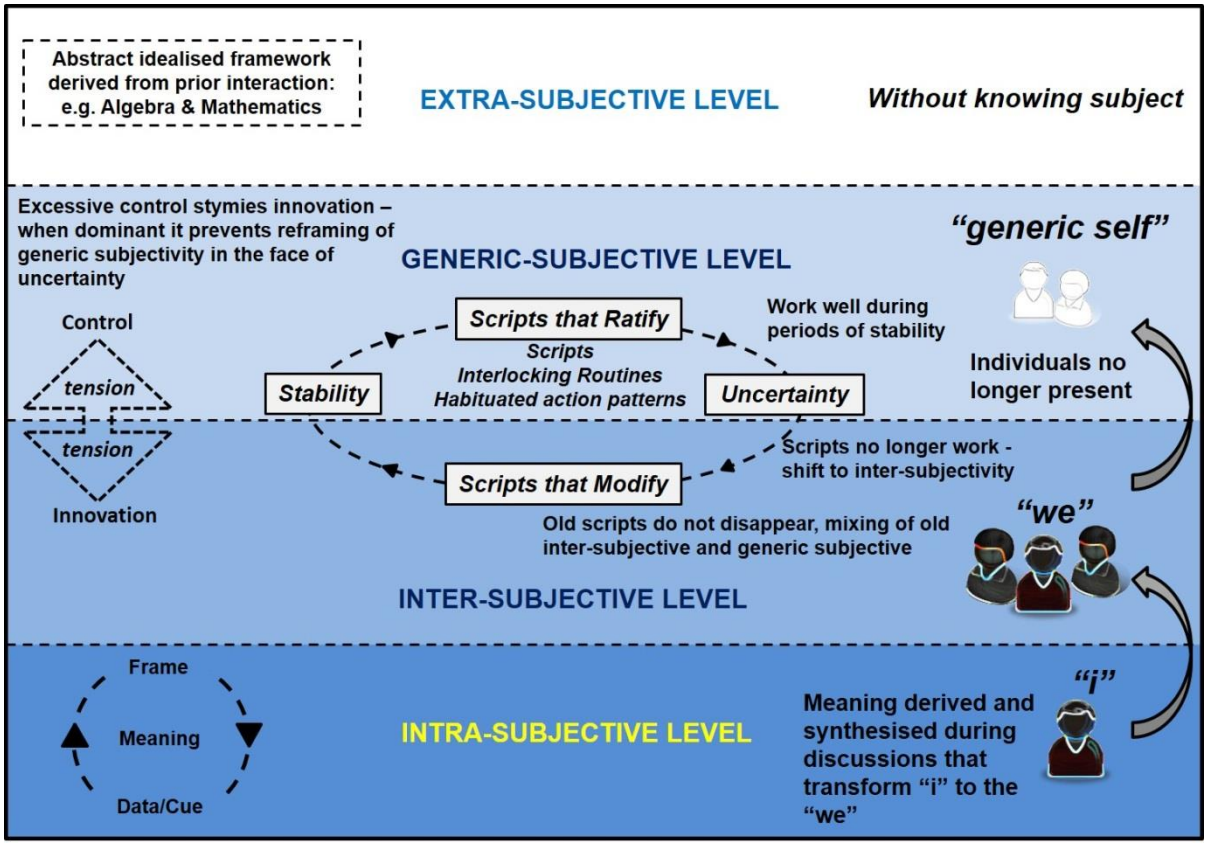


**Figure 11 - Levels of Sensemaking**[239]

In a similar vein, the property of "extracting cues" and the emphasis on "plausible" explanations necessitates a discussion as to what enables warning analysts to notice and elaborate on cues or signs present in an environment.

## 3.5 Frames within the sensemaking process

In warning and intelligence analysis the statement in normally made that the "dots" need to be connected. The cartoon (figure 12) on page 55 pithily illustrates the problematic nature of this conception of "connecting the dots."

[239] Self-constructed, based on Weick, KE. 1995. *Sensemaking in Organizations*

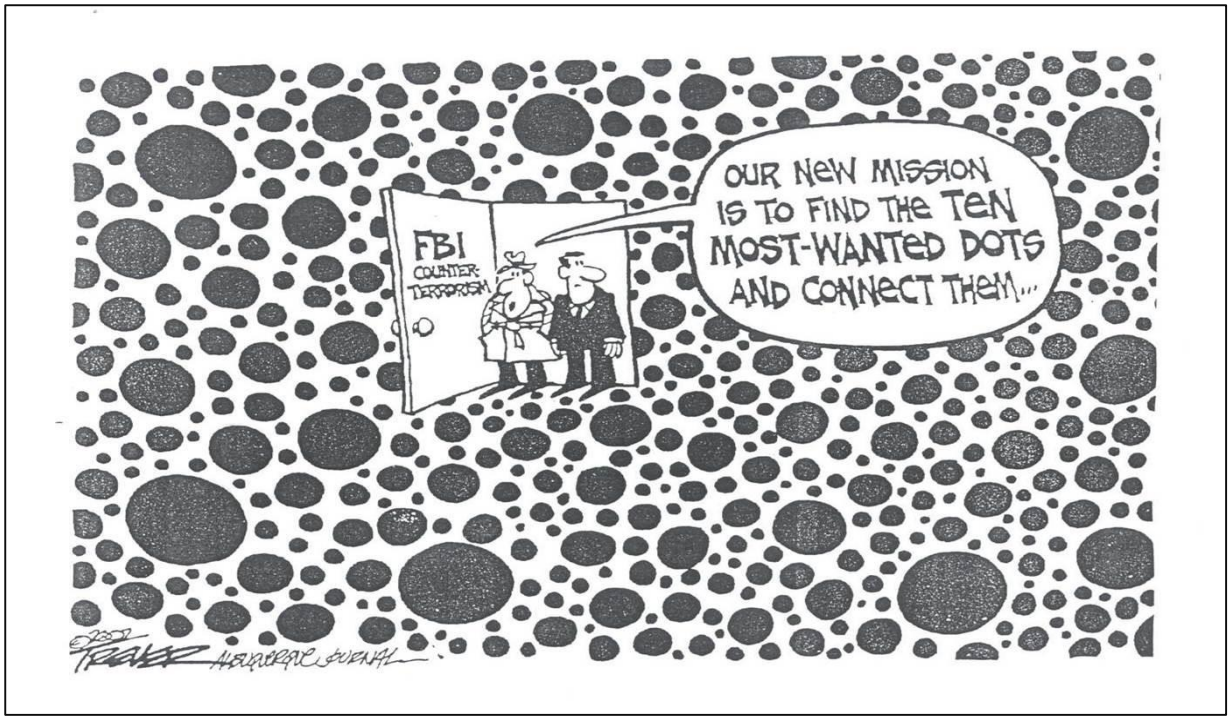


**Figure 12 - "Connecting the dots" cartoon**[240]

These "dots" generally refer to signals identified within a warning or intelligence collection system. Hollywood *Et al.*[241] relates this to a problem solver observing a stream of data about an environment and scanning this stream of data for "out-of-the-ordinary or atypical signals that significantly deviate from the expected status quo." However, these "dots" can only be "connected" by the problem solver if they have been noticed in the first place.

Starbuck and Milliken refer to noticing as an act of classifying and filtering stimuli as signals or noise that results from interactions of the characteristics of stimuli with that of the perceiver of the stimuli.[242] They note that noticing is a basic form of sensemaking in that "noticing requires distinguishing signal from noise, making crude separations of relevant from irrelevant." Weick centres on Starbuck and Milliken's distinction between sensemaking and noticing in his elaboration of the focus of extracting cues as a property of sensemaking.[243] In particular, Weick emphasizes the idea that noticing determines whether

[240] Source: John Trever, 2002, Albuquerque Journal

[241] Hollywood *Et al.* 2004. *Out of the Ordinary – Finding hidden threats by analysing unusual behaviour* (xvi)

[242] Starbuck, WH & Milliken, FJ 1988. Executive Perceptual Filters

[243] Weick, KE 1995. *Sensemaking in Organizations* (49-55)

people even consider responding to environmental events. If events are not noticed, they are not available for sensemaking.[244]

Starbuck and Milliken[245] quote a poem from RD Laing as cited in Goleman's[246] work relating to the psychology of self-deception to describe the essence of what "noticing" entails:

> *Noticing: Where to look and what to see*
> *The range of what we think and do*
> *is limited by what we fail to notice.*
> *And because we fail to notice*
> *that we fail to notice*
> *there is little we can do*
> *to change*
> *until we notice*
> *how failing to notice*
> *shapes our thoughts and deeds.*

What we notice is affected by context, which is an important dependency in terms of what an extracted cue will ultimately develop into. It affects both what is extracted as cues during searching, scanning and noticing and how these extracted cues are interpreted.[247] According to Weick the saliency or noticeability of cues are dependent on their indexicality, which refers to the contextual nature of objects and events. Without this indexicality, objects and events have equivocal or multiple meanings for people trying to make sense of a situation.[248] In specific, Weick makes reference to what individuals "draw on" to "construct the roles and interpret objects" and for him it is this "drawing on something" that suggests "the implicit or explicit operation of some sort of frame within which cues are noticed, extracted, and made sensible."[249]

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[244] Weick, KE 1995. *Sensemaking in Organizations* (52)

[245] Starbuck, WH & Milliken, FJ 1988. Executive Perceptual Filters

[246] Goleman, D 1985. *Vital Lies, Simple Truths: The Psychology of Self-Deception.* New York: Simon and Schuster

[247] Weick, KE 1995. *Sensemaking in Organizations* (51)

[248] Weick, KE 1995. *Sensemaking in Organizations* (52-53)

[249] Weick, KE 1995. *Sensemaking in Organizations* (109)

The concept of frames and framing has received attention across a wide range of disciplines such as framing processes and social movements in sociology,[250] cognitive psychology,[251] environmental sciences,[252] and human decision-making.[253] Goffman[254] in his seminal work *Framing Analysis* refers to frameworks as "schemata of interpretation." Goffman argues that a frame or framework "[may be seen] as rendering what would otherwise be a meaningless aspect of a scene into something that is meaningful." He refers to the concept that he terms "strip," which is an "arbitrary slice or cut from the stream of ongoing activity." This strip is as Goffman explains, a "raw batch of occurrences that one wants to draw attention to as a starting point of analysis."[255] Frames in his view are basic identified elements that are responsible for "building of definitions of a situation." There is a general congruency between Weick's concept of "cues" within frames and Goffman's "strips," in that they need to be extracted from an "ongoing" stream of experience/occurrences.

Benford and Snow[256] drawing on Goffman define a frame as a "schemata of interpretation" that assist people to locate, perceive, label, and identify events or incidents within their environment in order to render them meaningful, organise experience and guide action. They focus on collective action frames in social movements in which the core framing tasks are characterised as action orientated with interactive and discursive processes. Collective action frames are constructed as members of a social movement "negotiate a shared understanding of some problematic condition." Three core framing tasks present in the construction of meaning are: (1) diagnostic framing which relates to problem identification, (2) prognostic framing which relates to the articulation of a proposed solution and (3) motivational framing which provides the motivation for individuals in a specific movement to engage in collective action to achieve some stated goal.[257] The crux from a motivational framing perspective is the "construction of appropriate vocabularies of motive" and according to Snow and Benford highlights the agency component of collective action frames.

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[250] Benford, RD & Snow, DA 2000. Framing Processes and Social Movements (611–639)

[251] Fagley, NS Coleman, JG & Simon, AF 2010. Effects of framing, perspective taking, and perspective (264-269)

[252] Buijs, AE *Et al.* 2011. Beyond environmental frames (329-341)

[253] Tversky, A & Kahneman, D 1981. The framing of decisions and the psychology of choice (453–458)

[254] Goffman, E 1974. *Frame Analysis* (21)

[255] Goffman, E 1974. *Frame Analysis* (10-11)

[256] Benford, RD & Snow, DA 2000. Framing processes and social movements (614)

[257] Benford, RD & Snow, DA 2000. Framing processes and social movements (615-617)

Hallahan[258] states that the act of framing is an essential activity in the construction of social reality through a process of inclusion, exclusion, and emphasis. He makes use of a window or portrait frame metaphor to describe framing in the sense that it is "drawn around information," delimiting the subject matter and focusing attention on the salient points. Hallahan[259] posits that framing biases the information processing of a person via two suggested mechanisms. The first is the provisioning of contextual cues that guide decision-making and the drawing of inferences. The second is that of priming, which refers to "selective influencing" or activation of memory structures or schemata that facilitate the interpretation of an event or information received. In essence, this schematic processing as Hallahan states, refers to the "associations*"* and "expectations*"* that people use when drawing conclusions about a situation or information received.

Similarly Buijs *Et al.* state that frames are constituted of a connected range of categories and labels that are used to interpret issues. Through a process of framing, these categories and labels, are applied so that certain aspects or traits of an issue are placed in the foreground and others in the background and then related to personal experiences. They define the process of framing as "the communicative process through which actors propagate specific lenses and try to influence the interpretation of an issue by assigning specific meanings to that issue."[260]

Shmueli distinguishes between two research streams related to frames, researchers who see frames as cognitive devices and those who see frames as communicative devices. Cognitive devices are defined as "interpretive lenses through which we see and make sense of complex situations in ways internally consistent with our world views, giving meaning to events in the context of life experience, understandings and roles." Frames as cognitive devices function as tools to reduce complexity by filtering, simplifying and categorising information in effect reducing information load and "operate as models of reality that trade detail for clarity."[261] In particular, frames are linked by Shmueli to information processing, message patterns, linguistic cues and socially constructed meaning. As a communicative device, frames operate in a strategic process intending to persuade "others to one's own viewpoint, to gain advantage in negotiations, or to rally like-minded people to the cause."

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[258] Hallahan, K 1999. Seven models of framing (207)

[259] Hallahan, K 1999. Seven models of framing (208-209)

[260] Buijs, AE *Et al.* 2011. Beyond environmental frames (330)

[261] Shmueli, DF 2008. Framing in geographic analysis of environmental conflict (2049)

There are various communalities between Weick's theory of sensemaking and the research efforts of authors such as Shmueli[262] and Buijs *Et al.*[263] within the frames and framing disciplines. Shmueli, for one, clearly acknowledges that the concept of framing has evolved "at the intersection of several disciplines," such as decision-making, artificial intelligence, negotiations, business management and, environmental conflict management.

As showed previously on page 51 a core property of sensemaking is its focus on extracted cues and Weick places specific emphasis on context or indexicality provided by frames. The next section will unpack Weick's concept of "minimal sensible structures" which refers to the content of frames.

## 3.6 Frames and framing according to Weick

Weick differentiates between cues and frames by comparing them as vocabularies. Abstract words are equated with frames that include and point to cues, which are equated to less abstract words. These less abstract words or cues become sensible in the context created by the abstract and more inclusive words. As Weick explicitly states: "a cue in a frame is what makes sense, not a cue or a frame alone," for him the substance of sensemaking starts with three elements or units of meaning: a frame, a cue and a connection.[264] Weick sees frames as "past moments of socialization" and cues as "present moments of experience." Weick draws on Gary Klein's[265] work relating to recognition-primed decision making to lay emphasis on "past moments" connected to current moments of experience. The "substance" of sensemaking can be found in "the frames and categories that summarise past experience, in the cues and labels that snare specifics of present experience, and in the ways these two settings of experience are connected."[266]

### 3.6.1 Minimal sensible structures

Weick contends that the content of sensemaking is embodied in frames and these frames consist of six minimal sensible structures that describe these past moments of experience, present moments and connections:[267]

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[262] Shmueli, DF 2008. Framing in geographic analysis of environmental conflict

[263] Buijs *Et al.* 2011. Beyond environmental frames

[264] Weick, KE 1995. *Sensemaking in Organizations* (110)

[265] Klein, G 1989. Recognition-primed decisions (47-92)

[266] Weick, KE 1995. *Sensemaking in Organizations* (111)

[267] Weick, KE 1995. *Sensemaking in Organizations* (111-132)

#### 3.6.1.1 Ideology (vocabularies of society)

Ideology is a reasonably unified set of emotive beliefs, values and norms that share and bind individuals together so that they can make sense of their environment. Individuals tend to simplify what they perceive and ideology provides the structure to enable the simplification. Ideology thus acts as a filter through which cues are extracted or selected within an on-going stream of experience. The content of ideologies originate in what Weick[268] refers to as "extraorganizational sources" such as national cultures, regional and community cultures, industry ideologies, and occupational ideologies and these content sources are not in short supply. However, Weick warns that researchers need to be cautious in that individuals select from a vast pool of ideological substance only a "small portion that matters." It should never be assumed that ideologies are singular or homogenous and different meanings are perceived from ideological content. This meaning perceived from ideological content is also imperfectly communicated during the socialisation and re-socialisation process.

