Evidential Reasoning & Analytical Techniques In Criminal Pre-Trial Fact Investigation

Richard M Leary, MBE, LLB (Hons).

A Thesis Submitted To University College London for the Degree of Doctor of Philosophy

Faculty of Laws
University College London
ABSTRACT

This thesis is the work of the author and is concerned with the development of a neo-Wigmorean approach to evidential reasoning in police investigation. The thesis evolved out of dissatisfaction with cardinal aspects of traditional approaches to police investigation, practice and training. Five main weaknesses were identified: Firstly, a lack of a theoretical foundation for police training and practice in the investigation of crime and evidence management; secondly, evidence was treated on the basis of its source rather than its inherent capacity for generating questions; thirdly, the role of inductive elimination was underused and misunderstood; fourthly, concentration on single, isolated cases rather than on the investigation of multiple cases and, fifthly, the credentials of evidence were often assumed rather than considered, assessed and reasoned within the context of argumentation. Inspiration from three sources were used to develop the work: Firstly, John Henry Wigmore provided new insights into the nature of evidential reasoning and formal methods for the construction of arguments; secondly, developments in biochemistry provided new insights into natural methods of storing and using information; thirdly, the science of complexity provided new insights into the complex nature of collections of data that could be developed into complex systems of information and evidence.

This thesis is an application of a general methodology supported by new diagnostic and analytical techniques. The methodology was embodied in a software system called Forensic Led Intelligence System: FLINTS. My standpoint is that of a forensic investigator with an interest in how evidential reasoning can improve the operation we call investigation. New areas of evidential reasoning are in progress and these are discussed including a new application in software designed by the author: MAVERICK.

There are three main themes; Firstly, how a broadened conception of evidential reasoning supported by new diagnostic and analytical techniques can improve the investigation and discovery process. Secondly, an explanation of how a greater understanding of the roles and effects of different styles of reasoning can assist the user; and thirdly; a range of concepts and tools are presented for the combination, comparison, construction and presentation of evidence in imaginative ways. Taken together these are intended to provide examples of a new approach to the science of evidential reasoning. Originality will be in four key areas;

1. Extending and developing Wigmorean techniques to police investigation and evidence management.

2. Developing existing approaches in single case analysis and introducing an intellectual model for multi case analysis.

3. Introducing a new model for police training in investigative evidential reasoning.

4. Introducing a new software system to manage evidence in multi case approaches using forensic scientific evidence. FLINTS.
My dear family: Deborah, Ben and Lizzie.

Thank you.......
ACKNOWLEDGEMENTS

I have been fortunate in having access to many people at University College, London. Firstly, my thanks go to my supervisor Professor William Twining, FBA, QC for agreeing to supervise the research. I am only too aware how fortunate I have been to have his interest, time, knowledge and patience at my disposal. Few gain access to such expertise. Special thanks also to Professor Dawn Oliver for reading and making recommendations on the presentation of the thesis. Special thanks go to a number of other people who have given of their time and interest whilst asking nothing in return:

Professor David Schum, George Mason University, Washington DC: For allowing me to attend his lectures at George Mason University, Virginia and for introducing me to a close circle of fascinating evidence and intelligence specialists and for permission to reproduce (Figure 1.13) in Chapter 1. Professor Terry Anderson, University of Miami, Florida: There are very few people available with the knowledge and practical skills to teach others the conceptual issues surrounding evidence, proof and logic. I am grateful for access to his professional knowledge and practical advocacy skills in applying these concepts Professor Arthur I Miller. (Philosophy of Science) University College, London: For reading Chapter Four and discussions about using complexity theory. His recognition of the importance of imaginative reasoning in evidence based scientific investigation was insightful. Professor Kenneth Pease, OBE. Home Office, United Kingdom and Huddersfield University: For encouragement and drive to improve policing methods. Sir Edward Crew, DL, Ord. St. John, Chief Constable of West Midlands Police: For his support and encouragement in overcoming barriers in implementing the concepts in this thesis into policing procedures. Mark Compton, Autumn Consulting: For providing some assistance in configuring Microsoft Excel and Microsoft Access products to embody the author's methodology called FLINTS. Despite his lack of knowledge of police work, evidence and proof, he embodied my methodology and concepts in Microsoft Excel and Access. Microsoft Inc: For Microsoft Excel and Access operating systems used by Mark Compton to produce a software version of FLINTS. Nick Tofiluk, Assistant Chief Constable of West Midlands Police: For assistance in overcoming barriers in implementing the methodologies and concepts in this thesis into policing procedures. Professor Phillip Dawid, University College London: For discussions on the formalisation of the methodology and for permission to reproduce (Figure 1.12) in Chapter 1. I am also grateful to University of Virginia, United States of America, for permission to reproduce (Figure 1.6).

In addition a number of organisations outside the United Kingdom gave freely of their time during research visits: New York Police Department, New York City, gave access to staff for discussions and visits to operational departments. San Francisco Police Department gave access to staff for discussions and visits to operational departments. Federal Bureau of Investigation (Federal offices In San Francisco and Washington DC) gave access to staff for discussions and visits to operational departments. Defence Intelligence Agency, State Department and the Central Intelligence Agency of the United States of America in Washington DC gave access to staff for discussions and visits to operational departments. Finally, Embassy of the United States of America, London for arranging visits.
PREFACE

This thesis is the result of research conducted by the author into the benefits that can be gained by the application of a general theory and methodology to the process of managing and using evidence in police investigation and intelligence analysis. Central to this are methods and processes that let investigators and intelligence analysts ask good questions. Following is a brief chronology of the development of those ideas and research.

Following appointment as a detective officer in 1980, the author became dissatisfied with the methods and training provided to investigators and intelligence analysts. Having developed an interest in the use of Deoxyribonucleic Acid (DNA) in criminal cases, in 1990, he completed a research dissertation entitled *DNA Evidence: The Promise, Potential and Pitfalls*. This was submitted as an Honours Degree Dissertation. It involved a literature review and research interviews with forensic and legal experts debating the use of DNA evidence. This resulted in an interest in ways in which scientific evidence could be combined and used with other evidence in the investigation of crime.

In 1994, the author began experimenting with software ideas to aid the management and analysis of evidence. The author’s original ideas about the combination of different types of evidence and the reduction of uncertainty were presented at the First World Conference on Criminal Investigation and Evidence at the Hague in 1995. In 1994, the author became a member of the Forensic Science Society and in 1996 published two papers in the Police Research Group publication Focus. The first was entitled “A Revolution in Criminal Investigation” and concerned extending the application of forensic principles and genetic evidence. The second was entitled “DNA: The Promise” and challenged the traditional use of evidence. It proposed new approaches for the systematic management and use of evidence in the investigation of multiple cases rather than single cases. The paper and original ideas presented at the Hague together with the latter two papers provided the ideas for the systematic use of large collections of evidence and formulated the author’s original ideas underpinning the case study system called Forensic led Intelligence System, FLINTS. The author coined the term ‘forensic intelligence’ now used commonly to refer to the holistic use of forensic evidence for intelligence purposes. Prior to this, forensic evidence was solely used in the investigation of single isolated events for example, a burglary, a murder or a rape, rather than the routine investigation of linked and series of crime.

In late 1995, the author was seconded to the Home Office, London, to undertake research into better ways of managing and using forensic evidence. This resulted in a best practice guide and the author jointly authored a book entitled “Using Forensic Science Effectively” published by the Home Office. This is acknowledged as the ‘Best Practice Guide’ to using and managing forensic evidence in the United Kingdom and has been adopted and used in Europe.

In 1996, the author developed an interest in the methods of analysis and synthesis of evidence developed by John Henry Wigmore. Although this was exclusively concerned with single, isolated cases, it provided a foundational methodology for the Charting of logical relations between evidence in argumentation. At this time the author also developed an interest in the science of complexity. This provided valuable ideas about complex systems and the way information in such systems behaves and can be used.
In 1996, the author won the Forensic Science Society Scholarship to continue research into new ways of using and managing forensic evidence. Systemising the combination of different evidence types and developing intelligence from forensic evidence was the focus of the work. The author was by this time developing and testing ideas about systemising the management, analysis and synthesis of mixed masses of evidence in police investigation.

In 1997, having discovered the work of the author, Mark Compton offered to provide the author with programming expertise to develop a software code to operationalise the methodology in a computer. After discussion, the author accepted the offer to develop a computer application at the direction of the author using the neo-Wigmorean approach he developed. There were two main aims: Firstly, to demonstrate how to overcome elements of the five weaknesses identified by the author in police investigation and practice; secondly, to draw on the lessons from Wigmore, Biochemistry and Complexity Theory in developing a prototype system and case study. Mark Compton was directed in programming a computer to build the prototype case study in terms of the specification set by the author. See Appendix 1.

In 1999, the author was successful in applying to the Home Office for funding to develop a case study in the systematic management and analysis of forensic evidence. The author directed Mark Compton in building of the case study system based on his general theory and methodology for the management and analysis of evidence. The resulting case study was called FLINTS. Mark Compton programmed the computer code at the direction of the author to ensure that the conceptual foundations of the approach were embedded into the software. The results of this vision and direction can be seen in the illustrations of the system in Chapter 3. A key objective of the author was the ability of the system to ‘analyse’ evidence at the same time as manage it. FLINTS was built by configuring Microsoft Excel and Microsoft Access operating systems. The work was undertaken in stages: firstly, the author explained to the programmer with diagrams and draft papers what he was trying to achieve. The programmer then attempted to recreate this on the computer and reported back to the author with prototype results. The work was inspected and ‘fine tuning’ was undertaken after new instructions from the author. The work progressed in this cyclical way.

The author managed the whole project and was responsible for developing the system. The author received some assistance in configuring Microsoft Excel and Access to operationalise the methodology set by the author in the form of the work of Mark Compton. It will be clear from Chapter 1 that prior to 1999, the author acted alone and was only given assistance in 1999 in configuring Microsoft software to embody the methodology described in this thesis. All conceptual and theoretical work is that of the author. This is acknowledged in ‘open correspondence’ from Mark Compton.

In 1998, as a result of his research, the author was appointed Scientific Officer to West Midlands Police to put into place new methods of managing and using forensic evidence. In 1999, for the first time globally, the author experimented with the use of highly sensitive technology to recover DNA from surfaces merely touched by humans. Whilst it was usual to recover DNA from visible samples, in this experiment, the material was invisible to the human eye. The intelligence gained from this evidence was used to identify groups of criminals operating in networks. This was a distinct objective of the general theory and methodology being developed by the author in that evidence should be used to gain holistic as well as atomistic knowledge. In brief, evidence in one case could also be
evidence in another. The acknowledgement of the benefits of the investigation of criminal networks came from this work and was used as part of ‘Operation Liberal’ to target serious organised burglary teams targeting elderly victims. At this time, there was a national crime problem involving elderly householders. Confidence tricksters were gaining access to elderly peoples houses on the pretext of being public officials. Using 'super sensitive' recovery techniques, DNA was recovered from door-knockers, handles and objects merely touched by offenders. Applying new policy, procedures and techniques in accordance with the general theory and methodology described here, evidence was recovered that resulted in the detection of networks of criminals and crime. This was later responsible for the prosecution of key people involved in organising and committing these offences. The technique became a service offered to investigators by the Forensic Science Service.