#### 3.6.1.2 Third-order controls (vocabularies of organisation)

Third-Order Controls or premise controls are one of three forms of control that operate in organisations. Direct supervision is the first order, followed by programs and routines as second and third, premise controls, which comprise assumptions and definitions that are taken as given.[269] Premise controls, specifically, influence the suppositions individuals use when they evaluate or diagnose a situation in order to make a decision. Weick highlights the unobtrusive nature of premise controls in that they influence sensemaking in an "implicit, tacit, preconscious, mindless and taken for granted manner."[270] Premise controls are more pervasive when organisational technology is non-routine and it joins sensemaking with decision making. What makes premise controls powerful is that its early influence in decision-making is capable of affecting subsequent steps in the decision process. They include factual and value content and, because the probity of these premises are unknown, selection is made on other grounds such as ideology. When premise controls are in operation the content that is used to make sense of an organisational conundrum may have a common understood meaning.[271]

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[268] Weick, KE 1995. *Sensemaking in Organizations* (112)
[269] Weick, KE 1995. *Sensemaking in Organizations* (113)
[270] Weick, KE 1995. *Sensemaking in Organizations* (114)
[271] Weick, KE 1995. *Sensemaking in Organizations* (115)

Consequently the non-routine nature of work at higher or top levels of organisational hierarchies creates a situation where premise controls are more likely to be in operation.[272] Organisational designers tend to control lower levels of organisational hierarchies with first - and second-order controls working up towards management in higher hierarchical levels. Controlled work in lower organisational hierarchies creates non-routine derivatives or offshoots in higher organisational hierarchies that need explanation. Invariably technology is used to impose first and second order controls at the different levels of organisational hierarchies – and this is problematic from a sensemaking viewpoint. As Weick states[273]:

> People at the top often inadvertently make their task more difficult by their efforts to make it easier. When they impose first- or second-order controls on subordinates, they create interactively complex situations that enlarge in unexpected directions, with unintended consequences, in ways that defy comprehension. When top management creates incomprehension, the major sensemaking resource they have left to handle the resulting mess is third-order premises.

### 3.6.1.3 Paradigms (vocabularies of work)

Paradigms refer to inherent assumptions about what sort of "things make up the world" and how they interrelate.[274] They differ from ideology and third order controls in the sense that paradigms tend to be self-contained systems capable of serving different realities. In specific Weick defines paradigms "as sets of recurrent and quasi-standard illustrations that show how theories of action are applied conceptually, observationally, and instrumentally to representative organizational problems."[275] Paradigms capture conflict and the inductive origins of sensemaking as qualities from within an organisational perspective.[276] Conflict relates to the degree of consensus about a paradigm. Importantly this agreement on a paradigm is related to its existence rather than the paradigms rules or rationalized form.[277]

Weick argues that paradigms are similar to culture and that examples associated with paradigms "become the artefacts that symbolize the culture and aid its transmission." It is

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[272] Weick, KE 1995. *Sensemaking in Organizations* (116)
[273] Weick, KE 1995. *Sensemaking in Organizations* (117)
[274] Weick, KE 1995. *Sensemaking in Organizations* (118)
[275] Weick, KE 1995. *Sensemaking in Organizations* (120)
[276] Weick, KE 1995. *Sensemaking in Organizations* (118)
[277] Weick, KE 1995. *Sensemaking in Organizations* (120)

these "artefacts" that are interpreted differently, which enables the re-accomplishment of the paradigm in different ways. These differences may result in conflict or trigger new interpretations more suited to changes in the environment. Examples of paradigms take on the form of stories from which the on-going meaning of events is induced.[278]

### 3.6.1.4 Theories of action (vocabularies of coping)

Theories of Action are distinctive frames that filter and interpret signals from the environment and connect stimuli to response.[279] Theories of action are distinct for Weick as they build on the stimulus-response (S-R) paradigm. Individuals in organisations construct knowledge in trial-and-error sequences in response to the circumstances they encounter in their environment. These trial-and-error response sequences include processes of cautious organisational adjustment to reality, and the aggressive use of knowledge to enhance the organisational environmental fit. In essence, an organisation needs to map its environment and determine causal relationships operating in the environment so that it may identify stimuli properly and select the most appropriate responses. Weick defines theories of action as abstractions that simplify in the interest of action and that their content is "derived from socialization experiences that reflect ideology in the organization."[280] As Weick concludes, "maps, knowledge structures, and mental models all contain substance that provides a meaningful frame that facilitates meaningful noticing."[281]

### 3.6.1.5 Tradition (vocabularies of predecessors)

Tradition according to Weick is something that was created, performed, believed or existed in the past and has been handed down through generations with the qualification that it must have been passed on over three generations.[282] Importantly only images, objects, and beliefs can be transmitted as tradition, not action, but only patterns or images of action. Concrete human action and know-how embodied in practice can only endure or be transmitted if it becomes symbolic.[283] The symbolisation of traditions requires a complex transformation of action and know-how into symbols that may be transmitted. During this symbolisation the

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[278] Weick, KE 1995. *Sensemaking in Organizations* (118)
[279] Weick, KE 1995. *Sensemaking in Organizations* (121)
[280] Weick, KE 1995. *Sensemaking in Organizations* (123)
[281] Weick, KE 1995. *Sensemaking in Organizations* (121)
[282] Weick, KE 1995. *Sensemaking in Organizations*(124)
[283] Weick, KE 1995. *Sensemaking in Organizations* (125)

"contents of the images used to portray action are crucial because they determine what will be perpetuated." Their symbolic encoding enables their "handing down" across generations.[284]

### 3.6.1.6 Stories (vocabularies of sequence and experience)

Stories are important for sensemaking given individuals' predisposition to inductive generalisation. In this regard, striking or notable experiences become the empirical basis for "rules of thumb, proverbs and other guides to conduct."[285] These "guides to conduct" that the stories provide underline the notion that frames guide behaviour by facilitating the interpretation of cues which that conduct emphasises. Weick in particular draws on the work of Mitroff and Kilmann,[286] Polkinghorne[287] and Zukier[288] to accentuate the role that stories play in sensemaking as well as highlighting the idea that individuals think narratively as opposed to argumentatively or paradigmatically.[289] When individuals translate their lives into narrative form the stories that result from this translation do not duplicate the experience. Rather this experience is filtered and events in the story are given an order in the form of a sequence.[290] According to Weick sequencing is a powerful heuristic for sensemaking and because the "essence of storytelling is sequencing", stories provide powerful content for sensemaking. Ideologies, paradigms and traditions are recognised by their examples rather than their abstract framing principles. In this regard, stories are cues within frames and are also capable of creating frames.[291]

Weick thus conceptualises the six minimal sensible structures as the content embodied in frames. Consequently, it is necessary to investigate how these minimal sensible structures are imposed on an on-going flow of experience so that cues may then be extracted and connected to these frames. Weick proposes four ways in which people impose frames on an on-going flow of experience in pursuit of making sense of a situation. Sensemaking can start

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[284] Weick, KE 1995. *Sensemaking in Organizations* (126)
[285] Weick, KE 1995. *Sensemaking in Organizations* (127)
[286] Mitroff, II & Kilmann, RH 1976. On organization stories (189-207)
[287] Polkinghorne, DE 1988. *Narrative knowing and the human sciences*
[288] Zukier, H 1986. The paradigmatic and narrative modes (465-502)
[289] Weick, KE 1995 *Sensemaking in Organizations* (127)
[290] Weick, KE 1995 *Sensemaking in Organizations* (128)
[291] Weick, KE 1995 *Sensemaking in Organizations* (131)

with beliefs in the form of arguing and expecting or it may begin with actions in the form of committing or manipulating.[292]

Sensemaking represents an endeavour to link beliefs and actions in closer proximity because: (1) arguments facilitate agreement on action, (2) expectations that are made clear map the way for confirmed actions, (3) committed actions expose suitable justifications for their occurrence, and (4) bold actions make the world straightforward and clarifies what is happening. Therefore, the fundamental operations of sensemaking for Weick entail "taking whatever is clearer belief or action and linking it with that which is less clear."[293]

### 3.6.2 Belief-driven sensemaking: arguing and expecting

Weick emphasises the centrality of arguing in organisational sensemaking. In particular, Weick[294] cites the work of Schmidt,[295] which refers to organisational sensemaking as "debative cooperation." In this regard, one has to evaluate both the individual and social meaning of the word argument. Looking at it from an individual perspective, it relates to a piece of reasoned discourse and socially as a dispute between two or more parties. However, there is a connection between individually reasoned discourse and a dispute between parties. Weick sees social argument as "debate that expresses the contradiction implicit in any position that is articulated" and it is within this social argument that individual reasoning is embedded.[296] An argument may lead to adaptive sensemaking because the reasoning process present during the development and criticism of explanations help people discover new explanations.[297] Sensemaking occurs when the tension that underlies arguing gradually effects an elaboration and strengthening of initial or weak explanations as their advocates confront critics.[298]

Expectations on the other hand are more directive than arguments as they tend to filter more emphatically[299] The urge for confirmation of an expectation is more potent than the urge for rebuttal or contradiction of an argument. Weick states that this urge "resemble[s] the singular,

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[292] Weick, KE 1995. *Sensemaking in Organizations* (135)
[293] Weick, KE 1995. *Sensemaking in Organizations* (135)
[294] Weick, KE 1995. *Sensemaking in Organizations* (136)
[295] Schmidt, K 1991. Cooperative work: A conceptual framework
[296] Weick, KE 1995. *Sensemaking in Organizations* (137)
[297] Weick, KE 1995. *Sensemaking in Organizations* (139)
[298] Weick, KE 1995. *Sensemaking in Organizations* (145)
[299] Weick, KE 1995. *Sensemaking in Organizations* (140)

strongly felt unqualified beliefs of action rationality rather than the reasoned qualified beliefs of decision rationality."[300] Connecting a cue to an expectancy establishes a unit of meaning and the expectancy is used to test for and expand additional implications of the cues, which are then tested against new cues.[301] Weick draws from the work of Klein in arguing that where situations satisfice people's expectations (accurate enough), confidence is gained in situational assessments. Perception assimilates what is seen to what is expected and in this respect may be a source of inaccuracy during the sensemaking process. Expectations may, however, be self-correcting for when events and expectations diverge both may be adjusted. It is this "self-adjustment" that is an important construct in the study of self-fulfilling prophecies.[302]

Weick provides a critique of the work of Merton regarding self-fulfilling prophecies in his discussion of expectations as a belief-driven process of sensemaking. In essence, Merton as cited by Weick, states that a self-fulfilling prophecy starts out as a false definition of a given situation. This false definition then results in behaviour that makes it come true. Expectations are in a sense pliable as they are likely to change progressively if it seems that they are at risk of not being fulfilled. Weick sees self-fulfilling prophecies as a fundamental act of sensemaking. Prophecies, hypotheses and anticipations are the starting points or minimal structures around which inputs can be assimilated due to some kind of active prodding.[303] Weick deems expectations to drive this prodding.

An expectation relating to an event or situation results in noticing becoming focused. It affects what information is retained and selected for processing as well as what inferences are made. Weick argues that when perceivers act on expectations it is possible that they enact what they perceive or expect to be there. In his words "using their predictions as a lens, they often confirm their prediction."[304]

### 3.6.3 Action-driven sensemaking: commitment and manipulation

In both commitment and manipulation, sensemaking starts with action. If a person is responsible for the action, it shows behavioural commitment. Manipulation is responsible for

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[300] Weick, KE 1995. *Sensemaking in Organizations* (145)
[301] Weick, KE 1995. *Sensemaking in Organizations* (146)
[302] Weick, KE 1995. *Sensemaking in Organizations* (147)
[303] Weick, KE 1995. *Sensemaking in Organizations* (148)
[304] Weick, KE 1995. *Sensemaking in Organizations* (152)

situations where action has made a visible change in the world that is in need of explanation. The commitment process is focused on a single action whilst manipulation is focused on multiple simultaneous actions. Commitment places "a greater premium on explanation and cognition as a means by which sense is created" while manipulation emphasises the actual change in an environment.[305] Deliberation and social information processing play a larger role in commitment and are harder to produce than manipulation, as a specific situation that tends to occur infrequently is required. Weick states that manipulation is more robust and bold and "is about cunning."[306] Once individuals make a choice regarding the justification of actions that they may perform, they establish the frame through which their actions and beliefs will make sense in.[307]

Individuals will try to construct meaning around actions to which they have a very strong commitment and according to Weick, this focuses sensemaking on binding actions.[308] If one wants to understand sensemaking, the earlier binding actions of individuals (a committed act in search of explanation) and the justifications available need to be investigated as a starting point. Weick states that this binding behaviour must be explicit, public and irrevocable and a combination of these constructs the reality that the action occurred.[309] Commitment focuses attention, exposes unnoticed elements and "imposes a form of logic on the interpretation of action."[310]

Manipulation focuses on the meaningful consequences of the action itself and involves acting in a way that establishes an environment that people can understand. It generates clarity in a confusing environment. Whilst commitment focuses on the question, "Why did the action occur?" Manipulation centres on the question, "What did occur?" As Weick states, manipulation "[is] the meaningful consequences of action [and] generates clearer outcomes in a puzzling world." It may be operationalised in the statement "leap before you look." [311]

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[305] Weick, KE 1995. *Sensemaking in Organizations* (156)
[306] Weick, KE 1995. *Sensemaking in Organizations* (156)
[307] Weick, KE 1995. *Sensemaking in Organizations* (164)
[308] Weick, KE 1995. *Sensemaking in Organizations* (156)
[309] Weick, KE 1995. *Sensemaking in Organizations* (157)
[310] Weick, KE 1995. *Sensemaking in Organizations* (158)
[311] Weick, KE 1995. *Sensemaking in Organizations* (165-168)

Figure 13 below illustrates how minimal sensible structures, or the content of frames as imposed on an on-going stream of experience, by argument, expectation, commitment or manipulation, fit into that larger process of sensemaking as proposed by Weick.