In 1999, Nick Tofiluk, Chief Superintendent (later Assistant Chief Constable) West Midlands Police recognised the work of the author in developing the methodology and FLINTS. He became an enthusiast of the work and offered strategic assistance in overcoming organisational and political barriers in the police service. He encouraged senior and junior officers to use the approach. Responsibility for the development of the methodology and conceptual underpinnings continued and remained that of the author. This is acknowledged in 'open correspondence' from Nick Tofiluk.

In 2000, the research and development work undertaken by the author was recognised by the Prime Minister and he was invested into the Order of the British Empire for “Services to Policing” in the Queens New Year Honours List.

In 2001, the author began work in Montreal, Canada and Washington DC, United States, to put into place his general theory and methodology by developing the Integrated Ballistics Information System (IBIS) into a system that could provide forensic intelligence. The work is ongoing and involves extracting new evidence and intelligence from many thousands of pieces of ballistic evidence stored in databases across the USA. Prior to this work, the evidence in the system lay dormant awaiting a manual comparison to declare matches between a cartridge case, a bullet and a gun in single cases.

In 2002, the author began work on a case study to develop a new approach to managing the problem of shifting context and standpoint in evidence management. In 2003, the first iteration of the case study was programmed and used to simultaneously manage and analyse evidence in over 440 cases of fraud. Lawyers involved in litigation had been unable to manage the complex nature of the evidence involved as well as the complex nature of links between cases. Furthermore, whilst it was acknowledged that disclosure obligations existed under Proceeds of Crime and Terrorism Act 2000, it was proving difficult to meet these obligations due to the complex nature of the cases and links. The author was contacted to provide assistance and he did so using his new methodology and system called MAVERICK.

Whilst the system itself is outside the scope of this thesis, it provides advances on FLINTS and uses a unique methodology developed by the author to manage the way in which evidence is perceived and used. The major advance is the ability of the system to 'recognise' the standpoint and context of the problem being investigated. This is an important feature because every episode of fact investigation is unique to some degree. MAVERICK is introduced as an example of what the future holds for evidence management and investigative reasoning and the system is still developing. The author conceived the system and instructed a computer programmer to build the first case study.
to the author’s design. The system is an extension of the authors research and goes well beyond the design and functionality of FLINTS.

In 2004, the author, using MAVERICK, completed the work mentioned above for lawyers and financial organisations seeking assistance in meeting their disclosure obligations laid down by the Proceeds of Crime Act and Terrorism Act 2000. Two areas of work were involved and completed: Firstly, a formal ‘disclosure’ of certain classes of material to the National Criminal Intelligence Service about organised fund raising in connection with terrorist activity; secondly, the investigation of over 440 cases of financial crime involving over £8 Million. This has led to the review of the management of 1.2 million financial transactions that may also contain further evidence. The analytical work in this area is about to begin using MAVERICK.

The author personally and alone conceived of the methodology and need for a systematic approach to the management and analysis of mixed masses of evidence in police investigation upon which FLINTS and later MAVERICK are built. This included the original concept and design of a process in a computer program (FLINTS). The author promoted the idea internally to the police service and externally to the Home Office and National Security Services. The author had to overcome political as well as organisational resistance and apathy in gaining acceptance of what could be achieved by this new approach. The author continually undertook ‘lobbying’ of investigators, analysts and senior policy makers so that they could gain an understanding of what could be achieved with a formal deployment of the methodology. The author persuaded the Chief Constable and Management Team at West Midlands Police to change investigation policy and the methodology was deployed. Results eventually convinced policy makers, investigators and intelligence analysts that the approach had many benefits for police investigation. Eventually, the methodology and FLINTS became a central feature of policing in the West Midlands and beyond.

The role of the author and the effect on crime reduction in West Midlands was acknowledged by the Chief Constable of West Midlands Police in ‘open correspondence’. Once underway and progress began to be demonstrated, a number of people recognised the value of what was being developed and graciously provided assistance: In overcoming political and organisational resistance on the value of the approach, Nick Tofiluk played an important role. For software expertise in converting the concept into a computer code thanks go to Mark Compton.

Acknowledgements of the work of the author can be found in ‘open correspondence’ from Sir Edward Crew, Chief Constable West Midlands Police, Nick Tofiluk, Assistant Chief Constable West Midlands Police and Mark Compton, Autumn Consulting. References also appear in the text of the thesis.
CONTENTS

Title Page 1
Abstract 2
Dedication 3
Acknowledgements 4
Preface 5
Contents 9
Figures 13
Appendices 18

CHAPTER ONE A NEO-WIGMOREAN METHODOLOGY ............................................. 19 - 123
   Background 19
   Outline of the Argument in this Thesis 19
   The Structure of Chapter 1 22

CHAPTER ONE, PART 1 - DEVELOPMENT OF A NEO-WIGMOREAN METHODOLOGY .......................................................... 27
   1.1 Weakness 1: Dissatisfaction with Traditional Police Training and Practice 29
   1.2 Weakness 2: Evidence is Marshalled on the Basis of its Source, Not its Meaning 30
   1.3 Weakness 3: Role of Inductive Elimination is Not Understood and is Under-used 32
   1.4 Weakness 4: Managing Evidence on the Basis of Single Cases 33
   1.5 Weakness 5: The Credentials of Evidence are Often Assumed 34
   1.6 Police Systems 35
   1.7 The Traditional Management of Evidence 35
   1.8 The Response to the Author’s Dissatisfaction with Existing Approaches 51
   1.9 The Influence of Molecular Biology in Developing a Broadened Conception of Evidential Reasoning 63
   1.10 Parallels between DNA and Systems of Evidence 67
   1.11 The Recognition of Complexity 76
   1.12 The Influence of John Henry Wigmore 77
   1.13 Wigmore’s Method 80
   1.14 Wigmore & the Detective’s Viewpoint of Evidence 92

CHAPTER ONE, PART 2: SYSTEMISATION OF METHODOLOGY ........................................... 106
   2.1 Systemisation of the Management of Evidence 106

CHAPTER ONE, PART 3: OBSTACLES, BARRIERS AND PITFALLS .................. 111
   3.1 Changing the Mentality and Behaviour of Investigators and Analysts 112
   3.2 Dangers of Bureaucratisation of the Investigation Process 116
   3.3 Overreliance on Transactional Computers, Over-formalisation and Detraction from Good Thinking 119
   3.4 Training Needs for Investigators: the Logic of Enquiry in Context Conclusions and Context for the Remainder of the Thesis 121
CHAPTER TWO - ACKNOWLEDGING & USING EVIDENTIAL DIVERSITY

Background ........................................................................................................................................124
2. Evidential Diversity ...................................................................................................................................124
2.1 The Symbiosis of Evidence, Hypotheses and Questions ...........................................................................126
2.2 Testing the Authenticity – Asking Questions About Evidence ......................................................................135
2.3 Evidence Collection ..................................................................................................................................135
2.4 Recovery and Storage ..............................................................................................................................136
2.5 Questions About Laboratory Procedures and Actions ...................................................................................136
2.6 Standards in Evidence Management – Applying a Methodology .................................................................139
Conclusion ..................................................................................................................................................142

CHAPTER THREE FLINTS 1 & 2

Background ..................................................................................................................................................143
3. FLINTS 1 ...................................................................................................................................................144
3.1 Identifying "Unknown" Offenders ................................................................................................................147
3.2 Systemising the Identification of Unknown Offenders ...................................................................................148
3.3 First Generation of FLINTS .......................................................................................................................156
3.4 Integration, Linking and Analysis Tools .......................................................................................................157
3.5 Expanding FLINTS to Other Police Areas ..................................................................................................159
3.6 Volume Crimes and Volume Suspects: Not Single Events and Single Suspects ..............................................161
3.7 Performance Monitoring and System Identification .....................................................................................162
3.8 Using FLINTS: A Tour of the System as the User Sees It ...........................................................................163
3.9 The Intellectual Foundations of FLINTS ......................................................................................................179
3.10 What is it About FLINTS that Makes it Different? .....................................................................................181
3.11 A Case Study in Linked Burglary ................................................................................................................182
3.12 Forensic Decision-making .........................................................................................................................190
3.13 Second-generation FLINTS .....................................................................................................................200
3.14 Access to the System: Searching or Surfing? ..............................................................................................202
3.15 Asking Questions About People and Suspects ...........................................................................................205
3.16 Asking Questions About Crimes and Events .............................................................................................206
3.17 Displaying Modified Wigmorean Charts: Graphical Results in FLINTS .....................................................207
3.18 Geographical Analysis ...............................................................................................................................212
3.19 Temporal Analysis ...................................................................................................................................213
3.20 Prolific (Volume) Offenders Search ............................................................................................................215
3.21 Using Geography to Identify Prolific Offenders .........................................................................................216
3.22 Hot Spot Searches ....................................................................................................................................221
3.23 Vehicle Searching ....................................................................................................................................223
3.24 Analytical Audit Trails ...............................................................................................................................226
Conclusion ....................................................................................................................................................229
CHAPTER 4 POLICING AND COMPLEXITY

Background

4.1. Introducing Complexity To Policing
4.2 What are Chaos and Complexity?
4.3 What is a Complex System?
4.4 Tradition and the New World: Linearity and Complexity
4.5 Linear or Complex Systems
4.6 Has Complexity Replaced the Old Order?
4.7 Why Analyse for Chaos?
4.8 Predicting Chaos and Self-organisation
4.9 Period Doubling in Complex Systems
4.10 Combining Complex Real World & Linear Digital World for Predictive and Discovery Purposes
4.11 Thinking in Silos
4.12 The Complex Police Environment
4.13 Policing and Complexity
4.14 How Should Police Respond to Complexity?
4.15 What Are the Implications For Police Work?
4.16 Linked Strategies to Harness Complexity
4.17 The Implications for Policing: Reducing Uncertainty in Systems
4.18 Is Feedback a Threat?
4.19 The Driving Forces Behind Complexity in Policing
4.20 Complexity, Chaos and Communities
4.21 The Result of Chaos: Self-organisation
4.22 Systems, Data and Quality
4.23 Maintaining Stability in Complex Scenarios
4.24 The Danger of Self-organising Systems
4.25 Complexity and Prolific Offenders: Disrupting Networks
4.26 What Can We Do With Complex Crime Networks?
4.27 Complex Network of People Based On Histories of Co-offending
4.28 Generating Knowledge from Complex Systems: the Use of Attractors
4.29 Attractors and the Role of Elimination
4.30 Fixed-point Attractors
4.31 Cyclic (Fixed-limit) Attractors
4.32 Strange or Complex Attractors
4.33 Practical Use of Attractors
4.34 Asking Good Questions: Using Holistic Aggregation and Atomistic Disaggregation
4.35 Prediction in Complex Police Systems
4.36 Conclusion
CHAPTER 1