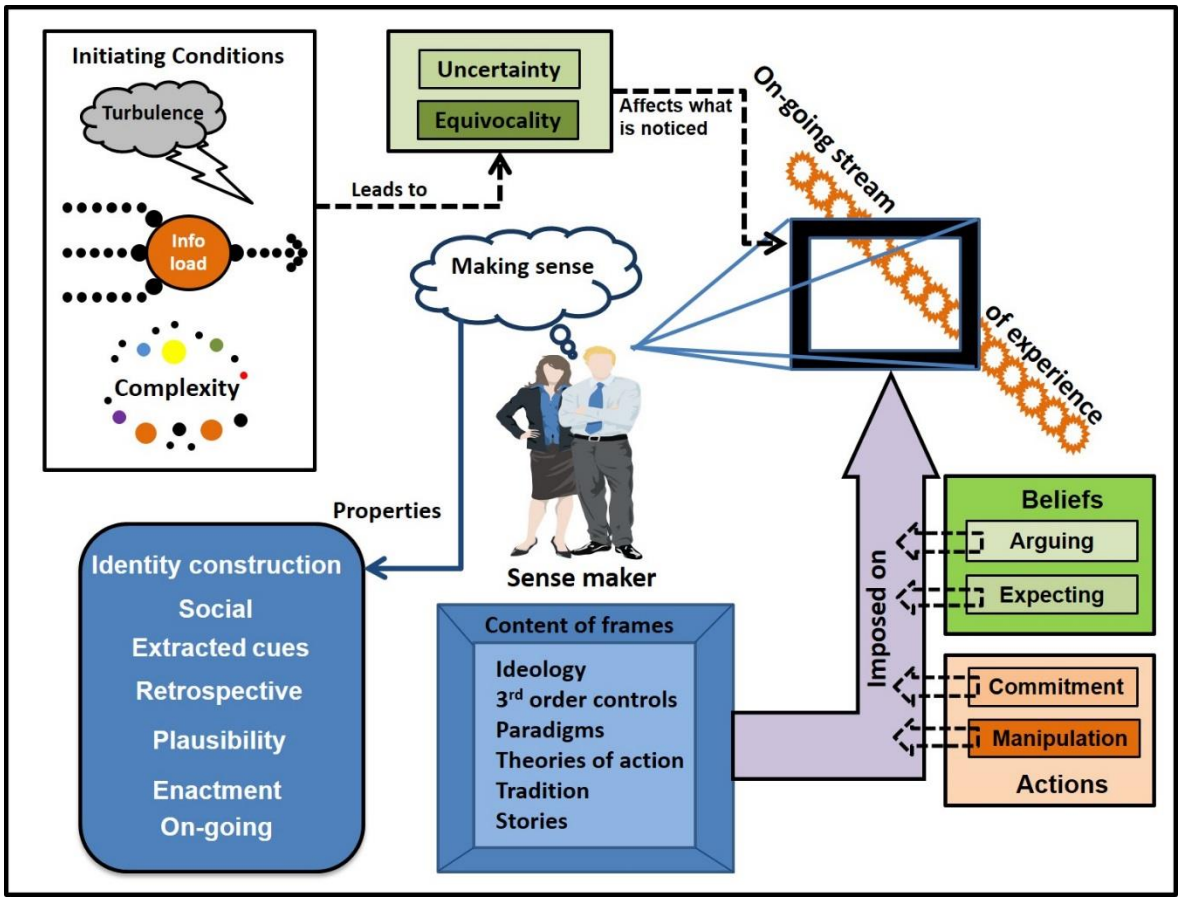


**Figure 13 - Sensemaking Diagram**[312]

## 3.7 Implications

Sensemaking as a process has seven fundamental characteristics. It is grounded in identity construction, retrospective, enactive of sensible environments, social in nature, ongoing, focused on an by extracted cues and driven by plausibility rather than accuracy. The essence of sensemaking, in Weickian terms, is the connecting of a cue with a frame which establishes a unit of meaning. Framing is a critical component of this process as without it no unit of meaning is established. Framing enables individuals to notice cues or "strips" within an on-going flow of experience. Individuals construct or craft sense after this noticing of strips and cues. Creation of meaning is linked to what has already occurred in the past, it is retrospective in that plausible explanations are sought in the past.

[312] Self-constructed – based on Weick, KE, 1995

The content of frames are represented by what Weick refers to as minimal sensible structures and are imposed on an ongoing stream of experience through beliefs and actions. The key to sensemaking is the saliency or noticeability of cues that relates to their indexicality, which refers to the contextual nature as represented by the content of frames. Noticing determines whether people even consider responding to environmental events. If events are not noticed, they are not available for sensemaking. Cues are only noticed if priming, activation of memory or minimal sensible structures occur.

The retrospective nature of sensemaking has a profound effect for the concepts detailed earlier in this thesis – in that accuracy can only be determined in hindsight. Furthermore, to direct attention to a cue and make sense of it implies that it must have existed in the first place to be noticed. Plausible, and not necessarily accurate explanations, are sought in past experience to explain noticed cues. Plausibility is important due to the open-ended quality of sensemaking, as cues are seen as "seeds" that are elaborated and embellished during the process.

However, this meaning is attached to the attention directed at the noticed cues and strips. The strips and cues can be seen as seeds in need of elaboration. Noticing is thus a critical act in making sense. The "dots" need to be noticed before they can be connected. The likelihood of noticing cues, signs and signals are dependent on how minimal sensible structures (the content embodied in frames) are imposed on a stream of experience though arguing, expecting, manipulation and commitment.

Organisational sensemaking occurs between the various organisational levels described by Weick. It is contingent on bridging operations between the intra-, inter-, generic, and extra-subjective levels. These bridging operations are essential reframing operations as the organisation shifts between stability and uncertainty as organisational scripts are modified and ratified. The critical issue is that sense is crafted through various interactions at various levels. As individuals perform warning analysis, and the warning systems are essentially situated within organisational structures, an understanding of the bridging operations is critical to ensure that sense of warning signs noticed is made on an analyst's as well as an organisational level.

The importance of expectation, as a way in which frames are imposed on a present situation have significant implications and questions for the functioning of early warning systems in a number of areas. Creating expectations, or invoking a capacity within the analyst's mind to

generate visions of the future, determines what cues the individuals will notice. This leads to the question as to how this is translated into warning analysis?

The intricacies, nuances and effects of expectation, as a belief-driven form of sensemaking within warning systems, need to be understood to apply it to warning systems. Furthermore, it needs to be established how framing applies to individual analysts and the warning organisation and what the interaction between the two is.

Finally, given the nature of Weick's sensemaking, can Visual Analytics, as a software solution, support analyst sensemaking and reframing in warning systems or can it only support representation constructions (sense-making)?

# *Chapter 4*

# Applying Weick's sensemaking theory to weak signals, early warning and Visual Analytics

*"Our expertise is as much about recognizing legitimate dots as about connecting them"*

*– Gary Klein*[313]

## 4.1 Introduction

Chapter Four represents an application and synthesis of Weick's theory of sensemaking, specifically framing, with the concepts discussed in Chapter Two of the thesis: weak signals, early warning systems and Visual Analytics software. In the first instance, Weick's theory of sensemaking is used as a framework to clarify the concept of weak signals and the role framing has on the noticing of cues. Secondly, the addition of the frames theory of sensemaking to early warning systems is discussed. This includes the initial stages of the early warning analysis process and the importance of "expectation" as a belief driven form of sensemaking within warning analysis. It is followed by a discussion of bridging levels in warning systems, culminating in the introduction of the Warning Event Bridging (WEB) sequence. The WEB sequence represents the levels that warning signals or cues needs to bridge in order to become effective. Thirdly, it deliberates the contribution that Weick and framing can make to improving Visual Analytics and whether it can support analyst sensemaking.

## 4.2 Weak signals: a Weickian perspective

As has been shown in Chapter Two, there are various interpretations in terms of what constitutes a weak signal and the terms used to define it include:

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[313] Klein, G 2009. *Streetlights and Shadows* (179)

1) Vague and imprecise signals or harbingers of possible future change[314]
2) Imprecise or early indications about impending events[315]
3) The first symptoms of strategic discontinuities or possible change in the future[316]
4) An idea or trend that will affect business[317]
5) Individual events or group of interrelated events - events may not seem important or far-reaching at first but may have far-reaching consequences for the future[318]
6) A sign of a future wild card - signpost wild cards or gradual future change[319]
7) The large impact of effect, positive or negative, that the phenomena must represent if the initial signal is to qualify as a weak signal[320]
8) Information about the likelihood of an event with a low probability estimate and high impact uncertainty[321]
9) Candidate weak signals, hypotheses or starting points for exploratory reflection.[322]

These variations centre around what exactly represents a weak signal in terms of its initial manifestation as well as its final impact. However, the imprecise, nebulous or vague state of the signal or sign when first noticed is a common aspect of weak signals within the Ansoffian and neo-Ansoffian tradition. There is a progressive nature or graduated response to the signal in converting it into a format which is more sensible. The focus of these two traditions is on identifying or recognising the signals or signs of impending change or discontinuity.

The link to Weick's theory of sensemaking and the use of it as a framework to evaluate weak signals is provided by a simple question. *How and why are signals identified in the first place? This question relates back to a key construct of Weick: a cue, frame and a connection creates a unit of meaning – not a cue or a frame by itself.* Any discussion of warning signs or

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[314] Ansoff, HI 1985. Conceptual underpinnings… (2)

[315] Ansoff, HI 1985. Conceptual underpinnings… (2)

[316] Ansoff, HI 1984. *Implanting Strategic Management*, Prentice-Hall International, London

[317] Coffman, B 1997. Weak Signal Research, Part I: Introduction, Journal of Transition Management, MG Taylor Corporation, http://www.mgtaylor.com/mgtaylor/jotm/winter97/wsrintro.htm, accessed 2011-03-22

[318] Kappinen *Et al.* 2002. Futures Studies, Foundations and Directions

[319] Hiltunen, E 2006. Was it a wild card or just our blindness to gradual change? (61-74)

[320] Maanermaa, M 2004. Heokoista Signaaleista Vahva Tulevaisuus, (Creating Strong Future with the Help of Weak Signals), WSOY, Porvoo as reported in Holopainen, M and Toivonen, M 2012. Weak signals: Ansoff Today (200)

[321] Mendonca *Et al.* 2004. Wild cars, weak signals… (201-218)

[322] Rossel, P 2009. Weak signals as a flexible framing space (312)

weak signals without an acknowledgement of the influence of frames or framing in its identification or noticing is ill considered.

Weick emphasises the notion of extracted cues as one of seven characteristics of sensemaking. A cue is an analogue to a sign or signal and according to Weick a "representative of the entire datum[323] from which it originates."[324] Given the initial vague and imprecise nature of a weak signal, Weick also underscores the metaphor of a "seed" to emphasise the adjustable or "open-ended" nature of the sensemaking process when extracted cues are used. He specifically uses the "seed" metaphor to describe the vagueness and uncertainty of outcomes (indeterminacy) associated with the process of sensemaking. Weick states that extracted cues are "simple familiar structures that are seeds from which people develop a larger sense of what may be occurring."[325] Essentially the cue or "seed" is not an exact blueprint for the greater whole or specific tree that it represents. Rather it is, at best, a rough outline as to what the greater whole or tree will look like based on specific environmental variables i.e. a point of reference. Embellishment and elaboration of an extracted cue, out of an on-going stream of experience, occurs when it is linked to a more general idea. This parallels the progressive nature of weak signals and the need to amplify the "strength" of the signal to illicit the meaning and ultimately its effect.

Weick is specific in his emphasis on how people first notice, then extract and subsequently embellish the cues.[326] Context is a dependency in terms of what an extracted cue will become in two important ways. It firstly affects what is initially extracted as a cue and secondly how it is interpreted. This initial noticing of the cue is the crux of the matter. Weick posits that noticing determines whether people will respond to environmental events and cues. This noticing refers to activities of filtering, classifying and comparing and is an informal,

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[323] Weick's choice of the term "datum" (singular term for data) is germane. At the signal's genesis point it represents what it signifies. As humans try to make sense of it, due to a variety of frames and minimal sensible structures, data are generated regarding the various interpretations regarding it meaning – this represents the "weakness" of the signal. Datum may also be referred to as the signatum. In this context signatum refers to "the object" or "referent", or "something beyond the sign from which it represents" (Chandler 2002:29): In Peircean terms, that "something" that the sign stands for; In Saussurean terms, that which the sign (signans or signifier) signifies (signatum) (Chandler 2002:33-35). That which is "signified" or the signatum/object is not confined to only the physical, but also the abstract (Chandler 2002:33-35).

[324] Weick, KE 1995. *Sensemaking in Organizations* (49)

[325] Weick, KE 1995. *Sensemaking in Organizations* (50-51)

[326] Weick, KE 1995. *Sensemaking in Organizations* (49)

involuntary beginning to sensemaking while sensemaking represents the interpretation and activity of determining what the noticed cue means.

Weick makes an important distinction between noticing and scanning. Whilst noticing is involuntary and informal, scanning is strategic, conscious and deliberate. Noticing is a dependency for sensemaking in that events or cues not noticed are not available for sensemaking.[327] As discussed earlier, environmental scanning as initially proposed by Aguilar and incorporated in systems such as Liebl's Phased Strategic Issue Management System, and Strategic Early Warning Systems (SEWS), is seen as a method to identify weak signals. However, the act of noticing, and contextual elements (frames) necessary for noticing cues, seldom feature in environmental scanning systems. Frames, according to Weick,[328] demarcate the area within which cues are extracted. Therefore frames enable the noticing of cues in a scanned environment.

In Weickian terms, the content of frames or minimal sensible structures, (which is a mixture of ideology, third order controls, paradigms, theories of action, tradition and stories) is imposed on an on-going stream of experience during either a belief- or action-driven sensemaking process. Certain initiating conditions such as turbulence, information load and complexity leads to uncertainty and equivocality that also affects what is noticed. The presentation of *expecting*, as a belief-driven form of sensemaking, is evident in various earlier discussions around weak signal and early warning analysis, for example:

- Grabo's distinction between "indication" and "indicator",
- Mendonca's concept of "imaginability" of surprise,
- Hiltunen's attempt to separate the sign from the phenomena that the signs represents (similar to Grabo's "indication" and "indicator"),
- Recher's concept of "Mind invoking."

These concepts create expectations, which filter input and, as Weick argues, it is this connection of a cue or signal to an expectancy that establishes meaning.[329] Importantly, from a "weak signal" perspective, an expectancy can be used to test, elaborate and expand on already noticed cues, which may then be tested against new cues. Noticing becomes more

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[327] Weick, KE 1995. *Sensemaking in Organizations* (52)
[328] Weick, KE 1995. *Sensemaking in Organizations* (59)
[329] Weick, KE 1995. *Sensemaking in Organizations* (143)

focused when events are compared with an expectation and has an effect on the information that is selected and retained.[330]

Weak signal analysis is decidedly future orientated. The present environment is monitored for cues and signals that may provide clues or pointers to some environmental state in the open-ended, unknowable future. The *ability to notice* is a determining factor in the noticing of clues or pointers to some possible future state. An individual's ability to notice is contingent on the content of his or her current frames. This content is made up of minimal sensible structures as posited by Weick.[331] The content of these frames are imposed on the present environment via belief- and action-driven sensemaking. Due to this future orientation of weak signal analysis, expectations, as a belief-driven form of sensemaking, are a key driver in terms of how an individual imposes his or her frames on the current stream of experience.

With this in mind and viewed within a singular framing event, a weak signal may thus be defined as:

*The initial vague or imprecise cue noticed, and then extracted, out of the present stream of experience, signposting some plausible future state, which then acts as a seeding platform for embellishment and elaboration in the ongoing sensemaking process, the ultimate effect of which can only be determined in retrospect.*

Weak cues or signals are extracted out of the present and combined with a selected frame that is situated in the individual's past cognitions and abridged experience - this is a retrospective action. The connection of the cue with a frame establishes a unit of meaning, and this established meaning is plausible rather than accurate. This extracted cue then acts as a seed for new meanings. Sensemaking is, however, ongoing[332], social and based on identity construction, which is a dynamic construction of different identities depending on the situation. The ongoing nature drives the embellishment and elaboration of the initially noticed cue. Embellishment of the extracted cue together with the concept of enactment in effect amplify the "strength" of the "signal."