FIGURE 1.1 Iterative Process Of Constructing And Testing Questions
1.2 Matrix Of Questions And Propositions
1.3 Network Of Crimes Linked To Suspect Reece
1.4 Network Of Crimes Linked To Suspect Watkins
1.5 Cells And Genetic Material
1.6 Base Pairing That Occurs Between Nucleotides In DNA
1.7 Base Pairs Of DNA Represent A Binary "Program" Similar To That Used In Computer Software
1.8 Sequences Of Base Pairs
1.9 Wigmore Chart - Commonwealth v. Umilian
1.10 Visual Depiction Of The Times & Dates Of Burglary Crimes Used To Facilitate Pattern Detection
1.11 Example Of A Directed Acyclic Graph
1.12 Schum's Analysis Of The Dawid and Evett (1997) Case
1.13 Diagram Of A System Linking Humans And Computers To Take Advantage Of Each Other's Strengths

CHAPTER 2

2. The Combination Of Evidence Types - Blood Stained Knife
2.1 Revealing Evidence - Example 1: Use Of Specialist Lighting Over Time For Physical Injuries
2.2 Revealing Evidence - Example 2: Footwear
2.3 Revealing Evidence - Example 3: Handwriting In Shoe
2.4 Magnified Fragments Of Glass, Debris And Fibres
2.5 Debris From Pockets Of Garments
2.6 Magnification & Identification Of Micro Objects
2.7 Chemical Treatment Of Suspected Blood Stain
CHAPTER 3

3 Hypothetical Series Of 10 Crimes Linked By A Single DNA Profile
3.1 Range Of Indicators Of Identity
3.2 Multidimensional Approach To Evidence Management And Analysis
3.3 The Flow Of Evidence Through FLINTS
3.4 Current And Future Communication Channels
3.5 Example One - Framing A Question In FLINTS
3.6 Example Two - Framing A Question In FLINTS
3.7 Links Being Formed In FLINTS
3.8 Network Of Links
3.9 Confirmed And Rejected Links In FLINTS
3.10 Regional Pattern Of Incidents And Potential Links
3.11 Geo-Referenced View Of Forensic Links To A Suspect
3.12 Sample Performance Reports That Can Be Generated By FLINTS
3.13 Histogram Of Hits On Ocu's (Geographical Police Areas), By Evidence Type
3.14 Answers To A Question Concerning Evidential Hits In FLINTS
3.15 Conclusion Generated By FLINTS That Calls A Key Finding (Correlation) To The Investigator's Attention
3.16 Listing Of Suspects With More Than One Hit
3.17 Link Between One Suspect And Evidence
3.18 Additional Links Suggested By FLINTS
3.19 Identification Of Complex Links By FLINTS
3.20 Intelligence Picture Generated By FLINTS
3.21 Simple And Corroborated Chains Of Evidence Generated By FLINTS
3.22 Annotated Photograph Of A Burglary Scene
3.23 Chronological Sequence Of Events
3.24 Bloodstained Denim Trousers
3.25 Footwear Mark In Blood
3.26 Footwear Used As Evidence
3.27 Footwear Used As Evidence
3.28 Tool Mark From The Point Of Entry At The Burglary Scene
3.29 Chart Of Links For The Linked Crimes And Offender
3.30 Main Functions Offered By The FLINTS 2 Toolbar
3.31 Logging Into The FLINTS System
3.32 Toolbar In FLINTS 2
3.33 Flints 2 Desktop Environment
3.34 Results Of Searching On A Suspect Name
3.35 Results Of Searching By Code (Burglary Dwelling
3.36 Results Of Searching Based On A Police Area
3.37 Graphical Display Of The Results Of A Search
3.38 Enlarged View Of The Results Toolbar
3.39 Sample Warning To Confirm The Validity Of Links
3.40 FLINTS - Access To Photographic Evidence
3.41 Icon For Selecting Geographic Overview. (2) Icon For Selecting A Subset Area. (3) Icon For Displaying The Results For A Selected View
3.42 Map Of Locations Within The West Midlands Region
3.43 Crimes That Have Been Recorded Across Two Police Areas
3.44 Icon Used To Select A Chronological Display
3.45 Example Of A Typical Chronology Of Crime For A Suspect
3.46 Searching For Prolific (Volume) Offenders
3.47 Disposal Types Used By FLINTS
3.48 List Of Available Operational Command Units (Ocus)
3.49 List Of Available Offence Types
3.50 Query Definition Dialog Box
3.51 Results Of Specifying A Date Range In A Query
3.52 Results Of A Query
3.53 Graphical Depiction (Map) Of Query Results
3.54 Summary Of Crime Results Plus Photograph Of Suspect
3.55 FLINTS Search Function For Identifying Hot Spots
3.56 Results Of A Hot Spot Search Based On Incidents Rather Than Crimes.
3.57 The Flints Vehicle Search Dialog Box
3.58 Options Available In The FLINTS Vehicle Search.
3.59 Results Of A Vehicle Search
3.60 List Of Links And Hypothesis Summary
3.61 Audit Trail - Hierarchy Of Links In A Network Of Associates

CHAPTER 4

4 Illustration Of A Linear System
4.1 Illustration Of A Complex System
4.2 Simple Linear System
4.3 Example Of A Nonlinear System (Frequency Flow), Demonstrating High Degrees Of Unpredictability
4.4 Nonlinear Systems - Predicting The Future Behaviour Of The System
4.5 A Bifurcation Diagram
4.6 Depiction Of Criticality, The Point At Which Stability Can Degenerate Into Chaos
4.7 Bifurcation Leading To Additional Bifurcations
4.8 Bifurcation Diagram Showing The Results Of Successive Iterations
4.9a A Simple, Linear Inference Chain
4.9b Nonlinear Inference Chain
4.10 Hypothetical Network Of Key Players And Associates – A Criminal Network
CHAPTER 5

5 Maverick Analytical Window
5.1 A Mixed Mass Of Evidence Modelled In MAVERICK To Identify Fraud
5.2 MAVERICK Used To Identify Bank Accounts Used To Pay For Multiple Policies
5.3 MAVERICK Being Used To Identify Multiple Financial Transactions
5.4 MAVERICK Used To Identify Separate Clusters
5.5 MAVERICK Demonstrating Non-Obvious Links Between Bank Accounts Used In Multiple Transactions
5.6 MAVERICK Being Used For Simultaneous Investigations
5.7 MAVERICK Being Used To Undertake Micro-Level Analysis Across Clusters Of Evidence
5.8 Unexpected Links Revealed By MAVERICK
5.9 Five Linked Clusters Of Evidence Revealed By MAVERICK
5.10 Determining Evidence Of Identity Theft And Fraud
5.11 Determining Evidence Of Identity Theft Using National Insurance Numbers, Names, Addresses And Insurance Claims
# APPENDICES

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Forensic Led Intelligence System: Conceptual Foundations.</td>
<td>359 – 366</td>
</tr>
<tr>
<td>2</td>
<td>Recurrent Forms Of Evidence. (Schum, D).</td>
<td>367 - 368</td>
</tr>
<tr>
<td>3</td>
<td>Wigmore Chart Method: Umillian.</td>
<td>369 - 382</td>
</tr>
<tr>
<td>4</td>
<td>Modified Wigmorean Chart Method. Modified Symbols By Anderson &amp; Twining.</td>
<td>383 - 386</td>
</tr>
<tr>
<td>5</td>
<td>Schum’s Analysis of the Dawid and Evett Case &amp; Key List. (Schum 2003).</td>
<td>387 - 388</td>
</tr>
</tbody>
</table>
CHAPTER ONE
A Neo-Wigmorean Methodology:
Development, Significance & Barriers to Implementation of the Methodology

Background
This Chapter is concerned with the development and significance of a neo-Wigmorean approach to evidential reasoning. The term neo-Wigmorean is used here in view of the fact that the Chapter discusses the author’s adoption and adaptation of Wigmore’s original methodology to create something new: a neo-Wigmorean approach. It explains how this methodology was developed by the author (see Appendix 1) and later embodied in "computer software" at the direction of the author, named FLINTS, which is an acronym for the "Forensic-Led Intelligence System".

Outline of the Argument in this Thesis
The argument in this thesis is based upon five weaknesses that the author identified in the way investigation is conducted and the way that investigators are trained:
1. The author developed an increasing dissatisfaction with police training and practice in the investigation of crime and in evidence management. This dissatisfaction was increased by the research and investigation conducted as part of the thesis itself.
2. The author discovered that the police service treated and considered evidence on the basis of its source rather than based on the contribution the evidence could make to the capacity for asking good questions.

2 4 March 1997.
3. The role of inductive elimination was underused and misunderstood.

4. A concentration on single, isolated cases rather than on the investigation of multiple cases that prevented evidence from being used to its full capacity.

5. The credentials of evidence were often assumed rather than considered, assessed and reasoned about within the context of an argument and the case as a whole.

Having seen that these weaknesses adversely affected the process of investigation, the author set about discovering new methods and approaches that could be applied to remedy these weaknesses.

Three sources of inspiration were used to develop the research:

1. Developments in biochemistry and genetics provided new insights into natural methods of storing and using information. The model for these insights was the molecule deoxyribonucleic acid (DNA). The study of how this molecule enables vast amounts of information to be stored, combined and used provided new ideas and challenges about the way in which humans and artificial systems could develop their own capacity to store and use information.

2. The work of the jurist John Henry Wigmore\(^3\) provided new insights into the nature of evidential reasoning and formal methods for the construction of arguments. Although this work was limited to the analysis and management of evidence in single cases, the processes involved in structuring and ordering evidence within an argument provided valuable insights into the development of an enhanced, broader understanding of the role of evidence in argumentation.

3. The science of complexity provided new insights into the complex nature of collections of information that could be developed into complex systems of information. This understanding demonstrated that what may appear simple on the face of things often hides extremely complex realities, and that what may appear complex can hide relatively simple relationships. This realisation, together with an enhanced

\(^3\) The extent of his influence in evidence can be seen in Wigmore (1940, 3\(^{rd}\) edn.).
understanding of the role of complex systems, provided new insights into the ways in which information and systems could be used.

These three sources of inspiration provided new ways of thinking about the process of inferential reasoning.

Wigmore’s work on the construction of arguments⁴ based on evidence was used as the foundation for a new approach to the analysis and synthesis of evidence in police investigation and intelligence analysis. The development of a formal structural approach was important both as an aid to investigative enquiry and as a potential model for training. It became clear to the author that the justification for using Wigmore Charts is that they offer an effective way of anchoring narratives. This was instrumental in developing the author’s thinking about the need and development of methodologies for FLINTS and MAVERICK described later in this thesis. This approach was extended by the study of the work of Tillers and Schum and the application of a substance-blind approach to evidence and forensic science. This term will be discussed in more detail later; briefly, this approach necessitates treating evidence not on the basis of its source or type but rather on the basis of what it can tell you. Distinguishing between two questions helps to explain the importance: A substance-blind approach entails the following question: “What does this evidence tell me?” A traditional approach to the management and classification of evidence would result in the following question: “What is this evidence?”