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[330] Weick, KE 1995. *Sensemaking in Organizations* (148)

[331] Weick, K.E 1995. *Sensemaking in Organizations* (102-139)

[332] Weick, KE 1995. *Sensemaking in Organizations* (34, 45)

## 4.3 The addition of frames theory of sensemaking in early warning systems – improving cue and signal recognition

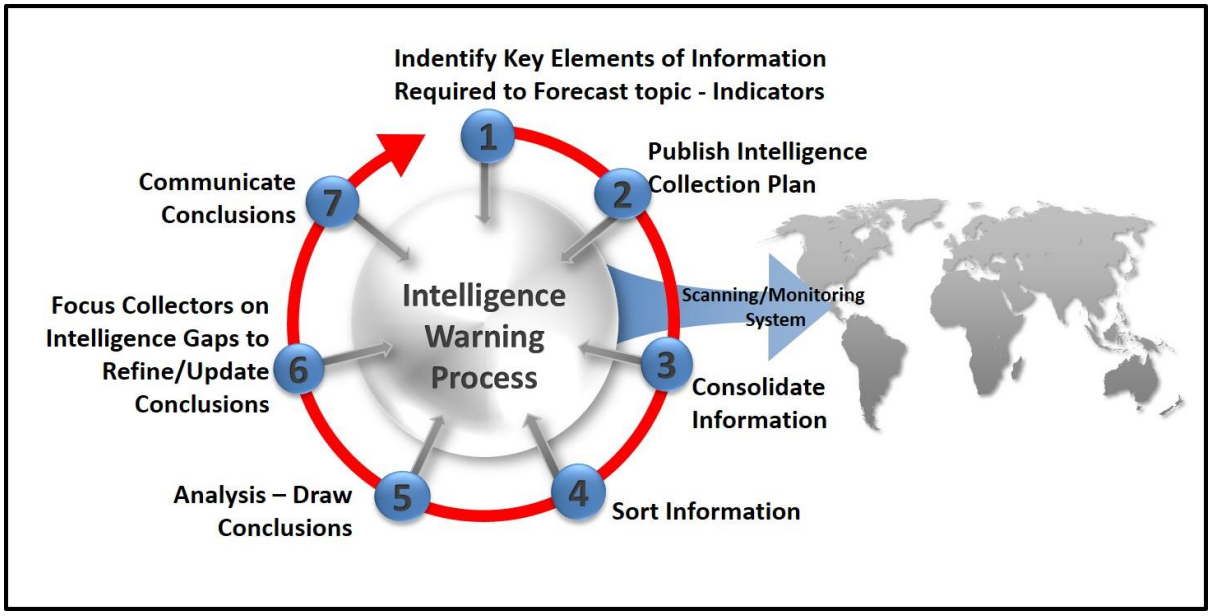


**Figure 14 - Intelligence Warning Process**[333]

The key to a successful warning system is the ability to notice weak signals and cues in the environment so that appropriate action may be taken. Figure 14 represents a graphic representation of Khalsa's warning process. It is similar to that of Pirolli and Card and Bodnar's models as reported earlier. These models tend to be descriptive of the steps that occur in a warning organization as well as steps that analysts follow in processing and analysing warning data and information. The analysis that follows will show how Weick's theory of sensemaking makes an important contribution to the effective operation of an early warning system, on both the level of the individual and that of the organisation. Weick's contribution to step one and two, as well as the scanning/monitoring system, are assessed first. Secondly, Khalsa's process has organisational elements, which necessitates an assessment of the influence of Weick's framing on an organisational level in warning systems, in specific, bridging operations. Thirdly, software, specifically Visual Analytics, is increasingly being used to manage and analyse warning data and information collected by the scanning and monitoring structures within an early warning system. This is represented by steps three, four and five and the contribution of Weick from a framing perspective, is also assessed.

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[333] Self-constructed based on Khalsa, S. 2009. (75-86)

### 4.3.1 Weick's sensemaking in relation to the first stages of the warning process

Belief-driven sensemaking plays an important role in early warning systems. The manner in which the content of frames is imposed on our present experience, by creating expectations, has a profound effect on the functioning of a warning system. These "indications" of indicators reflect back to the "weakness" ascribed to a weak signal. An "indication" is not a direct representation of an indicator, but rather its wispy, malleable representation. The "indication" is then embellished over time as the warning analyst's frames are updated as new information is assimilated into the warning system.

Expectations drive the development of indicators, which direct the search and scanning for "indications" pointing to the presence of indicators. In order to establish a range of indicators, to act as possible signposts to the likelihood or potentiality of future scenarios, a wide range of possible futures need to be constructed.

However, plausible futures form the basis of scenario construction.[334] Given the complex nature of early warning systems and scenario planning, the "exploration-of-the-space-of-possibilities," as posited by Milton-Kelly,[335] suggests that in unstable and rapidly changing environments a flexible approach based on requisite variety is required. This refers to Ashby's law of requisite variety[336] to which Weick[337] attaches the importance of highly varied "human thought and action" in comprehending "variations in an ongoing flow of events." The richness of a person's thoughts and language, according to Weick, influences sensemaking as it echoes this requisite variety necessary to see variations. Consequently, a wider and richer repertoire of plausible scenarios will more likely generate a richer and more varied number of indicators to monitor for in early warning systems.

This provisioning of varied contributions from different stories and sequences at an early stage of the warning process also relates to Weick's concept of mindfulness. This is the combination of ongoing scrutiny, refinement and differentiation of existing expectations based on newer experiences. The willingness and capability of the warning analysts "to

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[334] Chermack, TJ 2011. *Scenario Planning in Organizations* (16)

[335] Milton-Kelly, E 2003. *Ten Principles of Complexity & Enabling Infrastructures* (14)

[336] Ashby, WR 1956. *An Introduction to Cybernetics*. Methuen, London

[337] Weick, KE 1995. *Sensemaking in Organizations* (89)

invent new expectations" and a "more nuanced appreciation of context" and importantly "new dimensions of context" all contribute to establishing mindfulness.[338]

Weick and Sutcliffe[339] attribute the success of High Reliability Organizations (HROs) in managing the unexpected by their increased capability to "notice the unexpected in the making, [and] focus on containing it" – i.e. acting mindfully. This relates to maintaining cognitive operations that continuously update, develop and extend reasonable interpretations of the reigning contextual situation. In other words constantly reviewing and updating the frames through which the current environment is monitored. This is congruent with Rescher's principle of conceptual innovation and "mind-invokingness." In countering the unexpected, expectations play a cardinal role: to expect something is to be prepared for it.

Weick and Sutcliffe categorise surprise or the unexpected into five main forms[340]:

- Bolts out of the blue, incidents with no prior expectation, hint or model of event
- An issue that is recognized but the direction of the expectation is erroneous
- Situations where you discover that your timing is off
- The expected duration of an event proves wrong, and
- The magnitude of an expected problem is not foreseen.

Surprise in all these forms start with an expectation and when an expectation is disconfirmed it triggers an episode of sensemaking. The dynamics of warning and surprise are enmeshed with expectations, autonomic arousal, cues and signals, frames and reframing and the ability to bridge between intrasubjective, intersubjective and generic subjective levels of an organisation.

Autonomic arousal that occurs due to surprise or shock has a very specific influence on information requirements. Equivocality and uncertainty have very different information requirements to facilitate sensemaking. Trying to mitigate equivocality or uncertainty with the wrong kind of information will merely exacerbate nonsensical episodes. Equivocal refers to the presence of multiple explanations for a problem situation while uncertainty is a state of ignorance created by a lack of information.[341] Both create occasions for sensemaking where elaboration and reframing of frames are necessary. A cue or sign is noticed due to autonomic

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[338] Weick, KE & Sutcliffe, KM. 2001. *Managing the Unexpected* (41)

[339] Weick, KE & Sutcliffe, KM 2001. *Managing the unexpected* (3)

[340] Weick, KE & Sutcliffe, KM 2001. *Managing the unexpected* (35-38)

[341] Weick, KE 1995. *Sensemaking in Organizations* (95)

arousal caused by the shock of it. However, due to the new situation the memory structure selected has to be adapted to fit reality by modifying the details of the structure.

The ability to recognise equivocality or uncertainty is critical in a warning system because it requires very different information strategies. Ignorance or uncertainty is normally due to a lack of information and as such more information is required to resolve a situation. Equivocality results from multiple meanings. Resolving it requires collaborative interaction with colleagues or experts rather than using formal information systems. Weick states: "[that] the main reason to separate confusion from ignorance is that communication capabilities that help resolve one may hinder the other."[342] Scanning the environment for more information during equivocal situations will only compound the situation further. Only debate and collaboration with other people will resolve it.

The aforementioned raises questions regarding Hiltunen's[343] assertion that the "objective" two-dimensional axis (signal and issue) of a triadic sign is countable and, in theory, visible to everybody. She argues that the *amount* of information received from the "objective" dimension can be improved by systematic environmental scanning. This in turn improves the ability, of "open-minded' and "future-orientated" individuals, to interpret the subjective axis (interpretation) of a sign.[344]

The visibility and this supposed "countability" of the sign is subject to the individual's capacity to notice. Open mindedness is in the frame of the beholder, so to speak. In addition, systematic environmental scanning will only work in situations where uncertainty reigns, where equivocality reigns more scanning may increase incomprehensibility of the situation.

Furthermore, autonomic arousal focuses attention on the interrupting or threatening event thus hampering information-processing capabilities.

#### 4.3.1.1 Autonomic arousal and mindfulness

The arousal alerts people to the interruption but the focused attention on the interruption reduces the capability to recognise more cues. Cue loss further heightens the state of arousal leading to less sensemaking. In an "every day" sense the amount of attention that an individual will allocate to sensemaking will be regulated by "shocks" that interrupt the flow

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[342] Weick, KE 1995. *Sensemaking in Organizations* (99)

[343] Hiltunen, E 2008. The future sign… (256)

[344] Hiltunen, E 2008. The future sign… (256)

of events.[345] Martinie *Et al.* support this in their examination of why the performance of a person experiencing dissonance is facilitated in simple tasks but is impaired with complex tasks. They state that complex tasks involving a high level of cognition and strategic knowledge elicitation, engages explicit and conscious processes that require considerable working memory capacity. This is necessary for figuring out the multiple operations necessary to perform these complex tasks.[346]

Early warning environments, especially in anti-terrorism settings, place additional stress on analysts in terms of the high stakes involved regarding surprise. Cognitive dissonance[347] is particularly important when decisions are critical because dissonance created by decisions with high stakes in the outcomes can be enormous.[348] Furthermore, research shows that dissonance not only has psychological but also physiological effects. This includes changes in vasoconstriction, heartbeat, alpha waves and galvanic skin responses.[349]

This raises questions about whether individuals can function in an environment where they continuously have to operate in a peculiar cognitive state of operation such as high dissonance. What happens when analysts leave their place of work and have to operate in the normal cognitive state once they go home?

In this regard, Weick and Sutcliff provide a possible solution: they argue that the unpleasant experience associated with this autonomic arousal is managed by anticipation or expectation.[350] Your expectations enlarge the frames through which you view your environment. However, a simple set of expectations may result in not noticing serious problems. In order to facilitate a continuous cycle of elaborating, questioning, comparing and reframing of frames Weick and Sutcliff[351] propose the concept of "Mindfulness". In specific, they refer to the "combination of on-going scrutiny of existing expectations, continuous refinement and differentiation of expectations based on newer experiences." Their

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[345] Weick, KE 1995. *Sensemaking in Organizations* (85)

[346] Martinie *Et al.* 2010. Cognitive dissonance induced by writing a counterattitudinal essay… (592)

[347] Fontanari *Et al.* (2012:62), as part of a study understanding the underlying structure of emotions for robotic systems development, have only recently explored a new type of emotions – aesthetic emotions related to contradictions between two pieces of information. They state that currently there are "no specific words for most emotions of cognitive dissonance" as these emotions have not been systematically studied in psychological literature

[348] Lester & Yang 2009. Two sources of human irrationality: Cognitive dissonance and brain dysfunction (659)

[349] Martinie *Et al.* 2010. Cognitive dissonance induced by writing a counterattitudinal essay… (587)

[350] Weick, KE & Sutcliffe, KM 2001. *Managing the unexpected* (41)

[351] Weick, KE & Sutcliffe, KM 2001. *Managing the unexpected* (42)

characteristics of "mindfulness" are: (1) a preoccupation with failure, (2) reluctance to simplify interpretations, (3) sensitivity to operations, (4) commitment to resilience, and (5) deference to expertise.[352] More importantly, as previously discussed in Chapter 3, expectations can be self-correcting as joint adjustment of the expectation and the event is possible.[353] When people act on their expectations they tend to enact what they predict.

There is also some caution, Weick and Sutcliff[354] warn about relying too heavily on expectations. They act like "an invisible hand" and if warning analysts depend on a simple set of expectations, unexpected events will develop to serious levels before they are noticed as problematic. Ongoing scrutiny, continuous refinement and a willingness and capability to invent new expectations should become key features of early warning analysis and systems. These are analyst specific tasks that need to take place within the structure of "mindfulness." It is a continuous cycle where the minimal sensible structures of analysts as well as that of the organisation are continuously updated as the monitored environment changes.

This drive to develop varied and nuanced expectations (reframing operations), represents the foundation of indicator development that in turn provides the target boundaries of scanning systems. The intelligence collection plan is, in effect, an act of filtering. It is the product of the conscious authoring of expectations by warning analysts within the perspective of mindfulness, determining the target environment, reach and categories of scanning. However, this scanning is, as Weick posits, strategic, conscious and deliberate, while the reframing operations provides the involuntary beginning – the act of noticing, leading to cue extraction and its subsequent embellishment.

### 4.3.2 Framing operations - bridging levels in warning systems

Weak signals and warning signs also cannot only be reduced to the individual's level of analysis. Individuals normally operate as part of larger organisations. In order for an organisation to take notice and elaborate on extracted cues, weak signals and warning signs, they need to be bridged between various levels of the organisation. Framing operations are necessary to enable bridging between these levels.

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[352] Weick, KE & Sutcliffe, KM 2001. *Managing the unexpected* (10)

[353] Weick, KE 1995. *Sensemaking in Organizations* (147)

[354] Weick, KE & Sutcliffe, KM 2001. *Managing the unexpected* (15,44)

Weick states that these bridging operations are necessary between the intrasubjective, intersubjective, and generic subjective levels of organisation, and refers to this as organising. An example in illustration of this concept is the organising within Israeli Military Intelligence (AMAN) prior to the Yom Kippur surprise of 1973. This is evident in the work of Bar-Joseph[355] and Bar-Joseph and Kruglanski.[356] They described how senior AMAN officers, Maj. Gen. Eli Zeira and Lt.-Col. Yona Bandman, were incapable of accepting information from junior AMAN analysts that contradicted their "conception" or framework of when and how war would break out. In essence, a failure to bridge between the intra- and intersubjective levels of sensemaking, together with an inability to reframe, may be seen as contributing factors to the surprise Israel suffered at the start of the Yom Kippur war.

This bridging failure between the intra- and intersubjective level has its roots in tension between the generic subjective and intersubjective levels. Old organisational scripts, routines and habituated action patterns were not updated sufficiently with modifying scripts in the face of extreme uncertainty and ambiguity during the run-up to the war. Bar-Joseph and Kruglanski[357] also posit that both officers had a tendency to view the military situation in terms of Popperian "clocks" (highly precise and unequivocal) rather than "clouds" (ambiguous and a variety of possibilities). This failure to realize the complex nature of the situation contributed to the surprise.

This shows that warning does not operate in a vacuum of the individual warning analyst. How organisations organise, influences how sense is made of warning signals. Warning systems in organisations would need to follow a progression of bridging operations across these specific levels in order to make sense of signals and cues. In essence, a sequence of bridging events would need to take place from a sensemaking perspective for the appropriate organisational heeding of warning signals.

#### 4.3.2.1 Warning Event Bridging

In a formal warning intelligence unit, department or *ad hoc* functional body, an event sequence from a sensemaking perspective needs to occur to place the organisation in a state of warning. This sequence is also applicable to organisations that do not have formalised structures in place to deal with warning or countering surprise. Building on Weick's concept

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[355] Bar-Joseph, U 2005. *The Watchman Fell Asleep*… (45-47, 235-251)

[356] Bar-Joseph, U & Kruglanski, AW 2003. Intelligence Failure and the Need… (79,82)

[357] Bar-Joseph, U & Kruglanski, AW 2003. Intelligence Failure and the Need… (83)

of bridging, a Warning Event Bridging (WEB) sequence is proposed below to explain framing operations from an early warning system organisational perspective. This WEB sequence has various circular or iterative processes between the various levels and is outlined as follows:

1. Analysts make their expectations explicit and create indicator lists to start monitoring for indications – which is in effect a belief-driven form of sensemaking (taking into account that as part of an on-going process the expectations will be updated continuously due to reframing).
2. Cues and signals then need to be noticed by individuals in the organisation – noticing is contingent on the content of frames from an individual and organisational perspective.
3. The noticed cue or signal needs to be connected or placed within a frame in order for a unit of meaning to be formed.
4. The individual makes sense of the noticed cues or signals, within the context of Weick's seven properties, by fusing or welding together a set of meanings from what the individual's senses noticed.
5. The sense that was made by the individual now needs to be bridged from the intrasubjective to the intersubjective level – the "I" to the "we".
6. Once the intersubjective level has been bridged, further bridging to the generic subjective needs to take place as habituated action patterns, interlocking routines and scripts need to be adapted to institute meaningful action to mitigate the risk and warning triggered by the cue or signal noticed.