These approaches were developed into a method for the analysis and synthesis of evidence in single cases and the extension of this method to the analysis and synthesis of evidence in multiple cases. The subsequent embodiment of the methodology into computer software was therefore a contribution in its own right. Taken together, the methodology and the software provided new ideas about the way in which complex masses of evidence could be used as a source of material for answering questions and drawing conclusions based on evidence. It will be seen that the application of the general methodology resulted in new

⁴ See also Twining (2002a) and (2002b) on legal reasoning and argumentation.
investigative opportunities as well as new implications for police investigation and training. The methodology and FLINTS together represent the first example of this modernised neo-Wigmorean approach. A consolidated publication of sources on evidence proof and facts has appeared recently bringing together many useful works. See Murphy, (2003).

The Structure of Chapter 1
Chapter 1 is divided into three parts: Part 1 deals with the development of the methodology and differentiates it from the traditional approaches found in criminal investigation and in investigative training. This is followed by an explanation of the genesis of the methodology, including the impact and influence of genetic (DNA) evidence. An outline of the influence of the science of complexity on the development of the methodology follows. Part 1 concludes with a demonstration of how the thesis extends Wigmore's approach to detection (1931, p. 1016, Appendix V) from a model of argumentation based on evidence to a model of investigation based on inference and evidence. A distinction is made between hypothesis formation and hypothesis testing, and the justification for the use of the term neo-Wigmorean is explained.

Part 2 deals with the significance of this neo-Wigmorean perspective in terms of its impact on the logic of police enquiry and the new approach. It begins with an explanation of the benefits that can accrue from systemising the management of evidence, particularly when the traditional emphasis placed on the collection of large amounts of evidence is matched with an equal emphasis on the analysis and interpretation of this evidence. The analysis and interpretation of evidence are important skills in the process of reasoning because they provide the foundation for argument construction and evaluation. Argument construction involves the analytical process of discovering and formulating questions and logical inferences that create rational enquiry. Argument evaluation involves the analytical process of checking an argument for logical correctness and assessing whether any conclusion drawn by the analyst is logically and evidentially defensible. That is, evaluation tests

________________________

5 Science of complexity is dealt with in Chapter 4.
whether a conclusion is logically sound and provides sufficient inferential force to aid help the investigator and intelligence analyst in discriminating between competing arguments.

Both argument construction and argument evaluation often involve the analysis of complex chains of inferential reasoning. This will often involve not only the evidence the investigator possesses but also the contemplation of evidence that the investigator does not possess. In this sense, argument construction and argument evaluation involve not only the analysis of evidence in the possession of the investigator but also the synthesis of evidence not in the possession of the investigator. Chains or sequences of evidence can be marshalled into useful configurations and tested by questions designed to examine how well the argument withstands challenge. Arguments that withstand repeated challenge tend to become more persuasive. However, the investigator and analyst must always consider what evidence is missing and whether evidence that may exist somewhere in the environment, even if it is not in the possession of the investigator or intelligence analyst, might affect the conclusion.

Analysis is the process of "breaking down" an argument or chain of reasoning into its component parts, whereas synthesis is the process of "building up" an argument or chain of reasoning in support or negation of some hypothesis under consideration.

The collection of large amounts of evidence, often aided by powerful technology systems, has consequences for the process of investigation and intelligence analysis. An example of one such system would be a computer that stores details on the evidence collected by investigators, crime scene experts, and analysts. Systems can contain so much information about evidence already collected that investigators and intelligence analysts cannot simultaneously keep in mind all the evidence that is available (i.e., what they or the organisation already know). Furthermore, if they cannot keep in mind what has been recovered, they cannot possibly keep in mind all that has not yet been recovered.

The extent of the knowledge that investigators and intelligence analysts may have about their own or the organisation's possession of evidence falls into four potential states:
1. You know what you or the organisation know.

2. You know what you or the organisation do not know.

3. You don’t know what you or the organisation know.

4. You don’t know what you or the organisation do not know.

This methodological approach to the classification of knowledge about the evidence we do or do not possess helps investigators and intelligence analysts adopt a more open-minded, balanced attitude towards managing and using evidence. It prevents closed systems of thinking in which a hypothesis is decided upon and evidence is simply sought to justify that hypothesis. It also facilitates the creative thought processes that are useful in undertaking the discovery of evidence and seeking explanations that we do not already possess. This mindset is particularly important because it lets investigators and intelligence analysts contemplate evidence at both macro and micro levels and in terms of both the evidence that they possess and the evidence that they do not possess. They can consider evidence not only with regard to some immediate issue under investigation but also evidence and explanations about ranges of issues of interest encountered and discovered as the process of investigation unfolds. Access to masses of evidence thus becomes not only a problem in terms of management and analysis of information, but also an opportunity to enhance the process of discovery.

This approach helps investigators and intelligence analysts move towards the investigation of multiple cases rather than following a more traditional and limited approach based on investigating single events of crime in isolation and on a case-by-case basis. The role of the proposed new methodology in driving a change from the traditional approach to a neo-Wigmorean approach encompassing intelligence-led detection and preventive policing is examined. This highlights and explores a new way of thinking about the role of evidence in
criminal investigation and intelligence analysis. The final section of Part 2 places specific emphasis on two points: First, this section emphasises that FLINTS is based on a clearly defined methodology and general theory of evidential reasoning that has been embodied in the form of software. The FLINTS software provided, and continues to provide, an environment within which the processing of questions, answers, conclusions and hypotheses can thrive rather than replacing this form of reasoning. The effect on crime investigation can be profound:

"Leary described to me that he wanted to set up a Force-wide database which firstly would manage the simple process of ensuring the journey of evidence from suspect or crime scene at any location in the force through the necessary scientific processes and that matches would result in suspects being charged with offences. That in itself would have been progress. However, he went on to describe a system he had been thinking about that would take not just DNA but all other forensic evidence and add it to crime and suspect data. The system would manipulate the data so that evidence pointing to or away from a suspect's guilt could be accumulated...and so it was that Flints was born. As it grew under Leary's guidance, hard-bitten detectives grudgingly acknowledged its immense value. The number of primary detections® increased at a rate never experienced elsewhere, crime in all major categories fell and, except for violence, continue to do so."

One of the dangers is that FLINTS is seen as simply a machine. However, like Wigmore's method, FLINTS is a systemisation of an art in the form of an orderly way of approaching the management and analysis of a mixed mass of evidence. FLINTS is a tool to aid thinking; it is an embodiment of a way of thought, not just a computer programme. Part 2 emphasises that the methodology is augmented by the ability to access large amounts of evidence as well as the ability to formulate and ask "good questions" in a structured format. As well as discussing some of the barriers and pitfalls, Chapter 5 demonstrates how the systemisation of an art form can be further developed to provide even more powerful techniques and methodologies to aid police investigation and intelligence analysis.

Second, Part 2 emphasises that the process of accessing large amounts of evidence, asking good questions and drawing conclusions is an iterative cycle. For example, a question may

---

6 A term defined under Home Office Rules that means a crime has been solved.
7 Open correspondence to author: Sir Edward Crew, Chief Constable West Midlands Police.
be asked of evidence so that the answer produces a conclusion. That conclusion can be used as a new hypothesis that stimulates a new enquiry. Furthermore, questions can stimulate new questions, and the evidence produced as a result of one question can be used as evidence in some new scenario. Reasoning of this type is not passive, but rather a dynamic process of actively and imaginatively formulating new questions to make progress as the enquiry unfolds over time. Figure 1.1 is an illustration of this dynamic, iterative process. The arrows in the illustration represent inferential steps.

**Figure 1.1: Iterative Process of Constructing and Testing Questions.**

![Diagram](image)

This approach is based on the combined effect of enabling the user to engage in semantic reasoning whilst the software and computer manages the complex syntax of linked databases and evidence. Either aspect of the approach would be limited without the other aspect.

Part 3 of this Chapter deals with some of the obstacles, barriers and pitfalls encountered during the development of the new-Wigmorean methodology and the FLINTS software built at the direction of the author to embody these ideas. This section begins with an examination of the need to change the mentality and behaviour of investigators and the
dangers presented by over-bureaucratization of the process of investigative. The thesis then discusses the threat posed by the over-reliance on transactional computers as well as the dangers presented by overformalisation, which detracts from good thinking. Lastly, the need to train investigators in the logic of enquiry, which is directly linked to the opportunities presented in Part 2, is dealt with.

In terms of the historical development of the law of evidence, this thesis is concerned with the developments that have occurred since Wigmore's time.

**Part 1: The Development of a Neo-Wigmorean Methodology and FLINTS**

This thesis presents a case study of the application of a general theory of evidential reasoning and of a neo-Wigmorean approach. It demonstrates how this general theory can improve and extend pre-trial criminal fact investigations based on the investigation of crime events on a case by case and person by person basis. By extending the approach to the investigation of networks of crime events and of people, the new approach offers investigators a powerful tool. The methodology was designed by the author and later reproduced in the form of a computer programme to enable the benefits of the approach to be systemised, used and shared by multiple investigators and intelligence analysts engaged in the discovery of evidence useful to the construction of ideas and cases.

The importance and relevance of applying the methodology developed and described in this thesis to law is an issue that requires attention. This is true in terms of developing the capacity to ask good questions and use modern technology to aid the management of the data so that questions can be contemplated, formulated, asked and answered:

"I believe that there are some particular strategies for such activities that are both useful and do have a sound theoretical basis. A glance through any law periodical, such as the *American Bar Foundation Journal*, will reveal the existence of many computer based systems being advertised. Many of these systems show promise of assistance in the day to day running of a law practice. As of yet, however, no system has been set up with the primary objective of providing assistance in the generation or discovery of ideas and
evidence upon which the successful handling of any case depends. Modern computer facilities can assist us in marshalling our thoughts and evidence so that we ourselves may be prompted to ask more productive questions during fact investigation." (Schum 1999a, p. 453).

Schum recognised that any technology is only as good as the methodological processes upon which it is based. The FLINTS system was built at the direction of the author and is based on a methodology that develops the capacity for asking good questions.

The methodology was designed by the author and later reproduced in the form of a computer software at the direction of the author so that the benefits of the approach could be systemised, used and shared by multiple investigators and intelligence analysts. This approach extended the use and benefits of the methodology beyond a single person to the level of a whole organisation. This methodology also established high standards for evidential reasoning, gave access to masses of evidence in crime cases, and introduced a structured approach to asking wide-ranging questions, useful in the prevention and detection of crime. Central to the methodology is an interrogative approach developed by the author for the generation of questions about links and associations between people, places, times and events. These links and associations are based on the mixed mass of evidence routinely collected at crime scenes and during investigations; until this methodology was set in place, the evidence collection was left largely devoid of any subsequent strategic management and analysis. A central feature of this methodological approach is the use of a substance-blind view of evidence, in which what evidence can tell us is more important than what the evidence actually is.

The methodology enables links and associations to be drawn between suspects, crimes under investigation, historical crimes and new crimes, and the locations of crimes that have occurred and of crimes that may occur in the future. Central to this methodology is the emphasis on the ability of the investigator or intelligence analyst to ask "good questions". These may be singular questions based on some new hypothesis generated by routine work, or alternatively, a sequence of questions that lead productively from one hypothesis
to another. The methodology described in this thesis facilitates the interrogative questioning process, whereas the software supports this process by pursuing the sequences of queries or questions designed to find relevant information of use to the investigator or analyst.

Both single and sequential questions can generate new knowledge about networks of crime events, suspected and prolific offenders, and collections of evidence. These questions can be formulated sequentially so that they uncover evidence hidden in complex layers of information, thereby allowing investigators and analysts to gain an understanding of potential associations and relationships that would otherwise have been obscured by the mass of evidence.

1.1 Weakness 1: Dissatisfaction with Traditional Police Training and Practice

In the author's experience, police training and investigative practice in the United Kingdom and elsewhere, has developed a particular framework of traditions towards evidence in terms of the conceptual understanding of what evidence is, and how it is managed and used.

Evidence is seen in light of exclusionary rules rather than as part of a system for gaining an appreciation of the process of fact-finding and proof. English (1996) provides a good example of this. The manual is an example of a lengthy and extensive book written by a former senior police manager and trainer that concentrates on various aspects of legislation, statutory rules and national guidelines; thus, it does little to provide a framework in which investigators can go about their work and does nothing to allow them to gain an understanding of the skills and competencies required to undertake investigative reasoning and evidence-handling tasks. The service has not escaped criticisms of unimaginative approaches. (Greenway, 1994, p.14).

8 Also seen by author in United States, Canada and the Netherlands.
1.2 Weakness 2: Evidence is Marshalled on the Basis of its Source, Not its Meaning

Evidence is viewed by reference to its source rather than in terms of the contribution it can make to understanding what happened, what our problems are or where data might exist to fill a gap in our knowledge. Schum (1994, p. 4 and 508) provides a useful description of the way in which evidence should be viewed. This substance-blind approach involves recognising recurrent forms, properties, mixtures and combinations of evidence rather than just the source of the evidence. Schum's illustration of the "categories of recurrent forms of evidence" can be found in Appendix 2. This illustrates how any item of evidence can be categorised relative to the particular inferential situation in which it is used. The important point is that it is not only the source of the evidence that should concern the user but also the knowledge and bearing the evidence can bring to some inferential problem being considered. Additionally, it demonstrates that one item of evidence can be employed in more than one inference problem and that the status of that evidence in one problem can be very different from its status in another. Schum claims that there are five essential categories of evidence applicable to a substance-blind view:

1. Various kinds of tangible evidence (positive or negative);
2. Unequivocal testimony based on direct or second-hand observation or on the expression of an inference or opinion (positive or negative);
3. Two classes of equivocal testimony from another person (complete equivocation and probabilistic equivocation);
4. Missing tangible or testimonial evidence;
5. Authoritative records.

Classifications 1 and 2 note that evidence can be positive or negative. "Positive" means that the evidence refers to the occurrence or existence of something, whereas "negative" means evidence that refers to the non-occurrence or non-existence of something. It should be emphasised here that "evidence" is not described in terms of DNA, Fingerprints,
Footwear, Ballistics, Handwriting or any of the other numerous sources of evidence we could list and describe. Instead, using a substance-blind approach to the classification and use of evidence raises two questions that need to be answered: First, how does the user of the evidence stand in relation to the item of evidence? This requires the user of the evidence to take into account the credibility of the evidence. Second, how is the item of evidence relevant to the issues under consideration? Here, this means considering the direct or indirect relevance of the evidence. This evidence can, in turn, be broken down into directly relevant and circumstantially relevant evidence. Indirectly relevant evidence can be ancillary evidence related to the issues under consideration.

Adopting a substance-blind view of evidence has a profound affect upon our ability to systemise the use of evidence to gain knowledge about the environment in which it is collected—in short, using the evidence for decision-making, intelligence and discovery purposes. In a publication directed at those interested in artificial intelligence and the law, Schum (2001a, p. 165) explained the importance of systemising the use of evidence:

"How well we marshal or organise our existing thoughts and evidence influences how well we are able to generate new ideas in the form of hypotheses, new evidential tests of all hypotheses being considered, and defensible arguments linking our evidence and hypotheses. Existing thoughts and evidence can be marshalled, combined, or juxtaposed in various ways to meet different requirements that arise as the process of discovery unfolds over time different combinations or juxtapositions of existing information that may, in different ways, suggest new ideas and new avenues of inquiry."

_Mullin (1995) demonstrated that decision making amongst investigators based on the exercise of judgement is lacking and that training is needed. See also Robertson (1991) and Robertson & Vignaux (1997)._
The systemisation of our collections of evidence allows us to use the information for practical purposes and undertake many useful operations, such as identifying important links between items of data or evidence, explaining patterns or chronologies, and exposing geographical dimensions inherent in the data that would otherwise remain hidden. In Chapters 2 and 3, examples are given. Exposing these attributes requires imagination, thought and good heuristics. These requirements are central to the present thesis.

1.3 Weakness 3: The Role of Inductive Elimination is Not Understood and is Under-used

There is a tendency to settle early on a particular hypothesis and then to set out to find evidence to substantiate it rather than seeking evidence that either proves or disproves the hypothesis—or for that matter, evidence that generates a new hypothesis. This is

10 As Scientific Support Manager (author) to the West Midlands Police, consultations were conducted about forensic evidence. Investigators often settled on a theory quickly and then set out to find evidence in support of it. This was a consequence of not having been trained to think about problems of proof in a methodical ways. A typical conversation:
Detective: “I am trying to prove that there was contact between the victim and the suspect by using DNA and I would like to have the following exhibits examined at the laboratory. Can you assist please?”
Scientific Support Manager: “Can we just consider a couple of issues first so that we can clarify the position.”
Detective: “I am sure he is responsible, and DNA is strong evidence. What’s more, I am sure we will find some, as it can be recovered from small samples.”
Scientific Support Manager: “Have you considered testing your theory by trying to disprove it as well as prove it?”
Detective: “I am trying to find the evidence.”
Scientific Support Manager: “Can we consider the evidence and the problem from a wider position first. Firstly, can you describe the circumstances of the allegation and provide a list of the evidence you already have. That is, direct, and indirect evidence, including any evidence that might be available to be recovered. Secondly, can you let us have a summary of the hypothesis you are considering and the reason you have adopted that position. We would like to think about the case in
illustrative of the classic discussions of "suspect-driven enquiries" and "anchored narratives" by Wagenaar (1993). Ede and Shepherd (1997, p. 63) gave sustained treatment to problems associated with closed systems of thinking in police investigation that lead to poorly formed case theories, bias and the lack of imaginative thinking by investigators. Imaginative, rational thinking is not only important in terms of balance in the consideration of alternative hypotheses; it also facilitates the creative, open thinking important in the process of investigation and discovery.11

1.4 Weakness 4: Managing Evidence on the Basis of Single Cases

Investigations are conventionally managed on the basis of single cases. Each case is seen in isolation and each item of evidence collected is thought about in terms of its specific contribution to that case rather than its potential12 contribution to this and other cases. This contribution could be in terms of aiding the development or understanding of intelligence issues about networks of offenders or the development of our understanding of crime patterns and trends. This, in turn, can aid those charged with the responsibility of predictions about the environment in which crimes are being committed, and the responsibility of determining who within the general population may have committed those crimes. In terms of single cases, this means (for example) that a burglary, a murder or a theft will be reported to the police, after which a report is compiled. The case is allocated a unique number and then assigned to an investigator. Because the investigator is rewarded and tasked on the basis of their efficiency in solving that case, their effort is concentrated upon that case. This approach provides no support for the detection of linkages based on evidence between crimes (e.g., by repeat offenders) or for the solution of other crimes

Detective: "Why do you need all that?"

11 Considering one explanation in isolation does not provide a rational basis for evaluating the weight of evidence. In addition, if that explanation cannot be justified, we are left with nowhere to go.

12 General or specific contribution, depending upon the circumstances.
using evidence from the current crime. The methodology described here dictates that often
the evidence needed to solve one crime is to be found in another. For example, let us
assume that two crimes of burglary occur in the same locality but at different times and on
different dates. At one crime a DNA stain is found and subsequently profiled. At the second
crime a fingerprint is found and searched against the Fingerprint Collection. The DNA
profile does not match with any person but the Fingerprint matches with a former known
criminal. The evidence obtained from the Fingerprint may provide an investigative
hypothesis about the identity of the donor of the DNA in the first crime of burglary. In just
two cases this may be thought insignificant but imagine 10,000 crimes systematically
searched and cross examined in this way. Many hypotheses can be raised for testing
against evidence that may produce useful results.

1.5 Weakness 5: The Credentials of Evidence are Often Assumed
Evidence is always context-specific. That is, it never arrives in our hands with its credentials
stamped upon it. Here, "credentials" refer to the relevance, credibility and weight or
probative force that can be attached to the evidence. These parameters must be settled by
the user of the evidence in the context under which the evidence was discovered, was
recovered, and is intended to be used. For example, evidence that may be utterly irrelevant
or redundant in one scenario may be important and relevant in another. Chapter 2 deals
with this area in terms of physical, forensic and contact trace evidence as well as
testimonial evidence from witnesses. Some types of evidence are assumed to possess
"good credentials" simply on the basis of their type. Examples here would be DNA and
Fingerprint evidence. Establishing the relevance and credibility of evidence is a necessary
task regardless of the evidence type. Furthermore, these credentials must be supplemented
in every situation by an assessment of the inferential force of the evidence or the weight
that the evidence has on the issue under consideration.

13 DNA recovered in a rape case from the victim "X" may indicate the donor as suspect "Y". If the
identity of "Y" is unknown, the DNA evidence may be crucial. However, if "Y" admits intercourse but
claims that consent was given, then the DNA evidence would be redundant. Other evidence would
be needed to answer questions surrounding consent.
1.6 Police Systems

Systems used to record, collect and disseminate evidence tend to be isolated rather than integrated. DNA evidence is stored in one system, Fingerprints\textsuperscript{14} in another, Ballistics in another, Footwear in yet another, and so forth. Intelligence systems that deal in "human information"\textsuperscript{15} are common in police organisations globally, yet none\textsuperscript{16} (until FLINTS was adopted by the West Midlands Police) routinely integrated that information with physical, forensic and contact trace material, despite clear benefits from doing so. Although these many database systems may operate within a single organisation, users do not have the ability to cross-reference the disparate data sets and integrate their potential knowledge-generation ability. This exemplifies the failure to recognise the substance-blind characteristics of evidence and the way in which one item or type of evidence can inform another or fill gaps in scenarios presented elsewhere.