This WEB sequence is complex due to the numerous variables and processes that come into play, not to mention cognitive analytical biases, which fall outside the scope of this thesis. It has various circular elements analogous to the principles of Heidegger's and Gadamer's hermeneutical circle,[358] in particular framing and reframing operations on an individual and

[358] Hermeneutics refers to the nature and means of interpretation or theory of interpretation. The circle signifies a methodological process of understanding. In order to understand the meaning of the whole and coming to understand the parts are interdependent activities. As Schwandt (2007:133) states, "construing the meaning of a whole meant making sense of the parts, and grasping the meaning of the parts depended on having some sense of the whole." Heidegger and Gadamer placed more radical and stronger emphasis on the notion of the hermeneutical circle. They see the circularity of interpretation not merely a methodological principle, but rather an important feature of all knowledge and understanding. (Schwandt, 2007:134). See also Heidegger Heidegger, M. 1971. *On the way to language*. New York: Harper & Row Publishers and Gadamer, H 1982. *Truth and method*. New York: Crossroad

organisational level. The hermeneutical circle may be used as a metaphor to describe the relationship between cues/data and frames in the reframing process and the reframing of generic subjectivity and authoring of new scripts, routines and habituated action patterns.

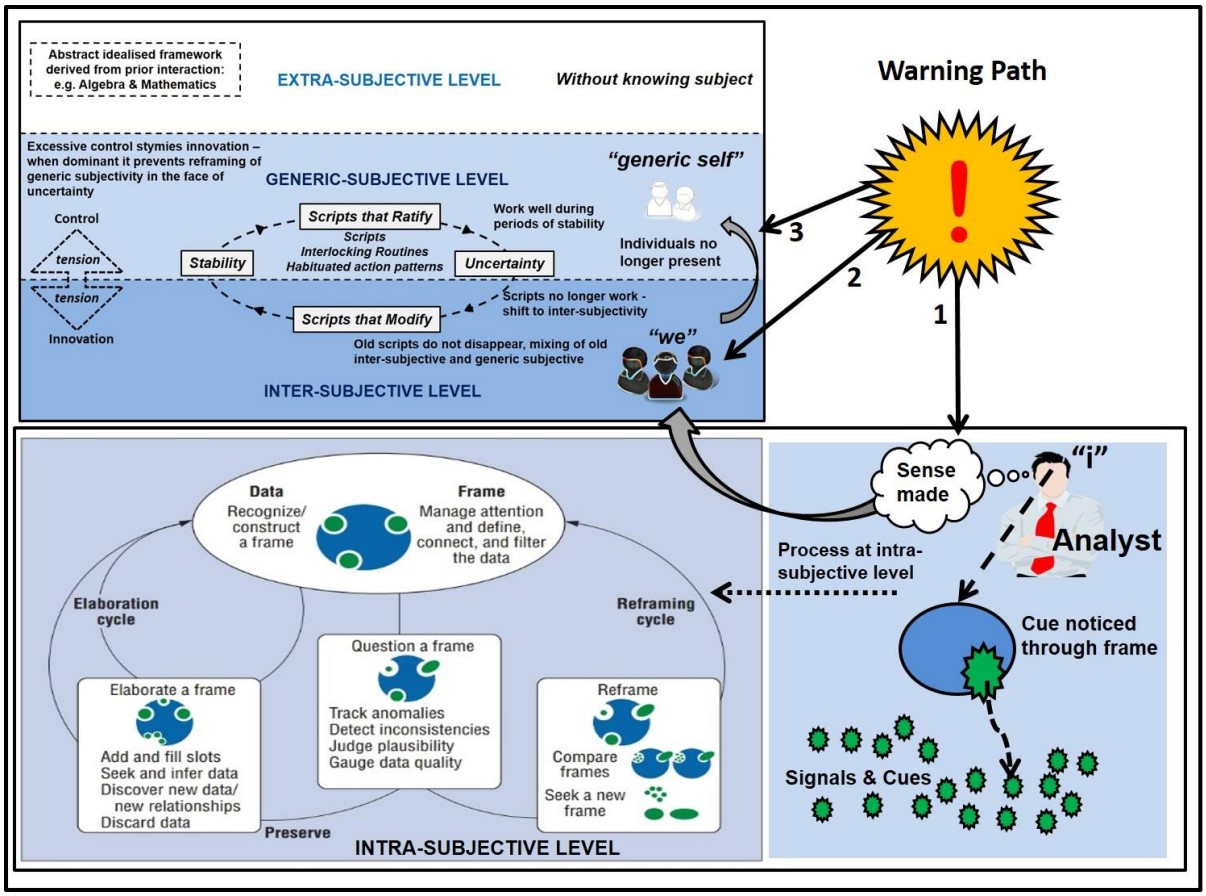


**Figure 15 - The WEB Sequence**[359]

This circularity is evident at the level of the warning analyst (intrasubjective) and the warning organisation (inter and generic -subjective). While Khalsa's model of the analyst warning process (depicted in figure 14 on page 75) operates in the foreground, and is a representation of a methodological process, the WEB sequence (figure 15) operates in the background and is a representation of Weick's concept of organising. However, the success of the warning process is dependent on the organisational reframing ability within the WEB sequence, as continuous reframing operations are necessary on both levels.

[359] Self-constructed, based on Weick 1995 and Klein *Et al.* 2007

#### 4.3.2.2 Intrasubjective level reframing within the WEB Sequence

The merits of Weick's sensemaking as applied to an individual analyst's sensemaking was discussed in earlier sections of this chapter. This being said it must be emphasised that Weick's sensemaking is an inherently social process. However, Gary Klein's[360] data/frame theory of sensemaking which is focused on individual sensemaking on the intrasubjective level is compatible and consistent with Weick's sensemaking on this level. Both contribute to the comprehension of framing operations at the intrasubjective level of the WEB sequence.

In this regard, Weick and Klein regularly reference each other's work in building their respective theories of sensemaking.[361] Attfield and Blandford also recognize that both Weick and Klein focus on the interdependency between data and frame (Klein) and cue and frame (Weick).[362] Both Russell[363] and Klein[364] focus on the sensemaking processes of individuals and do not take cognisance of how interaction between individuals may affect the sensemaking process.[365] Klein *Et al.*[366] and Sieck *Et al.*[367] propose the data/frame model of sensemaking which consists of six separate functions; 1) elaborating the frame, 2) questioning the frame, 3) preserving the frame, 4) comparing frames, 5) seeking a frame, and 6) reframing. Figure 16, page 85, illustrates the interaction and sequence of these six functions.

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[360] Klein *Et al.* 2007 A data/frame theory of sensemaking

[361] Sieck *Et al.* 2007. *Technical Report 1200, Focus: A Model for Sensemaking* ; Weick, KE. 1995. *Sensemaking in Organizations* (111,146,172); Weick *Et al.* 2005. Organizing and the Process of Sensemaking (409-421); Klein, GA 2009. *Streetlights and Shadows* (134)

[362] Attfield, S & Blandford, A 2011. Making sense of digital footprints (41)

[363] Russell, *Et al.* 1993. The Cost Structure of Sensemaking (269-276)

[364] Klein *Et al.* 2007 A data-frame theory of sensemaking

[365] Paul, SA & Morris, MR 2011. Sensemaking in collaborative web search (78)

[366] Klein, G Moon, B & Hoffman, RR 2006b. Making sense of sensemaking 2 (90-92)

[367] Sieck *Et al.* 2007. *Technical Report 1200, FOCUS: A Model for Sensemaking* (1-28)

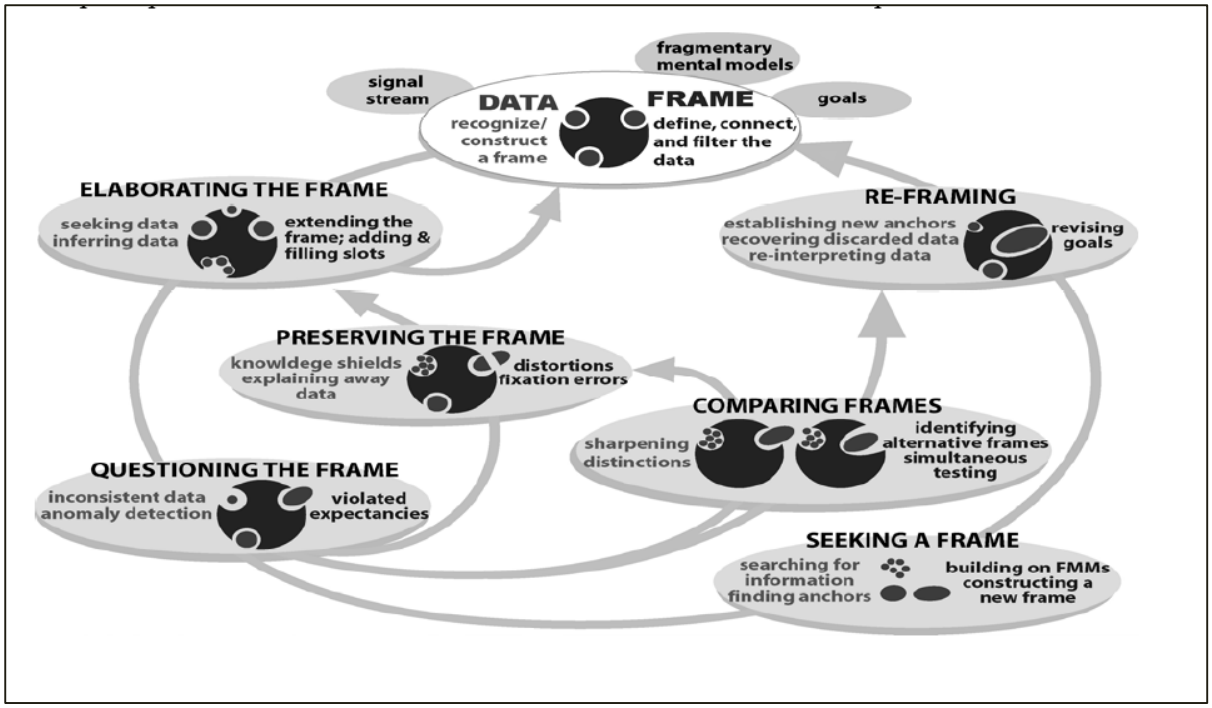


**Figure 16 - Klein's Data-Frame Model of Sensemaking**[368]

Equivalent to Weick, Klein refers to a frame as "an explanatory structure that defines entities by describing their relationship to other entities." Frames take the form of stories, scripts and maps, and the frame itself filters, defines and connects data.[369] Klein *Et al.* refer to mental models which they define as "our causal understanding of the ways things work" that can also take the form of stories "as we imagine the sequence of events."[370] Klein *Et al.*[371] and Sieck *Et al.*[372] state that comprehensive mental model development for a complex open system is unrealistic. Rather, it is a set of fragmentary mental models that contribute to the frame that is constructed by an individual making sense, and this constructed frame guides the selection and interpretation of data. The suggestion that comprehensive mental model development is unrealistic is on par with Weick's[373] assertion that sensemaking is driven by plausibility, pragmatism and reasonableness rather than accuracy.

This idea of "a set of fragmentary mental models that contribute" to the construction of a frame is supported by Weick's contention reported earlier, that theories of action are

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[368] Sieck *Et al.* 2007. *Technical Report 1200, FOCUS: A Model for Sensemaking*

[369] Klein *Et al.* 2007. A data-frame theory of sensemaking (118)

[370] Klein *Et al.* 2007. A data-frame theory of sensemaking (130)

[371] Klein *Et al.* 2007. A data-frame theory of sensemaking (130-132)

[372] Sieck *Et al.* 2007. *Technical Report 1200, FOCUS: A Model for Sensemaking* (vi)

[373] Weick, KE 1995. *Sensemaking in Organizations* (57)

abstractions that simplify in the interest of action. Similarly, in terms of traditions or stories, only patterns or images of action can be transmitted or handed down because concrete human action can only be sustained in symbolic form. Likewise, with stories or vocabularies of sequence - when individuals translate their lives or "guides to conduct" into narrative form, the stories that result do not duplicate the experience. The story that results is a filtered one.

Furthermore, the importance of the effect of indexicality on the noticing of cues as highlighted by Weick[374] is equivalent to the conclusions of Sieck *Et al.* that the context of a situation defines what data is noticed. The purpose of the frame is to define and describe elements of the situation, significance of these elements, relationships, filtering of relevant and irrelevant messages and importantly the context – not just the data alone.[375] The process of "fitting data into a frame" helps with the filtering and interpretation of data while testing and improving the frame.

Weick's argument for the embellishment and elaboration of cues is supported by Sieck *Et al.'s* notion that data elements are not accurate or perfect representations of a situation but rather a constructed one. That the "initial one or two key data elements serves as anchors" and affect what frame is adopted.[376] However, as Weick states, it is the "drawing on something", the implicit or explicit operation of a frame, within which these data elements or cues are noticed in the first place that is important.[377] Concomitantly, Klein, Moon and Hoffman state that "recognizing a frame and recognizing data are different from elaborating a frame that has already been adopted."[378] They see this as a "two way street" where frames shape and define relevant data and the data also decrees what frame will change in a fundamental way[379] leading credence to the hermeneutical metaphor referenced earlier.

#### 4.3.2.3 Intersubjective and generic subjective level reframing within the WEB Sequence

As part of the WEB sequence from an organisational point of view, there is circularity or reframing present in the creation and adoption of Weick's minimal sensible structures between the intersubjective and generic subjective levels. During periods of union and

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[374] Weick, KE 1995. *Sensemaking in Organizations* (52-53)

[375] Sieck *Et al.* 2007. *Technical Report 1200, FOCUS: A Model for Sensemaking* (8)

[376] Sieck *Et al.* 2007. *Technical Report 1200, FOCUS: A Model for Sensemaking* (8)

[377] Weick, KE 1995. *Sensemaking in Organizations* (109)

[378] Klein, G Moon, B & Hoffman, RR 2006b. Making Sense of Sensemaking 2 (88)

[379] Klein, G Moon, B & Hoffman, RR 2006b. Making Sense of Sensemaking 2 (88)

stability an attribute of generic subjectivity is a reliance on scripts, interlocking routines and habituated action patterns that ratify. During periods of uncertainty these scripts no longer work and a shift back to the intersubjective is necessitated in order to reframe or modify existing scripts. The old scripts do not fall away, they serve as seeds or new templates and are mixed between the intersubjective and generic subjective. The WEB sequence is a highly iterative and continuous process and cannot be seen as a linear step-for-step sequence with a beginning and end. As shown, there is circularity on all levels as individuals and organisations make sense of signals in their warning environment.

Weick and Sutcliff provide direction in terms of maintaining a high level of reframing operations in warning organisations by equating them with High Reliability Organisations that entrench the capability of "mindfulness." This is achieved by complimenting and embedding anticipatory activities from an organisational perspective. These activities include learning from failure, complicating perceptions, a commitment to resilience and remaining sensitive to operations. In specific the sensitivity to operations is notable. This refers to an attentiveness to "[the] front line, where the real work gets done."[380] The "Big Picture," as they state, is less strategic and more situationally located. Well-developed situational awareness promotes continuous adjustments in the warning system that facilitates noticing. The link between sensitivity to operations and relationships, counteract a situation where fear of "speaking up" enacts an ineffective warning system. Again the Yom Kippur intelligence failure provides a good example.

Lt.-Col. Bandman and Maj. Genl. Zeira had a significant effect on how junior intelligence officers analysed information received from a host of HUMINT and SIGINT[381] sources before the outbreak of the war. Both officers exhibited an authoritarian and decisive managerial style. They did not allow open discussions relating to alternative viewpoints of the junior officers, which countered their current and reigning intelligence assessment of Egyptian military capabilities and intent to attack Israel. Junior officers who openly questioned the current intelligence assessment or conception were also threatened that their promotions would be overlooked.[382] In effect, mindfulness as a capability, was not embedded

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[380] Weick, KE & Sutcliffe, KM 2001. *Managing the unexpected* (13)

[381] HUMINT – Human Intelligence, SIGINT – Signal Intelligence – these are standard acronyms used in the intelligence environment to categorize the different sources of information that feed an intelligence system others are OSINT – Open source intelligence

[382] Bar-Joseph, U & Kruglanski, AW 2003. Intelligence failure and the need for cognitive closure (84)

in AMAN, and this encumbered their ability to reframe the operational picture in their minds as to what was occurring in the lead-up to the Egyptian invasion.