What seems to be clear is that policing, with its array of different systems and traditions about the classification of evidence, has developed a great ability for the collection of information and evidence in many different forms. However, this ability to collect evidence far out-strips the ability to use it to inform decision-making.

1.7 The Traditional Management of Evidence

The author's experience indicates that the traditional approach to the management of evidence in policing has often involved narrow conceptions of the way that evidence needs to be managed, analysed and used. This includes how it should be collected and the many uses to which it can be put. A common experience has been that even though cases may appear "on paper" to be proven, simply adopting another standpoint or considering an alternative explanation can both generate an alternative conclusion and make that conclusion persuasive.

\textsuperscript{14} Fingerprint evidence is discussed in Chapter 2.

\textsuperscript{15} Usually information from police, informants, agents and electronic eavesdropping devices.

\textsuperscript{16} Exception is FLINTS.
A problem that requires particular attention is the manner in which investigators sometimes treat and interpret evidence in the light of a single hypothesis. This usually manifests itself in the form of suspect-driven enquiries. Alternatives are not always considered, or if they are, they are dismissed too readily. Narrow or single hypotheses often take the form of a "case theory". For example, that theory may propose that a particular act was perpetrated by a particular individual, or that an event took place in a particular way, thereby favouring a particular explanation. The consideration of a single hypothesis, proposition or case theory affects how potential evidence may be viewed by the investigator as the enquiry unfolds over time. The relevance of some evidence may be overlooked, the credibility of other evidence may be misjudged, and the overall conclusion drawn by the investigator or analyst may be rendered erroneous.

Wagenaar et al. (1993, p. 85) distinguished between "suspect-driven enquiries" and "offence-driven enquiries" in criminal investigation. They claimed that the distinction lay in the diagnostic value of the resulting evidence. For example, in an offence-driven investigation, the narrative is the product of an inferential process based on information. However, in a suspect-driven investigation, the narrative is the starting point and the information is the product. Furthermore, in an offence-driven investigation, investigators collect so much information that the investigation logically excludes all possible alternative suspects, whereas in suspect-driven investigations, investigators can limit their search to only that which would prove the case against the suspect. This is an important distinction and one recognised by the methodology presented in the present thesis. For example, the investigator or analyst using the methodology can investigate offences and cases from many perspectives. Once a question is asked, the resulting information or evidence that is discovered provides new questions to answer, and the narrative takes form as the investigation proceeds.

Just as narrow views persist about the nature and characteristics of evidence, narrow views also exist about the nature and characteristics of the relationship between crime types and criminal types. At a strategic level, human resources are often organised into teams and
even whole departments to tackle crime on the basis of a specific crime type. For example, it is common to see specific departments organised to tackle specific crimes such as fraud, murder, burglary and theft of vehicles. The nature or seriousness of the crime rather than the complexity in establishing its cause often dictates this allocation of resources. This can undermine effective management of evidence and intelligence because the organisation of resources does not reflect the way in which crime is committed or the types of persons who commit it. Records of convictions against offenders maintained by the Criminal Record Office often demonstrate wide differences in the methods of offence and in the crime types committed by the same person. Each crime may involve a number of criminal acts and the crime itself may be a preparatory act, albeit a criminal act in itself, for the commission of some other crime. An example here would be a criminal stealing a car to obtain a means of going to and escaping from an armed robbery. Similarly, a burglary at a farm may have been committed so as to obtain a shotgun that can be adapted into a close-quarters weapon (i.e., a sawn-off shotgun) for use in an armed robbery. Another example would be a fraud committed against an insurance company to obtain money to fund terrorists or to finance large-scale importation of illegal drugs through remote ports. All these activities demonstrate a propensity for adaptive behaviour on the part of criminals. The consequence of this behaviour for policing is that in order to solve a robbery, it may be necessary to solve a car theft; in order to identify terrorist funding, it may be necessary to investigate insurance fraud. Therefore, investigating crimes on the basis of limited views of the way crime is committed (narrow hypotheses) or on the basis of bureaucratic organisational approaches to crime (e.g., ignoring the propensity of criminals to commit multiple types of crime and failing to manage evidence imaginatively) limits the effectiveness of the investigator and intelligence analyst.

During a visit to a North American Metropolitan Police Department in San Francisco in 1996, a striking example of this type of deployment was seen by the author. One large department had been established to investigate thefts from vehicles, while another department in the same headquarters building investigated only thefts of vehicles. Neither department shared information and intelligence, and each planned their work in isolation. This implied an assumption on the part of senior staff that there was little or no association
between the incidence of thefts of and from vehicles. That is, senior staff assumed that those persons who committed thefts from a vehicle were not also committing thefts of vehicles. Furthermore, it was assumed that there was no association between these crimes and other types of crime, often more serious crimes.

As demonstrated by Leary & Pease (2003), successful strategies can be devised that treat both criminal behaviour and evidence in a substance-blind manner. In this example, DNA was taken from offenders regardless of the crime type and early in a criminal career to let analysts develop a better understanding of the relationship between different patterns of offence and the effectiveness of strategic management of evidence. It was established that aligning the processes of collecting DNA from suspects and scenes of crime, as well as submitting the samples swiftly for forensic examination, could result in increasing and maximising match rates ("hits")—regardless of assumptions about crime type or criminal type. This has lessons for the way in which evidence should be treated and managed.

Narrow views of evidence have implications for intelligence analysis and predictive enquiry. These views can prevent users of evidence from considering fruitful lines of investigation that could potentially prevent a threat from becoming a reality. In the worst form of this phenomenon, simple explanations or those that appear obvious are considered at the expense of explanations that are more difficult to uncover or not so obvious. The neo-Wigmorean methodology proposed in this thesis demonstrates that what may appear simple or obvious on the face of things may often hide complex realities, whereas that which appears complex and less obvious may in fact be simply explained by a single item of evidence somewhere nearby. Collections of evidence often contain many layers of information among which indirect links and associations may not be immediately obvious. Accessing and testing these areas of our collections of evidence presents many opportunities for the discovery of new knowledge. To overcome these problems and the natural human tendency to prefer simple explanations, investigators and intelligence analysts need to be trained to develop clarity of thought, open-minded approaches and the ability to perform critical analysis. Understanding these problems and aspects of human nature provided the author with valuable lessons about the way evidence is sought,
collected and used, and provided crucial insights into how to develop a better approach. What seemed to be missing was the development of a truly systematic, interrogative approach towards the management and use of evidence.

The traditional role of the Scene of Crime Investigator and scientist is a reactive one. Attendance at the scene of a crime is at the request of an investigating officer who wants to locate "contact trace material" that might indicate the identity of the offender. Traditionally, each case is treated in isolation and by reference to the search for particular types of evidence based primarily on the need to identify suspects. Favoured evidence types have in the past been Fingerprints and, more recently, DNA, in the form of blood or other bodily secretions rich in genetic material. These evidence types are considered to provide good evidence of identity. What we see here is the early formation of a hypothesis that any Fingerprint or DNA evidence recovered at the scene must be that of the offender. (See for example, Allen 1953). Too often, little other evidence is noted and recorded that could provide corroboration or an alternative explanation. Not only is this approach a narrow conception of the role of evidence—it prevents evidence being seen and used in intelligent ways. Evidence can answer a range of questions if managed carefully and intelligently.

Other evidence that may be present is sometimes disregarded if it falls outside the perceived "identification category" of Fingerprints and DNA. This is especially so in prevalent crimes such as burglary, car theft, assault and wounding. Furthermore, where there are multiple evidence traces, such as several Fingerprints or a number of DNA stains or a range of potential witnesses, the most "favoured" evidence will often be selected. The danger in this approach is that the selection of evidence can involve the collection of evidence supporting a particular hypothesis whilst rejecting other evidence that may negate the same hypothesis. The decision about selection of evidence is therefore crucial to effective investigation. Once an investigator has left the scene of a crime, it is difficult to determine whether evidence was disregarded other than by reference to the testimony of the investigator, scene examiner or scientist. It is not common to hear an investigator, scene examiner or scientist state they have disregarded one source of evidence in favour of...
another. Evidence disregarded in this way is often justified by a rigid adherence to some "anchored narrative" about a particular hypothesis accompanied by a claim that the material disregarded was not relevant.

Furthermore, the traditional approach to the management of evidence can be seen in the way crime scenes (the places at which crimes are committed) are selected for forensic examination. This usually happens on the basis of the seriousness or nature of the crime rather than based on the potential that exists for the recovery of evidence. For example, burglary crimes where large amounts of property have been stolen will invariably attract a forensic examination, whereas a failed attempt to commit a burglary even in the same geographical area may not. This occurs despite the fact that the latter scene may reveal a wealth of contact trace evidence such as Fingerprints, Blood and Footwear Marks. This may be near a window that was the attempted point of entry. An early examination of the attempted burglary may reveal evidence that both connects it with the serious burglary and reveals the identity of the offender in both cases. The United States Department of Justice (Reported by Iredale and Robertson's, 8th February 2004), has demonstrated highly significant differences in detection and conviction rates for burglary across eight different countries, including the United Kingdom and the United States. It has been the author's experience that one of the explanations for differences of this kind is, in part, from the way in which each nation's police forces collect and interpret evidence.

Barclay, Leary and Rankin (1996) demonstrated that strategic and imaginative approaches to scene management can provide enormous benefits in evidence yield rather than simply the collection of evidence of identification. For example, evidence that can answer specific questions of importance to the investigation such as how the crime was committed, where it was committed and at what time.

Crime occurs within a dynamic and constantly evolving environment. The crime scene presents many opportunities to recover evidence. This may be physical contact trace evidence as well as testimonial evidence from witnesses and victims. Taking a substance-blind approach can enhance the effectiveness of the process of investigation as well as the
recovery of evidence. This is because the approach enables investigators to consider evidence not only based on the nature of the evidence but also based on the nature of the knowledge it can impart to the investigator about issues of interest and importance to the investigation.

Evidence is located by a process of questioning. Even though the process is not taught during police training courses and generally not studied independently by students, formulating good questions is central to effective investigation and intelligence analysis.

Principal questions set the overall objective or goal to be answered by an investigation. The principal question in a homicide investigation would be Who Killed the Victim? Interrogative questions provide the smaller inferential steps in the reasoning process towards or away from the ultimate proposition and conclusion. Answers to interrogative questions provide new evidence that can be used in the development of new logical inferences towards or away from the principal question.

In this way, the answer to the principal question is established not by means of a single answer but rather by means of a series of answers generated by smaller inferential steps, and that answer is reached by asking a series of interrogative questions. A single interrogative question will usually form only a single inferential step in the overall reasoning process.

A claim of this thesis is that this process of questioning need not be limited to the investigation of the cause of a single criminal event, which usually involves a closed sequence of questions. The process can instead be applied in such a way that questions are asked as part of a continuous process of complex reasoning that involves a complex sequence of questions. Once the investigator has arrived at the answer to a particular principal question in this process, this conclusion can be treated as the initial premise for a new inquiry. This open-ended sequence of questions is central to the methodology
developed in this thesis and can be thought about in terms of "genetic algorithms"\(^\text{17}\) in the form of heuristic questions. The question arises as to why this is important, and the explanation is twofold. First, the purpose of investigation is the eradication of doubt. Doubt is often present due to a lack of evidence or the inability to generate more than an incomplete or unsatisfactory explanation. Second, if the evidence or explanation is incomplete or unsatisfactory, it is necessary to go beyond the evidence and explanations possessed by the investigator or intelligence analyst. The process advocated in this thesis aids investigation because it lets the investigator and analyst deduce conclusions that go beyond those that might be produced based only on the original evidence and explanation. This lets the investigator or analyst design strategies and experiments that would promote the search for missing evidence and explanations. The search can be short and contained, or elaborate and extending into complex networks and linked series of facts and events. The ability to think logically and imaginatively are both equally important in this process.

Consider the following very simple example: "Tyler" is identified by means of relevant, reliable evidence as a principal suspect for a burglary committed on 14 November 2002. It is known that three people committed the crime, but the identities of the remaining two suspects are not known. Investigation reveals that Tyler is known to associate with the "Tyler Gang", some of whom also have convictions for burglary using a similar, unusual method. The burglary was committed using a particular type of methodology considered rare.

Two conclusions can be drawn. First, the answer to a series of questions leads us to a conclusion that persuasively answers the principal question: was Tyler involved in the crime? Indeed, Tyler is identified on the basis of relevant, reliable evidence as a principal suspect, and it is considered likely that he was the offender. Second, a series of questions about the nature of the burglary reveal a rare *modus operandi*. The traditional approach to police investigation would stop at this point, and "Tyler" would be arrested on suspicion of

\(^{17}\) Genetic Algorithms are a sequence of questions, repeated iteratively until an optimal solution is reached. Heuristics contributes to this by provision of guidelines in which to frame questions.
the crime. However, the questioning process need not stop there because the conclusion reached by answering the principal question (is Tyler guilty of the crime?) can be used to generate new principal questions: Is there evidence that other crimes of burglary have been committed bearing the same *modus operandi*? If there have been similar crimes, is there evidence that Tyler could have committed them? Is there evidence that would support or negate a hypothesis that any members of the "Tyler Gang" committed or participated in the crime of burglary for which Tyler will be convicted? Is there evidence that any members of the "Tyler Gang" could have been involved with Tyler in committing the crimes bearing a similar *modus operandi*? The process of generating new questions could continue indefinitely by asking about other crimes and other people to generate a far more complex inquiry that would lead to additional arrests.

The matrix of questions and propositions in Figure 1.2 was developed during this thesis to help investigators and intelligence analysts formulate good questions. It is now being introduced in the training of investigators and intelligence analysts by National Police Training.

**Figure 1.2: A Matrix of Questions and Propositions Designed to Guide the Formulation of Good Questions**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A). Who?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B). What?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>c). Where?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D). When?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>E). How?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F). Why?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The principal question / ultimate proposition (an explanation for who committed the crime and how) is supported by the three classical sub-propositions of motive, opportunity and
means. These provide a structured approach for designing and using principal questions and ultimate propositions. These questions help to discriminate between persons who may have committed the crime that is the subject of the investigation. The six questions (who, what, where, when, how and why) help investigators generate interrogative questions that can be used in making smaller inferential steps during the process of reasoning towards or away from the principal questions and ultimate proposition. For example:

1. "Who had motive, who had exclusive opportunity and who had means to commit the crime?"
2. "What sort of motive was it, what sort of exclusive opportunity was there and what means did the offender have to commit the crime?"
3. "Where was the motive formulated, where did exclusive opportunity arise and where was the means obtained to commit the crime?"
4. "When did the motive arise, when did exclusive opportunity arise and when did the means arise to commit the crime?"
5. "How was the motive formulated, how did the exclusive opportunity arise and how did the means arise to commit the crime?"
6. "Why was the motive relevant, why did the exclusive opportunity present itself and why was the means to commit the crime adopted?"

A useful strategy would be to attempt to link crimes together in networks of links and await the recovery of vital pieces of evidence to identify offenders for one or more of those crimes. The same approach can be used with suspects by collecting evidence of ways in which certain criminals associate together. The investigator and intelligence analyst can set about identifying networks of events and people, including repetitive serial courses of actions and events. Circumstantial or forensic evidence may link crimes together in series if the evidence is collected in such a way as to reveal those links. A problem here is that physical and contact trace evidence such as DNA, Fingerprints, Footmarks, and Toolmarks are managed by means of different processes and in different management systems and case files. Similarly, testimonial evidence is collected in documentary formats and stored in case files. Linking cases and groups of suspects is made difficult because evidence is limited to being used in the case for which it was collected rather than treated as evidence
collected from the broader environment in which crimes are continually and dynamically being committed.

For these reasons, the process is constrained towards the investigation of single cases, and evidence in any one case is treated only as evidence in that case. What is needed is a methodology for dealing with all evidence so that any one item of evidence may inform another and evidence in one case may become evidence (formerly missing) in another case. This desirable outcome should be possible regardless of the crime type and evidence type.

Rather than viewing crime as a series of isolated events, investigators using this approach can see crime as potentially part of a series or network of events, and sometimes committed by groups or networks of persons. For example, a series of cars may be stolen from car parks to let criminals commit armed robbery offences, and the funds generated by these robbers can subsequently be applied to financing a drug operation. Another example may be a series of burglary offences committed with the sole intention of stealing credit cards that will subsequently be used to defraud retailers. In each case, if the series of events could be linked, any credible evidence recovered from any one event might potentially provide the vital evidence needed to identify the offender(s) in the whole series. A cheque book containing 20 cheques that was stolen in a single burglary may result in 20 subsequent fraudulent transactions using those cheques. Effort needs to be expended and procedures need to be designed to let investigators routinely recover such evidence. If the investigating officer of the burglary offence can track each cheque and transaction, they may obtain as many as 20 opportunities (in the form of the 20 cheques) to recover evidence. This evidence may be a mixed mass of evidence, including testimony from witnesses and victims, Handwriting, Fingerprints, DNA, or other physical evidence on the cheques. If the person fraudulently issuing the cheques is identified and was clearly not the burglar, then by implication, they must have obtained the cheque book in some unlawful transaction with the thief. If they receive or handle stolen goods, then they may be part of a criminal network involved in the burglary crimes. This network of relationships may lead
the investigator to evidence that would implicate the burglar and possibly other members of the criminal network.

Viewing crime in this way provides investigators with the opportunity and attitude necessary to think strategically about increasing the likelihood of detecting and preventing crime. Furthermore, because the approach demands that the investigator keep their mind open to a range of possibilities and likelihoods, the investigator is always open to alternative explanations.

Many offenders move from one crime type to another, often escalating in seriousness from minor offences to more serious offences, throughout their career as an offender. Furthermore, offences are often committed by groups of people who engage in semi-organised and organised networks. Evidence collected at any one of these scenes of crime may provide the missing link in detecting another.

For example, suppose that five crimes of burglary have been committed within a small geographical area at about the same time and day of the week, and that the method used in each bore striking similarities—so much so that if the crimes were all carefully documented and photographed we might be able to draw a strong inference that (circumstantially) all five are connected. If each of these crimes were to be treated in isolation, that same inference of association could not be drawn. Furthermore, if none of these crimes had been selected for forensic examination, the likelihood of the recovery of physical contact trace evidence would be low. The likelihood of detection would be correspondingly low.

However, a more proactive and imaginative approach would be to gather basic and detailed evidence of the *modus operandi* for every crime that is committed, regardless of how serious it is. Even if limited resource levels do not allow for every crime to be examined by a forensic expert, intelligent decisions can at least be made about the best scenes to attend so as to gather forensic evidence. For example, if a crime is believed to be one of a series of crimes committed by the same person, that scene should attract special attention from a
forensic examiner. Furthermore, where a person is arrested shortly after a crime has been committed, then the arrest scene should be examined in an attempt to locate evidence that would implicate or eliminate the suspect. This should include any evidence (not just Fingerprints and DNA) because a wide range of evidence may provide what is needed to implicate or eliminate the suspect. An unusual fibre, a Footwear imprint, and paint or dust on clothing can all provide answers that would eradicate at least some of our doubt and perhaps even solve the questions at hand.

If a crime is suspected to have been committed by two persons and evidence is located that identifies just one suspect, the network of people that suspect is believed to associate or offend with may be a productive source of evidence indicative of the identity of the as-yet unidentified offender. Furthermore, if there are other crimes in which two or more persons have been involved and one or both have been identified, the crime scenes may also be useful sources of evidence in the production of hypotheses about who the unidentified offender may be.

These hypothetical cases illustrate how evidence can be used in an interrogative way to answer ranges of questions. These questions need not be restricted to questions about the principal question sometimes called an ultimate proposition. They can be designed to reduce the uncertainty we experience in attempting to understand the knowledge that our mixed mass of evidence contains. Knowledge is often hidden within the mixed mass of links and connections within the evidence we already possess as well as within the evidence we do not yet possess but may come to suspect exists during the course of the investigation and the process of asking questions about what we already know and do not know. Extracting that knowledge can be initiated by questions designed to help the investigator and analyst make the smaller inferential steps in the process of reasoning towards or away from the principal questions and ultimate proposition. For example, these questions may concern the nature and characteristics of events, people, locations, times, and combinations of these parameters, as described in the matrix of questions and propositions presented earlier (Figure 1.2). The answers to these questions can produce a better yield of "knowledge" or "intelligence" about issues of interest to investigators and analysts than
would be the case when treating crimes as single, isolated events committed by single, isolated offenders.

In Chapter 5, examples will be given that illustrate how extensive and productive this approach can be. These examples are provided in the context of new work currently underway by the author, designed to enhance the human ability to produce "knowledge" and "intelligence" from collections of evidence.