## 4.4 Visual Analytics software and Weick

The influence of framing and reframing on scanning was briefly discussed previously in that it sets the target boundaries of environmental scanning systems operating within early warning systems. The collection of vast amounts of information relative to the collection plans, which are based on indicator development, is a core functional requirement within early warning systems. This has to be processed by analysts as an important component in the warning analysis process. In current warning environments, big data is becoming problematic in terms of its velocity, variety and volume passing through the scanning and warning system. The use of technology, in particular software, can alleviate this problematic situation, but the strengths and weaknesses of software in the warning process need to be understood.

Sense of weak signals and warning signs are made against a milieu of Weick's initiating conditions such as turbulence, info load and complexity.[383] In the aftermath of 9/11, the development of Visual Analytics has attempted to turn the issue of information load into an opportunity. This section assesses issues and problems relating to models in Visual Analytics and their capability to support analysts' sensemaking as per Weick's theory of sensemaking.

Making sense of signals in a complex environment, with the help of technology to bracket salient features and cues in a constant flow of information, is also a key element of early warning systems and the military Command, Control, Communication, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) environment. Weick[384] specifically recognises the importance of the relationship between sensemaking and information technology. He sees "a disparity between the speed and complexity of information technology and the ability of humans to comprehend the outputs of the technology" and views military command systems as the "canary in the coal mine" alerting us to potential problems. Weick[385] views Lanir's[386], summation, that humans cannot fully meet the requirements of the normative rational model of decision making, but they can design systems that do so, as key to this issue. The issue here is that once these systems are in place,

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[383] Weick, KE 1995. *Sensemaking in Organizations* (85)

[384] Weick, KE 1995. *Sensemaking in Organizations* (177)

[385] Weick, KE 1995. *Sensemaking in Organizations* (178)

[386] Lanir, Z 1989. The reasonable choice of disaster… (479-493)

military decision makers find it hard to challenge them. Lanir found that as alertness and complexity increases, $C^3I$ early warning systems[387] place decision-makers under pressure as the causal logic underpinning these systems discards the cognitive quality of reframing or "repunctuation of the punctuated."

Furthermore, Tsoukas[388] states that the growth and development of information and communication technology has created a society that is fundamentally dependent on knowledge for its functioning. This dependency on, and availability of information in the knowledge society, is a paradox in the sense that it has increased uncertainty and unpredictability. Hence, the availability of information in the emerging knowledge society contributes to the complex environment within which early warning systems need to function.

Tying directly with Tsoukas' statement above are Weick's[389] three initiating conditions that lead to ambiguity and uncertainty as occasions for sensemaking. These initiating conditions or properties relate to the probability that individuals will notice what is happening around them. The first is information load which is a "complex mixture of the quantity, ambiguity, and variety of information that people are forced to process." The second is an increase in complexity, which can increase uncertainty, and the third, turbulence, which is a combination of instability and randomness.

Weick has a specific interest in information load as an occasion for sensemaking. He directs his attention to its "sheer volume" and views it as "a generic property in the flow of events." As this load increases, individuals take steps to manage it by omission, queuing, filtering and abstracting. Information load is an important link in this thesis in tying the concepts of software, in general, and Visual Analytics, in particular, to early warning systems, sensemaking and signals. To paraphrase Weick:

> My interest in load is that, in their effort to cope with a generic property in the flow of events, namely, its sheer volume, people punctuate that flow in predictable ways (e.g. they neglect large portions of it). Those punctuations they do make highlight portions of the residual and heighten its impact on subsequent sensemaking. Any device that reduces information prestructures what people will notice and affects

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[387] $C^3I$ is a precursor term to $C^4ISR$

[388] Tsoukas, H 2005. *Complex Knowledge* (21, 31-34)

[389] Weick, KE 1995. *Sensemaking in Organizations* (86-87)

> the sense they then can make. Information load, in other words, is an occasion for sensemaking because it forces cues out of an ongoing flow.[390]

Within warning systems, the different collection domains such as HUMINT, SIGINT, MASINT and OSINT result in very high volumes of information that need to be collated, assessed and analysed within a reasonable time frame to ensure relevance and usability of the information gathered. In this respect, there is an understandable focus on the Pirolli and Card notional sense-making model from a Visual Analytics perspective - because of the focus on negating or mitigating the cost, and effort, of the analyst working with large data sets. As shown in Chapter Two, other models are available that describe sense-making during the Visual Analytics process. These reported models are not without problems, on both a conceptual and technological level.

### 4.4.1 Supporting analysts' sensemaking?

There is an emphasis in Visual Analytics on mitigating the information load on the analyst during the analytical process. Weick's[391] distinction between ignorance and equivocality has bearing on Visual Analytics in terms of its ability to resolve instances of both uncertainty and equivocality. Visual Analytics may facilitate a more varied and rich filtering of information in the visualization of larger data sets, but is it likely to resolve situations that require the solving of paradoxical or equivocal situations?

The importance of *noticing*, and that it is an informal involuntary beginning to sensemaking, is another key aspect in viewing the contribution of Weick's sensemaking relative to Visual Analytics. As Weick states, noticing refers to activities of filtering, classification and comparison. Similarly, the marshalling, processing, and analysis of data and information in order to create a specification, culminating in a visual representation, is an act of filtering, classification, and comparison. Filtering information, forces cues out of the ongoing stream of experience, which is an act of framing. The "connecting the dots" metaphor is also used regularly in Visual Analytics' literature,[392] but does it facilitate the noticing of dots?

Weick's minimal sensible structures (content of frames), as well as his emphasis on the importance of the sequence of noticing, extracting and subsequent elaboration of cues, is

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[390] Weick, KE 1995. *Sensemaking in Organizations* (87)

[391] Weick, KE 1995. *Sensemaking in Organizations* (95)

[392] Shrinivasan, YB & Gotz, D 2009. Connecting the dots with related notes; Naranjo, D 2013. *Connecting the Dots: Examining Visualization Techniques for Enterprise Architecture Model Analysis*

directly related to Klein's question of "What counts as a dot?" This is where expertise and tacit knowledge come into play, as Klein states, "our expertise is as much about recognizing legitimate dots as about connecting them." The metaphor "connecting the dots" does not emphasise the need to notice and identify cues in the first instance. Klein emphasises the key role of intuition, which he defines as "ways we use experience without consciously thinking things out."[393] This includes tacit knowledge and the ability to recognize patterns stored in our memory.

Data and information collected via the scanning process are transformed by an analyst according to a specification. This specification may include hardware, applied algorithms and elements such as format conversion, data augmentation, marshalling and modelling of information. Furthermore, the analysts may also make a decision as to which collected information sets will be included in the specification.[394]

The creation of a specification determines which portion of collected data or information is visualised. Therefore, it pre-structures what the analyst will notice in the visual representation and affects what sense is made. However, analysts with a larger or more varied repertoire of frames will notice more salient cues than those with a less varied repertoire. Consequently, this larger and more varied repertoire of frames will result in a more elaborate specification for a representation. Minimal sensible structures, representing the content of frames, are imposed upon the representation via expectation as a belief-driven form of sensemaking. The only difference from a Visual Analytics perspective is that it is by visual cues.

#### 4.4.1.1 Visual cues

Dix *Et al.* refer to the concept of distributed cognition, which relates to a theoretical framework describing interaction between persons and artefacts in an information space. This theoretical framework extends the problem space boundaries to incorporate knowledge in the mind of the user and in the world. They see everyday problem solving as a "co-ordinated use of knowledge systems in the mind, in our environment, and other individuals." [395] This co-ordinated use of knowledge systems allows for "insight discovery" which they define as visual cues recognised via a "complex process of sensemaking [through] the exploration of information presented by visualisation." They refer to "insight" or visual cues as an

[393] Klein, R 2009. *Streetlights and Shadows* (71)

[394] Personal communication – Russell Arnott, Chief Data and Information Specialist, Suritec 2013

[395] Dix *Et al.* 2010. Perception and cognitive aspects (114-116)

individualised "observation about the data by the participant, a unit of discovery." The characteristics of insight or visual cues are: (1) complexity, (2) "deep" in the sense that they build over time and are not exact, (3) unexpected, and (4) relevant.[396] The latter characteristics match some of Weick's properties of sensemaking as well as his "seed" analogy for cues. However, Dix *Et al.'s* "unexpected" characteristic is likely to refer to the "surprise" or autonomic arousal associated with noticing unexpected cues as discussed in an earlier section of this chapter.

Sense is made, as per Weick's seven properties of sensemaking, of noticed visual cues in a visualisation determined by a specification. Although it is important to take into account that it is a highly filtered visualisation. The expectations that were used to form the basis for identified indicators, which provided a collection plan that directed scanning behaviour, are also at play in determining the earlier specification. This is illustrated in figure 17, page 93. Three iterations are depicted. The orange iteration represents the noticing of a visual cue. This triggers the development of the second (green iteration) specification, resulting in a new (green) visualisation. This then enables the embellishment and elaboration of the original cue noticed in the orange visualisation. This leads to reframing as the content of the analyst's frames are updated and meaning is ascribed to the embellished cue noticed in the visualisation. The sense made results in the updating of expectations, which in turn leads to the updating of the indicator list represented by the third iteration (black). Visual Analytics also allow for interactive updating of visualisations without affecting the specification. This iteration is not illustrated in the diagram.

[396] Dix *Et al.* 2010. Perception and cognitive aspects (117)

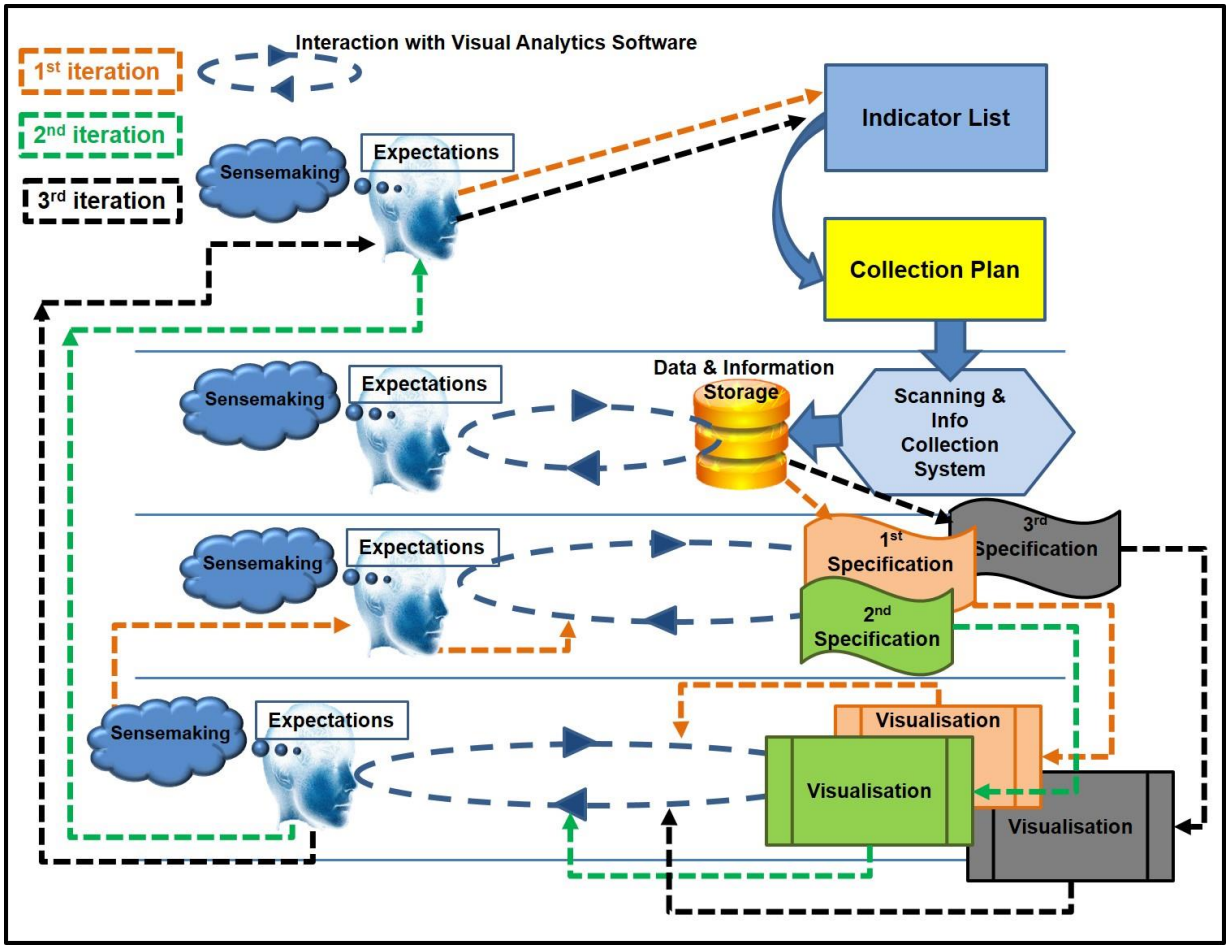


**Figure 17 - Expectations to Visualisation**[397]

### 4.4.1.2 Focal and subsidiary awareness in relation to specifications, visualisations and tacit knowledge

In the present Visual Analytics process, an analyst has a focal awareness of the specification and visualisation, whilst his tacit knowledge operates on a subsidiary awareness level to recognise salient cues and patterns in the visualisation. It is this subsidiary awareness of the minimal sensible structures, which will enable the analyst to connect plausible visual cues to expectations. In this regard, a situation has been created where both tacit and explicit knowledge of the analyst interacts with that visualisation. Expectations are made explicit via the process of indicator identification which drives the scanning process. The minimal sensible structures will be highly tacit as the analyst interacts with the visualisation. Accordingly, it will not be possible to articulate or convert all minimal sensible structures or

[397] Self-constructed, based on Weick 1995, Khalsa 2009 and, Van Wijk 2005

the content of analyst's frames into explicit knowledge. As Weick states: "There is always slippage between words and what they refer to."[398]

In support of this, a similar analogy would be the interpretation of radar consoles or human machine interfaces (HMI). Different radar types require distinctive signal processing and have specific use characteristics.[399] It would be very difficult to provide explicit knowledge in document form to train an individual in interpreting radar signals from ground surveillance radars (GSR). Understanding of the signal plots and tracks within a clutter background in an HMI can only be conveyed through experiential learning under supervision of an expert radar operator. This knowledge cannot be readily articulated. Furthermore, the same GSR radar console operator would have difficulty interpreting maritime or air surveillance radar. Again, the different signal interpretation nuances can only be acquired through experiential learning and guidance from a seasoned operator. Some of the knowledge necessary to operate the console can be made explicit but the highly nuanced radar specific interpretation within the HMI remains highly tacit.

The essence here is that tacit and explicit knowledge are not two opposing sides on a continuum, but rather two sides of the same coin - "even the most explicit kind of knowledge is underlain by tacit knowledge." In particular Tsoukas[400] argues that:

> to treat practical or (tacit) knowledge as having a precisely definable content, which is located in the head of the practitioner and then 'translated' (Nonaka and Takeuchi 1995: 105) into explicit knowledge, is to reduce what is known to what is articulable, thus impoverishing the notion of practical knowledge.

Of importance here is the subsidiary knowledge associated with the tacit knowledge of the user. Polanyi as quoted by Tsoukas[401] states that "subsidiary or instrumental knowledge is not known in itself but is known in terms of something focally known, to the quality of which it contributes; and to this extent it is unspecifiable." Tsoukas explains subsidiary awareness using the analogy of thinking about hitting a nail with a hammer.[402] Hitting the nail with the hammer is the main objective. However, I am aware of the feeling of the hammer in my hand

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[398] Weick, KE 1995. *Sensemaking in Organizations* (106)

[399] Unknown Author, Radar Fundamentals, Chapter 1, NAVMARCORMARS Operator (NMO) Courses; Basic Radar Tutorial Website http://www.radartutorial.eu/index.en.html , accessed 2012-11-17

[400] Tsoukas, H 2005. *Complex Knowledge* (154-155)

[401] Tsoukas, H 2005. *Complex Knowledge* (146)

[402] Tsoukas, H 2005. *Complex Knowledge* (146)

and I also know and rely on the feelings (sensations) in my hand when hitting the nail into a piece of wood. This is a subsidiary awareness of the feelings in my hand combined with a focal awareness of using the hammer to drive the nail into the wood. Subsidiary and focal awareness are mutually exclusive. Similarly, confusion reigns when a pianist shifts attention from the piece being played to the movement of his or her fingers.

In the case of the radar console or HMI, the operator has a subsidiary awareness of the nuanced signal processing and behaviour of radar energy reflections within the type specific radar learned through experiential learning. Conversely, the operator has a focal awareness of the HMI as a tool to interpret the radar signal environment. The experienced operator has a richer subsidiary awareness allowing for an increased accuracy in interpreting signal plots in an HMI.

Tsoukas argues[403] that tacit knowledge is triangular in nature taking into account the relationship between subsidiary particulars, the focal target and the linkage by the knower. This integration of the subsidiary to the focal target is essentially tacit in nature and irreversible. The structural components of tacit knowledge are threefold: the functional, the phenomenal and the semantic. Functional consists of the subsidiary to the focal target whilst the phenomenal involves transformation of subsidiary experience into a new sensory experience. The semantic aspect represents the meaning of the subsidiary – "the focal target on which they bear."

In terms of focusing on information load as an opportunity or initiating condition for sensemaking, Visual Analytics certainly has the ability to force cues and signals out of a flow of events. The iterative development of specifications as well as visualizations, allow for the "repunctuation of the punctuated" and does not discard the cognitive quality of reframing. Strictly speaking, the nature of Visual Analytics software, particularly the focus on data and information processing to create a specification, only solves problem scenarios where uncertainty creates a state of ignorance due to lack of information. However, sensemaking is a social process and focused on identity construction. In equivocal situations, where multiple meanings reign, nothing prevents an analyst from indulging in collaborative interaction with colleagues or experts regarding a visualisation. The resulting meaning may then be integrated within the next iteration to create an updated specification for a visualisation.

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[403] Tsoukas, H 2005. *Complex Knowledge* (146-148)

Visual analytics employed in a collaborative scenario should ensure a more varied input in the determination of the specification that will then result in a pre-structuring or filtering of information that enhances the capability of team members to notice cues. Weick[404] emphatically states that the content of frames "pervades organizations" and "colors interpretations" and are at play all of the time. Understanding how these frames operate both from the level of the individual was well as the organisational context will enhance cue recognition. Sensemaking, as Weick states, is never a solitary undertaking and what an individual analyst does internally "is contingent on others."

### 4.4.2 Representation construction (sense-making) or sensemaking (Weick)?

In promoting a socio-cognitive approach to knowledge transfer, Ringsberg and Reihlen[405] argue that the use of technology, "in specific computer memory systems", has added to the myth that knowledge can exist in "disembodied structures such as databases, files texts and instructions." This "myth" also includes the notion that this knowledge is stored with "self-evident meaning independent of the inquiring and interpreting mind." In a separate study, the two authors demonstrated empirically that knowledge artefacts depend on individuals' understanding and interpretation of it. In this study, consultants constructed different interpretations of the same data source stored in a digital knowledge management system. In support, they cite Mahner and Bunge's[406] argument "that the meaning of information always depends on the mindful receiver."

#### 4.4.2.1 The ineffability of tacit knowledge

Wang *Et al.'s* [407]statement (in Chapter Two), that explicit knowledge is "independent from the user or his tacit knowledge" is problematic. Tsoukas[408] in particular, has commented on the misunderstanding in management sciences relating to the concept of tacit knowledge. He argues that Nonaka and Takeuchi's interpretation of tacit knowledge as "knowledge-not-yet-articulated" or knowledge awaiting its "translation" or "conversion" into explicit knowledge

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[404] Weick, KE 1995. *Sensemaking in Organizations* (132)

[405] Ringberg, T and Reihling, M 2008. Towards a socio-cognitive approach to knowledge transfer (915)

[406] Mahner, M and Bunge, MA 1997. *Foundations of Biophilosophy*, as cited in Ringberg, T & Reihling, M. 2008. Towards a socio-cognitive approach to knowledge transfer (915)

[407] Wang *Et al.* 2009.Defining and applying knowledge conversion processes… (617)

[408] Tsoukas, H 2005. *Complex Knowledge* (141-161)

is erroneous. Tsoukas states that this interpretation ignores "the essential ineffability of tacit knowledge" and thus reduces it to what may be articulated.[409]

Furthermore, in reference back to Wang *Et al.*'s[410] addition of a knowledge base (KB) to Van Wijks model (Chapter Two), they emphasise the representation of such a knowledge base via ontological knowledge structures. Ontology from this perspective likely refers to Gruber's definition of Ontology, that of "[an] explicit specification for a conceptualisation."[411] Babaie *Et al.*[412] refers to this as a structured depiction that is centred on the identification of concepts in a domain, their explicit definitions and how they relate to each other in order to make them machine-readable.

This machine readability is facilitated through the construction of taxonomies that are formalised in topic maps through use of languages such as Extensible Markup Language (XML) or Resource Definition Framework (RDF). In addition, standards, such as ISO 13250 Topic Maps,[413] provide a basis to formalise groupings of information objects around topics and "occurrences" of the topics, and the relationships between topics and the "associations" in a data structure. This data structure then follows a Topic – Association – Occurrence mapping. It enables the machine readability of "knowledge structures" across various software systems but, as raised by authors such as Aaltonen,[414] Weick[415] and Snowdon,[416] is problematic from an ontological perspective.

This problem relates to what different ontological domains of ordered, complex and chaotic require in terms of making sense. The process as proposed by Wang *Et al.* (Chapter Two) will be sufficient in an ordered setting but will most likely breakdown in dealing with complex or chaotic situations. The mutual exclusivity of taxonomic structures needed for machine readability will not be able to cope in chaotic situations, where the number of topics and possible associations with occurrences are unknowable. Furthermore, the data – information – knowledge (DIK) approach, on which Wang *Et al.* base their addition to van

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[409] Tsoukas, H 2005. *Complex Knowledge* (158)

[410] Wang *Et al.* 2009. Defining and applying knowledge conversion processes… (617)

[411] Gruber, TR 1993. Towards Principles for the Design of Ontologies… (1)

[412] Babaie *Et al.* 2006. Designing a modular architecture… (271)

[413] http://www.isotopicmaps.org ; http://www.topicmaps.org

[414] Aaltonen, M 2007. Strategic Decision-making

[415] Weick, KE 1995. *Sensemaking in Organizations* (178)

[416] Kurtz, CF and Snowden, DJ 2003. The new dynamics of strategy (462-483)

Wijk's model, does not take into the account the complex relationship between explicit and tacit knowledge as articulated by Tsoukas.[417] As illustrated in the previous section, this compounds the failure of machine readable ontologies in the face of complex and chaotic situations.

In addition, problems were recently highlighted in the analyses of very large data sets relative to Visual Analytics within the United States' Distributed Common Ground System-Army[418] (DCGS-A). These range from the overwhelming of advanced 3-D visual analytic support tools when the number of analysed nodes run into the tens of thousands to problems of scalability of data volumes.[419] Estes[420] posits that there is "no fixed ontology or model that can characterize the key data into knowledge for all time." The lesson learned for Estes is that a fixed ontology forces a compromise between depth and breadth and affects adaptability because it cannot handle the subtleties in situations.

#### 4.4.2.2 Design issues and problems in Visual Analytics

Wong and Varga[421] in reporting design issues of Visual Analytics systems, have listed three important related problems. The first is the keyhole problem, which relates to the data issues where a small sub-set of data is used because of computational constraints. Without understanding the context relative to the large dataset from which the subset was derived, determining the significance of visualisations is difficult. The second problem, black holes, relate to missing or incomplete data in a dataset. Visual Analytics systems cannot construct the missing data. The issue is more that analysts are not aware or do not know that data are missing, whether deliberate of through natural occurrence. The third is known as the brown

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[417] Tsoukas, H 2005. *Complex Knowledge*

[418] The United States' Distributed Common Ground System-Army[418] (DCGS-A) has created an unprecedented amount of information drawing from a multitude of different sensors for the American war fighter. DCGS is a battlefield intelligence system that establishes a network-centric information platform that handles collaborative intelligence production, tasking of sensors and processing and exploitation of data. The main goal is to provide access to information to support battlefield visualisation, intelligence, surveillance and reconnaissance (ISR) management within the US Army's common operational environment. (Distributed Common Ground System – Army (DCGS-A). Weapon Systems 2012. Available at: http://fas.org/man/dod-101/sys/land/wsh2012/88.pdf , accessed 2012-10-18.

[419] Heer (2008:106-107) have previously discussed problems and difficulties related to the available display size and screen resolution to visualize large datasets in a common desktop computer environment. Similarly Keim *Et al.*· (2008:166-167) have noted technical challenges relating to Visual Analytics and vast amounts of data such as: (1) scalability with data volumes and data dimensionality, (2) data quality and graphical representation, (3) visual representation and level of detail, (4) display devices and (5) user interfaces and infrastructure. Given these noted issues, the DSCG-A difficulties reported by Estes are not surprising.

[420] Estes, T 2011. Entity-centric advanced analytics using synthesys (29-31)

[421] Wong, BLW & Varga, M 2012. Black Holes, Keyholes and Brown Worms

worm problem, and refers to the detection and handling of deception and misleading data. There are analytical techniques such as Analysis of Competing Hypotheses (ACH) to estimate reliability of evidence but representing such in a Visual Analytics system is very difficult.

The aforementioned highlights the problematic nature of Wang *Et al.*'s addition to Van Wijks model. In addition, Klein[422] lends credence to this in his criticism of the data-information-knowledge-wisdom "assembly line model" in which data is filtered to make sure decision makers get pre-digested material. Information search is, in a sense, removed from the control of the decision maker. This is typical of a situation Weick describes where premise controls (vocabularies of organisation) operate at higher levels of an organisational hierarchy because organisational designers use first and second order controls at lower levels of the organisation. This makes it difficult for decision makers to build their own mental models because they are forced to depend on "dots" and analyses of individuals at lower levels with less expertise. The context in which data was collected is obscured. Klein therefore states, that the assembly line model, only fits in orderly situations where only explicit knowledge is handled.

In interacting with a visualisation an individual, working with a Visual Analytics software tool, certainly has to work through a series of steps to create the visualisation. This is where the representation construction model, such as that of Pirolli and Card describe this process which has a descriptive orientation. Similarly, Wang *Et al.'s* model tries to compensate for this description orientation by their additions to Van Wijk's model. The representation models focus on the mechanical or task orientated process of actually filtering, classifying, and categorising data for visualisation, while Van Wijk's model focuses on the cognitive reframing process while interacting with a visualisation and specification.

Weick's sensemaking not only extends, but fits well within Van Wijk's visualisation model as well as Green *Et al.'s* adaptation of it. The seven properties of sensemaking provide a theoretical platform to evaluate how individuals will make sense of visualisations within an organisational context. In addition, the content of frames and the manner in which they are imposed on our experiences, especially expectations (belief-driven sensemaking), underscores the cognitive operations at play when users manipulate and interact in an

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[422] Klein, G 2009. *Streetlights and Shadows* (192)

iterative process with visualizations. Iterative development of specifications and resulting visualizations are contingent of the process where data/cues are forced out of a visualization by frames but the data/cues also determine how a frame will be tested, elaborated, or changed.

The problems associated with data management and the issues reported by Wong and Varga are problematic from an accuracy perspective for Visual Analytics. But herein lies the value of Weick's sensemaking. It is about plausibility, not accuracy, it's about extracting and embellishing cues, is ongoing, social and about enacting the environment. As Weick states, the strength of sensemaking is that it does not rely on accuracy, but rather plausibility, pragmatics, reasonableness and invention.[423] Because cues may have multiple meanings it is important to get "some interpretation to start with than to postpone action." Early warning is a time sensitive endeavour and "quick responses shape events before they become crystallized into a single meaning."[424] The use of "minimal cues" as Weick posits, is what gives adequate lead time so that one can adjust to events. Seen from within this perspective, sensemaking, as proposed by Weick, certainly provides a wider theoretical foundation for Visual Analytics on a level above the representation construction models.

## 4.5 Conclusion

This penultimate chapter shows that Weick's theory of sensemaking makes a significant contribution to expanding our knowledge and understanding of sense, signals and software in early warning systems. The analysis has implications on both a theoretical and practical level and are discussed in detail in Chapter Five, which concludes this thesis.

[423] Weick, KE 1995. *Sensemaking in Organizations* (57)

[424] Weick, KE 1995. *Sensemaking in Organizations* (58)

# *Chapter 5*

# Implications: Sense, signal and software in early warning systems

*"An extracted cue is used to prophesy the nature of the referent from which it was extracted"*
*– Karl Weick*[425]

## 5.1 The objective in retrospect

This thesis set out to examine the contribution that Karl Weick's theory of sensemaking can make to enhance weak signal analysis within warning systems. Two specific research goals were stated. The first was to reveal possible improvements in signal and cue recognition through an attentiveness to the frames theory of sensemaking in the analysis phase. The second goal was to show how it could be included into the theoretical foundation of Visual Analytics in support of warning systems. Given the recent intelligence and warning related failures within the military, security and financial environment since the events of 9/11, a re-evaluation from within a sensemaking perspective can contribute to a strengthening of current theory underpinning signal analysis in early warning systems.

This thesis did not include an evaluation of the effect of analytical or psychological bias on the part of analysts in relation to the noticing of weak signals and cues in a warning system. A large body of research exists which has considered these effects on analysis and intelligence analysis in particular. The effects are acknowledged but fall outside the scope of this thesis. In addition, the concept of framing is highly abstract and an ongoing process that forces cues and signals out of a constant stream of experience. This "ongoing" nature sometimes necessitated an artificial delimitation during analysis that viewed framing as a singular event. Consequently, it allowed for a window through which to view what Weick refers to as the substance of sensemaking, placing cues within frameworks to establish meaning.

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[425] Weick, KE 1995. *Sensemaking in Organizations* (54)

The topic of warning, which Bodnar[426] defines as "a prediction of the future," had a distinct theoretical implication for this thesis. Arguments about the nature of the *future* and *predictions* of the *future,* by authors such as Tsoukas[427] and Narayanan and Fahley[428], who posit that the future is, from an ontological perspective, non-existent, open-ended, and un-knowable confirms the notion that the accuracy of weak signals or warning signs can only be determined retrospectively.

In applying Weick's theory of sensemaking to weak signals, warning systems analysis and Visual Analytics the following implications on a theoretical and practical level are evident.

## 5.2 Implications for weak signals

Karl Weick's theory of sensemaking presents a framework that provides conceptual clarity to the concept of weak signals. Furthermore, weak signals as a concept is decidedly complex, a nominal or reductionist approach that seeks to define a set of characteristics fails to account for this complex nature. Weick's construct of cues, in particular his "seed" metaphor, goes to the essence of what drives debates in the weak signal discourse. This metaphor underscores the vagueness and uncertainty of outcomes and that it is the embellishment and elaboration of cues that represent the progressive nature of weak signals. A weak signal is a representative, not a blueprint, of the entire datum[429] from which it originates.

Restated, as defined earlier[430], from a Weickian perspective a weak signal is:

*The initial, vague or imprecise cue noticed, and then extracted, out of the present stream of experience, signposting some plausible future state, which then acts as a seeding platform for embellishment and elaboration in the ongoing sensemaking process, the ultimate effect of which can only be determined in retrospect.*

The content of our frames, as imposed by belief- or action-driven sensemaking, determines how we notice signals and cues. The ability to notice cues and signals, is entirely dependent on the richness and extent of the frames we are able to draw from. In the ongoing process of sensemaking, these weak signals are embellished as we continuously ascribe meanings to

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[426] Bodnar, JM 2003. Warning analysis for the information age… (11)

[427] Tsoukas, H 2005. *Complex Knowledge* (276)

[428] Narayanan, VK and Fahey, L 2004. Invention and navigation as contrasting metaphors… (39)

[429] See footnote 323 on page 72

[430] Page 74 above

them in an effort to make sense. The richness and range of the sensemaker's frames will determine:

1) If cues and signals are noticed in the first instance. By implication, the more varied and rich the individual's repertoire of frames is, the more likely they will be noticed.
2) The "weakness" of the noticed signal or cue.

The "strengthening" of an extracted "weak" signal or cue refers to its subsequent and ongoing embellishment. The process of re-framing, which allows for the updating of our current frames enables the "re-punctuation of the punctuated." This "two way street" or hermeneutical like process referred to earlier above, where our frames outline and define relevant cues and data and these cues and data also dictate what frame will change in an fundamental way, underscores the notion of "strengthening". The ultimate potentiality of a weak signal, or what it will ultimately become, is only discernable in hind-sight, due to the retrospective nature of sensemaking.

This lends support to Rossel's[431] earlier stated contention that all weak signals are "candidate weak signals, hypotheses or starting points for exploratory reflection". The further embellishment of them, the ongoing nature, and the enactment of sensible environments, as per Weick's properties of sensemaking, strengthens this notion and alludes to the "self-fulfilling prophetic" nature of the so called "weak signals" that were noticed in the first instance.

The importance of "noticing" and the cardinal role that framing plays in the act of noticing signals and "dots" in warning systems was also confirmed. The ability to *notice* cues is paramount in making signals and cues available for analysis in a warning system. If they are not noticed, they are not available for sensemaking (you can only connect the dots after you have noticed them). This "noticeability" of cues is dependent on their indexicality or contextual nature represented by the frames that we impose on a sequence of events to extracts cues or signals.

## 5.3 Implications for early warning systems

It is evident that expectation, as a belief-driven form of sensemaking, in various permutations such as indicators[432], "imaginability" of surprise[433], and Rescher's "mind invokingness"[434]

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[431] Rossel, P 2009. Weak signals as a flexible framing space (312)

[432] Grabo, CM 2004. *Anticipating Surprise* (3-4)

ensures that noticing becomes focused. In this regard, the thesis has demonstrated that belief-driven sensemaking, in the form of expectations, are important in situations where the future potentiality of cues and signs need to be evaluated – such as weak signal analysis and early warning systems. Therefore, Weick's sensemaking theory is of value in the early stages of early warning system analysis. Expectations ensure that noticing becomes more directed and attentive to the presence of discontinuity and threat in a surveillance and monitoring environment.

Weick's sensemaking, as applied from an organisational perspective to early warning systems, culminated in the construction of a descriptive sequence – Warning Event Bridging. The WEB sequence is a description of the framing operations at work during the warning process at both an individual and organisational level of analysis. To enable an adequate warning event, noticed cues need to be elaborated and bridged in terms of the WEB sequence of circular framing cycles between the intra-, inter- and generic subjective levels of sensemaking. Warning systems may be seen to operate on three interrelated planes as depicted in figure 18.

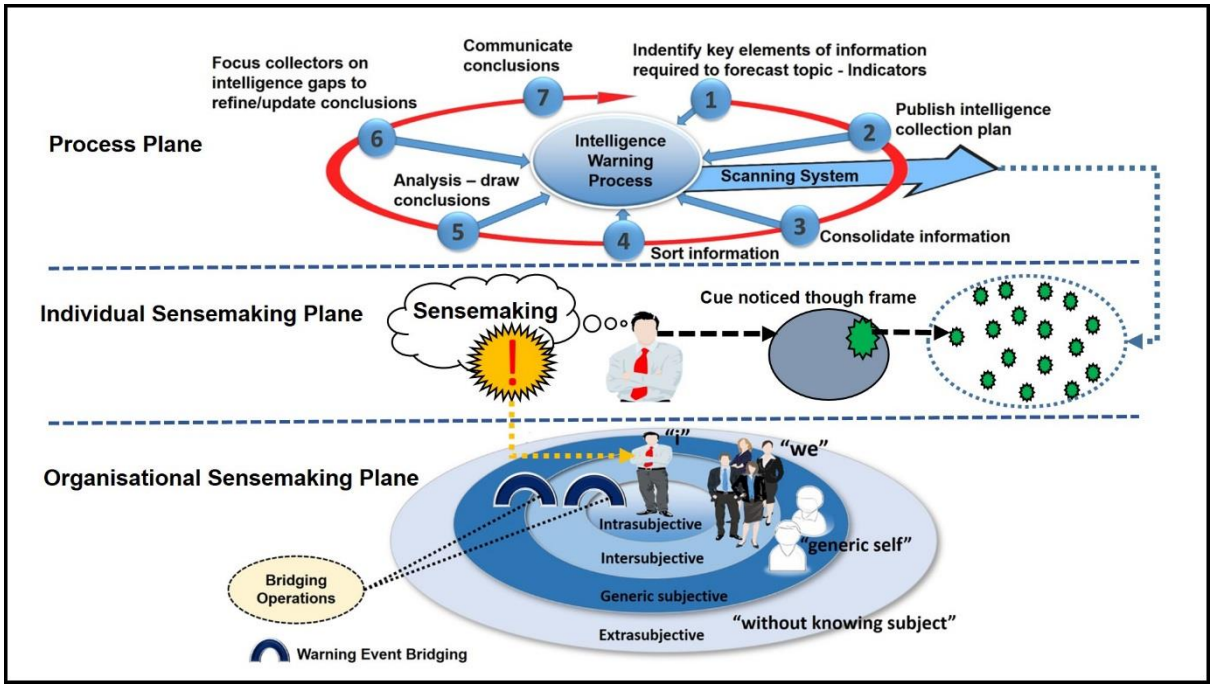


**Figure 18 - Early Warning: Process and Sensemaking Planes**[435]

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[433] Mendonca *Et al.* 2004. Wild cards, weak signals… (203)

[434] Narayanan, VK and Fahey, L 2004. Invention and Navigation as contrasting metaphors… (54-55)

[435] Self-constructed, combination of Weick (1995) and Khalsa (2009)

### 5.3.1 The process plane

The process plane relates to the actual processes in place from a functional perspective. Models that describe this process are represented by that of Khalsa,[436] and notional models of intelligence analysis as represented by Pirolli and Card.[437]

Weick's concept of framing and reframing has an early influence in the early warning process. The result of this framing and reframing process is represented by a method of making expectancies explicit in the form of indicator lists. This can be improved by applying and embedding the principles of Weick's concept of "mindfulness," present in High Reliability Organisations, to early warning systems. The key is to ensure ongoing scrutiny, refinement and elaboration of expectations to ensure that the "invisible hand" of a simple set of expectations do not lead to surprise. The composition of a warning team, and the breadth or repertoire of frames present under the member analysts, will determine the range and mix of possible indicators generated. It will also increase the odds of noticing warning signs.

Furthermore, methodological improvements in environmental scanning systems on their own, focused on identification of information sources, modes and methods, will not necessarily improve the efficacy of the scanning system. Scanning system enhancement is rather a combination of methodological improvements with, (1) a clear understanding of the influence and role of frames and reframing on analysts, (2) embedding "mindfulness", and (3) facilitating the ability of analysts to make their expectations explicit in the form of indicator lists. When monitoring an environment this will facilitate the ability to focus attention on the noticing of cues and signals.

Making expectations explicit categorises and delineates the scope of the scanning environment, which is in its self an act of filtering. There is, however, never a guarantee that analysts will notice all signals, as this is contingent on the variety, repertoire and continuous reframing of the content of the analysts' frames. The wider the range of indicators, the higher the likelihood of noticing "indications" due to autonomic arousal of surprise caused by the cue not conforming to the expectations generated.

The embedding of processes that facilitate the development of varied and nuanced expectations (reframing operations) within the process plane, represents the foundation of

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[436] Khalsa, S 2009. The Intelligence Community Debate over Intuition versus Structured Technique (75-86)

[437] Pirolli, P and Card, S 2005. Sensemaking processes and leverage points… (1-6)

indicator development. This in turn delivers the target boundaries and categories of the intelligence collection and scanning system. The intelligence collection plan completed during steps one and two (Process Plane, figure 18), is in effect an act of filtering. The conscious authoring of expectations, in the form of indicator lists, and within the perspective of mindfulness, determines the target environment, reach and categories of scanning.

### 5.3.2 The individual sensemaking plane

The second plane, represented by individual sensemaking, relates to the individual analysts within a warning system as a unit of analysis. In this regard the individual analyst notices cues or signals in the scanned environment. The boundaries and scope of the scanning systems are predetermined by the indicators generated by the expectancies of the analyst or group of analysts. Analysts notice "indications" of indicators, not the actual indicators or "indications" that are surprising due to not conforming to expectations. These "indications" relate back to the "weakness" or "wispiness" of the cue originally noticed in the scanned environment.

There is an interdependency between the analyst's frames and the cues or signals noticed. Not only are the signals embellished but the analyst's frames are also updated and elaborated during the process of making sense. Once an analyst makes sense of a cue or signals and determines that the meaning of it represents a warning, this warning needs to be communicated to the warning organisation.

The influence of Weick's seven properties of sensemaking, together with frames and framing, appear ever present with analysts seeking to make sense of warning signals.

### 5.3.3 The organisational sensemaking plane

One cannot only evaluate framing operations from within a warning system at the individual level of analysis. Weick's concept of organising, which are the operations necessary to bridge between the intrasubjective, intersubjective and generic subjective levels of organisation, drives home the notion that the sense must be made at an organisational level for warning to be successful. Specific examples were provided in illustration of this statement, such as the conditions present in AMAN prior to the outbreak of the Yom Kippur war of 1973. Consequently, a Warning Event Bridging (WEB) sequence was proposed to represent the circular iterative processes, of framing and reframing, at these various levels of organisation , that are needed to ensure the heeding of warning signals. The aforementioned is a valuable contribution that Weick's sensemaking can make to an effective early warning process.

Given that warning is an assessment of probabilities, a prediction of the future, and does not exist until communicated to policy and decision makers, organisational sensemaking of warning signals are crucial. Apart from the initial bridging between intrasubjective to intersubjective level, the individual analysts to the analyst group ("I" to the "we"), bridging operations between the intersubjective and generic subjective levels also needs to occur: Organisational scripts, routines and habituated action patterns need to be modified due to the uncertainty created by warning so that action can be taken to create organisational stability.

An understanding of these three planes may facilitate an improved operation of early warning systems. This understanding provides a basis for creating improved warning structures that embed mindfulness and are cognisant of the notions of expectation, "re-punctuation of the punctuated" and warning event bridging sequences.

## 5.4 Implications for Visual Analytics in warning systems

In warning systems where Visual Analytics are employed to facilitate analysis and deal with situations characterised by high information load, Weick's theory of sensemaking makes a significant theoretical contribution. It is critical that the role of framing is understood in terms of the analyst's focal awareness of the specification and visualisation and his/her subsidiary awareness as represented by frames. Again, the implication of belief-driven sensemaking and the role that expectations play is present. The conscious act of creating or developing expectations (indicators) early in the warning analysis process ensures not only that noticing becomes more focused, but also at the same time ensures the elaboration of frames.

Weick's perspective is in harmony with Van Wijk and Green *Et al.'s* visualization models, but less so with Wang *Et al.'s* adaptation. His emphasis on "noticing" as an act of filtering, classification and comparison goes to the very nature of constructing a specification of data for the creation of a visualisation. A larger or more varied range of frames, on the side of analysts constructing specifications for visualisations, will result in the noticing of more salient cues and signals in a visualisation.

The ability of Visual Analytics to include and facilitate framing and reframing operations in warning systems has been detailed in the previous chapter.[438] If technology, and software in particular, discards this cognitive ability of decision makers in situations where alertness and complexity is the norm, it places warning analysts and decision makers under pressure as it

[438] Page 90 - 99 above

abandons the "cognitive quality of reframing."[439] This relates to the ease of challenging and comprehending the outputs of information technology solutions. Visual Analytics as a software technology, does not attempt to constrain these outputs (visualisations) in an inflexible monolithic form.

The creation of a specification by the warning analyst, occurs after data and information as part of the end-result of a scanning system (see figures 14,[440] 17,[441] and 18[442]), is stored in a data storage structure. This specification construction is a further act of filtering, as it is a decision of the analyst as to what part of the collected data and information is eventually part of the interactive visualisation. However, the interactive nature of the visualisation, and the flexibility in changing the specification, facilitates an iterative process needed to support reframing operations.

Weick's theory of sensemaking supports Visual Analytics on a wider rather than a narrower perspective. Thomas and Cook[443] may have trivialised the important contribution Weick's work could make by: (1) Only referring to a set of "mental minimal sensible structures" and, (2) Categorising it as applicable at the organisational level and in a time scale of months and years. In noticing or recognising signals in an environment to provide adequate warning of some future event of positive or negative consequence, Weick's[444] substance of sensemaking, a frame, a cue and a connection, goes to the very essence required to recognise warning signals. In addition, the seven properties of sensemaking provide a theoretical framework that explains how analysts would make sense of visual cues and signals on both an individual and social level. The analyst's reasoning does not take place in a sterile vacuum unaffected by variables such as identity construction – the events of the Mann Gulch disaster, have a similar bearing on warning analysts as was the case with the smoke jumper team.

Current models in Visual Analytics focus on a mechanistic approach by analysing how it supports notional models and the various steps in the analyst's analytical process. This is impoverished in a sense that it does not focus on the core issues around the properties of sensemaking such as plausibility, identity construction and their social nature. Some models

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[439] Lanir, Z 1989. The reasonable choice of disaster… (479-493)

[440] Page 75

[441] Page 93

[442] Page 104

[443] Thomas, JJ & Cook, KA 2005. *Illuminating the Path*… (44)

[444] Weick, KE 2005. *Sensemaking in Organizations* (110)

in Visual Analytics such as that of Wang *Et al.*[445] prefer to perpetuate the myth that knowledge can exist in "disembodied" structures such as databases with indisputable meaning. To emphasise Lanir's argument, the rigidity of formalised taxonomic structures cannot contend with complex situations where there are indeterminable outcomes for future possibilities. This is already creating issues in the United States Military's Distributed Common Ground System – Army (DCGS-A) as described earlier by Estes.[446]

To this effect, the application of Weick's theory of sensemaking, makes a valuable contribution to a more effective use of Visual Analytics in early warning systems. However, the focus of Visual Analytics in warning systems would likely be the interactive visualisation of collected information by the environmental scanning system. This implies that Visual Analytics would be more conducive to situations where uncertainty reigns and that the software could speed up the analyst's task process. Nonetheless, the analyst's frames are still in operation in forcing cues out of visualisations. Analysts are also able to engage other analysts in social interaction by arguing the merits of a particular visualisation if it creates an equivocal situation.

There is also a pre-occupation with issues of accuracy in representations of specifications, such as missing information and the key-hole effect, which is viewed as problematic in warning and intelligence systems. However, the nature of Weick's sensemaking, that plausibility is sufficient, that cues are embellished and that it is an ongoing process, directs attention to the iterative nature of Visual Analytics. Weick's sensemaking focuses on the notion of plausibility rather than accuracy, and its progressive nature - that the meaning of initial cues and frames will be updated continuously while analysts make sense of them. Visual Analytics seen within this Weickian perspective not only speeds up the analysis process, and supports analysts' short term memory processes with visualisations, but also contributes to reframing due to interactive specification and visualisation processes. The latter, simply stated, facilitates and supports the interaction of a warning analyst's tacit and explicit knowledge.

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[445] Wang *Et al.* 2009. Defining and applying knowledge conversion processes

[446] Estes, T 2011. Entity-centric advanced analytics using synthesys (29-31)

## 5.5 Final thoughts and comments

The role that action-driven sensemaking in the form of commitment and manipulation can play in the noticing of cues in warning systems has not been fully considered in this thesis. Action can generate clarity in a confusing environment and more research is needed to facilitate ways of incorporating it into framing operations of warning analysts.

The social nature of sensemaking drives home the importance of collaboration in the framing operations of warning analysts. This is equally applicable to Visual Analytics both from a specification and visualisation perspective. It is possible that individual analysts may notice a warning signal or cue in a monitored environment and fail to bridge between the intrasubjective and intersubjective levels of sensemaking – the results of which, always demonstrated in hindsight, can simply be catastrophic.

Applying the principles of Weick's sensemaking to early warning systems, provides organisations with the ability to construct a better view of a future full of possibilities. It allows them to anticipate, as well as prepare for, possible disruptive future events.

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