It will be seen that the task of investigation can become one of maximising the recovery and production of evidence from criminal events as a whole rather than one of focusing on those crimes that are believed to be more serious than others. (The latter approach is symptomatic of the "single case" approach.) The objective of taking the broader view is to maximise the yield of "knowledge" or "intelligence" from the overall evidence yield with a view to solving series of crimes and identifying repeat offenders. (A single person as well as a group of persons can quickly commit large numbers of crimes.) Evidence can be tested in many ways to assess its reliability; the only major barrier is our inability to construct imaginative strategies to generate these tests. Asking good questions of the evidence provides valuable insights into the levels of confidence we can invest in it. Tangible and physical evidence can be examined to assess "what" it actually is and "how" it relates to other evidence we possess now or may possess in the future. This examination is only limited by our imaginative approach to problem solving, our intellectual ability to sense evidence that is relevant to some issue of interest to us, and by our technological ability to collect that evidence. We can undertake experiments to assess the impact of doing particular things to an item of evidence and can investigate the history of the item and its purported chain of custody. We can check records about the evidence itself and can attempt to reconstruct events in the past. In the case of witness testimony, we can assess the relative veracity, objectivity and observational sensitivity of the witness by systematically asking questions, assessing the answers, then asking supplementary questions. This serves to demonstrate that underlying the process of testing evidence is the ability to ask good questions. In Chapter 2, reference is made to the importance of this activity when using evidence in investigative reasoning.
Forensic science has played an increasingly important role in crime investigation over at least the past 120 years, and to some limited extent before that. What has not developed over the same time period are methods for assisting users of evidence to draw useful, defensible conclusions from evidence. The police service is now turning more and more to forensic science to help in the investigation process. It is the way in which forensic science is deployed, however, that will determine the impact it makes. Forensic science tends to be looked upon as a discipline that somehow does not need to be managed; a common perception on the part of investigators (in the author’s experience) is that all too often assumptions are made about the reliability of forensic evidence. Little thought is given to the way forensic science should be used and the manner in which many of the techniques it has produced should be deployed. Forensic evidence is like any other form of evidence: it must be handled with care and tested to assess its reliability, relevance and weight. (Blakey 2000). Tilley and Ford (1996) drew attention to the weak knowledge base of officers concerning how forensic science and evidence is used. The need for more training and awareness as well as for better management strategies were central to their findings: "Present systems are poorly placed to yield the most fruitful outcomes." More recently, (Times 14 April 2004), serious criticisms were made public about forensic experts in their management of forensic evidence.

The development and use of forensic science discussed in the present thesis is important, but the author does not want to give the impression that the methodology developed as part of this thesis is solely concerned with forensic evidence. The methodology is designed to be equally applicable to the management and use of a mixed mass of evidence.

18 The report was critical and concluded that scientific evidence needs to be managed as well as collected. Key personnel should be trained, and their skills acknowledged. Blakey states in Conclusion, 9.2, that “Barclay, Leary & Rankin (1996) is a seminal document for providing guidance and that most of its recommendations remain valid today”; Conclusion, 9.4, that “Scientific and technical support can provide essential evidence and intelligence to facilitate effective investigations.”
regardless of its source and regardless of the nature of the event being investigated. However, this approach has valuable lessons for forensic scientists too because they also have to deal with evidence, raise hypotheses, and develop questions and answers as part of their work. A distinct feature of forensic investigations, however, is the same "single case" approach. Forensic scientists have until now been almost exclusively involved in dealing with single events and limited collections of evidence connected with only the crime under investigation.

For example (and in general), chemists tend to deal with property crimes such as burglary and arson, whereas biologists deal with violent crimes and sexual assaults and toxicologists deal with drugs and suspicious deaths. When cases are sent to a forensic laboratory, they are allocated to a specific scientist to deal with based upon the nature and type of problem considered relevant to solving the crime. Links and connections between cases and the evidence under examination is not, as a matter of course, considered. Some limited progress towards a more holistic approach has been made in investigating serious crimes such as homicide, but there is still much that could be done to develop approaches that would aid the production of evidence and knowledge by means of a more systematic analysis of evidence in forensic laboratories. The police service invests substantial sums of money in the collection of evidence and forensic analysis. However, little has been done to improve the methods and techniques that would aid investigators in using these vast collections of evidence. Most importantly, there is a need to develop techniques that would enable investigators and analysts to draw defensible conclusions from the evidence. Using combinations of these scientists to handle mainstream crimes as well as to investigate links between cases that are not immediately obvious would do much to overcome the traditional concentration of effort on solving single, isolated cases rather than cases in general.

19 In 2001, West Midlands Police spent £4 million commissioning forensic tests from laboratories. Does not include employment costs for more than 100 Scenes of Crime Examiners and support services staff.
1.8 The Response to the Author's Dissatisfaction with Existing Approaches

The genesis for the development of the neo-Wigmorean methodology described in this thesis lay in the five weaknesses outlined earlier. Inspiration for the new methodology was based on a new and emerging understanding of the science of biochemistry, of the work of the jurist John Henry Wigmore, and of the science of complexity. A discussion of these themes will now follow.

In the late 1980s, the author became a Practitioner Detective in the West Midlands Police. The limitations of training as well as the unsuitability of some of the resources provided to investigators as preparation for the roles the author had to perform were obvious. Training was provided by only two courses: a Junior Detective Training Course and an Advanced Detective Training Course both of which the author attended. Whilst the author became well versed in aspects of "black letter" criminal law and the rules of evidence, there was no practical or theoretical guidance in the logic of enquiry or evidential reasoning, and very little guidance in forensic science. The lack of suitable courses was matched only by an intransigent attitude in the service towards professional development and advancement of learning. Alternative means of professional development were sought by the author. Interesting, useful and recently published materials were found by the author relevant to developing reasoning skills in detective work. None of these appeared anywhere in police training references: For example, Jackson (1983), (Jackson 1988), (Jackson 1988a),

---

20 Extracts from key texts like Twining & Miers (1999), Twining & Hampsher-Monk (2003) would do much to aid a broader perspective. There are many others.


22 Reading for a Degree in Law and studying nature and use of evidence. The growing debate in the 1980's about DNA evidence crystallised the author's interest in evidence, leading to the completion of an Honours Dissertation in DNA. This resulted in a secondment to the Home Office to undertake a study for the police service concerning more effective use of forensic evidence. In 1995, a Research Scholarship Award from the Forensic Science Society resulted in the author's continued research and development of tools related to the management, analysis and use of forensic evidence.

The aims of this study were to enhance understanding of and extend knowledge about the potential for new scientific techniques to resolve criminal litigation disputes, and to develop a rationale for the use and evaluation of evidence by practitioners using advances brought about by the use of information technology. The aim was to take more traditional approaches to evidence (for example Cross & Tapper 1999) and combine these with applied approaches. Early ideas were presented to the Forensic Science Society (Leary 1995a). For example, on 16 July 1995, the author presented a lecture to the Forensic Science Society at the College of Ripon and York St John, Ripon, entitled "Management & Use of Forensic DNA Evidence – A Legal View.” The author explained his ideas about better ways in which DNA could be used to enhance the investigation process and how lessons from DNA could be transferred to other types of evidence. These ideas involved two new approaches: First, effective and imaginative use of DNA evidence supported by information technology capable of managing large amounts of DNA evidence in ways that exceeded the then-current applications. Second, better recovery and management techniques. The former concerned the use of large databases of evidence and knowledge extraction techniques and the latter concerned the use of nano-technology capable of collecting small amounts of liquefied human secretions such as blood, semen and saliva that could be analysed on-site, converted to a digital code and then sent to the database. Although these were futuristic and beyond the then current applications, they were intended to demonstrate how evidence could be used more effectively and imaginatively.

The West Midlands Police expressed interest in the author’s work, and interest also grew outside the service. In 1995, the author presented a paper (Leary 1995b) at the First

---

23 July 1995, correspondence from K. Evans (Head of Criminal Investigation, West Midlands Police) to the author: "[Leary's research] will be of great benefit to the force and the investigation processes nationally.”
World Conference on New Trends in Criminal Investigation and Evidence in the Hague that reflected his ideas for better management and use of evidence. The paper concerned the potential impact of science and information technology on criminal investigation. A central theme was the need to combine evidence types in a way that concentrated investigators attention not on the source of evidence but the reduction in uncertainty that evidence provide in resolving questions of fact.

The author published two papers (Leary 1996a and 1996b) that laid the foundations for developing ideas for an evidence management system that would initially use DNA but that would subsequently be extended to the management of other forms of forensic evidence. "The challenge for forensic science now in the author's view is to develop systems capable of retrieving as much of the variable [DNA] sequence as technology will allow in simple, reliable cost effective ways—which can be speedily retrieved from a computer." (Leary 1996b).

The latter paper introduced the concept of using forensic DNA evidence to link series of different crimes across geographical boundaries using computer-aided analysis. The routine detection of volumes of crime across wide geographical areas was realised. In March 1997, these papers were followed by the publication of the author's Methodology & User Requirement for an Evidence Marshalling System (Appendix 1). This approach was

---

24 On 13 November 1995, an invitation was received from the Deputy Coroner, Sheffield, Dr. A.R.W. Forrest, to present a paper to the South Yorkshire Medico Legal Society entitled "DNA & The Investigation of Crime – Some Questions Answered."

25 November 1995, correspondence from C. McDonald (Chief Supereintendent, Head of Policing Operations, West Midlands Police) to the author, he acknowledged: "important research already done by Leary".

26 DNA evidence was subjected to severe treatment in legal debates. See Robertson & Vignaux (1997).
designed to be capable of using not only DNA but also of combining other evidence types in one systematic approach that could be embodied in computer software.27

Between July and December 1997, the author worked in conjunction with the Forensic Science Service developing procedures and strategies for the use of forensic evidence. There were three areas to this work: the use of new, highly sensitive techniques that could recover small amounts of DNA from inanimate objects merely touched by human hands; the development of a technique capable of predicting the ancestral origins of a suspect;28 and enhancing the interpretation of different forensic evidence types.29

From July 1997, the author began work to raise the possibility of using supersensitive DNA techniques, otherwise known as "low copy number DNA" and these are discussed in more detail later in this Chapter, with Dr. Peter Gill of the Forensic Science Service, to recover extremely small amounts of DNA from gear levers and steering wheels in stolen cars.30

27 Correspondence: G. Pugh (Assistant to Director General, Forensic Science Service), Forensic Science Service, to R. Packham (Assistant Chief Constable, Crime, West Midlands Police) on 2 April 1997: Acknowledgement of the author's analysis of the investigative process and the system the author wished to put in place to maximise use of all available information.

28 Correspondence: Dr. A. Urquhart (Research Forensic Geneticist, Forensic Science Service) to author on 12 December 1997: Discussion of possibility of using DNA to predict ancestral origins of persons from samples left at crime scenes. Agreement to undertake research to test the idea.

29 Correspondence: Dr. K. Sullivan, Forensic Science Service, to Sir E. Crew on 22.1.98: Acknowledgement of the work and ideas of the author between January 1997 and January 1998 in developing systemised approaches to the management of forensic evidence. In particular linking crime scenes via combination of different evidence types, development of use of supersensitive DNA techniques for evidence recovered from inanimate objects and prediction of ancestral origins from DNA.

30 This material could then be used to identify suspects who might have stolen the vehicle. Although this method had never been performed previously, it was aimed at the recovery of DNA in the investigation of linked crimes rather than single cases. The goal was to develop use of low levels of DNA evidence from inanimate objects.
This approach would later be transferred to burglary offences in which persons who had merely touched door handles or knockers could be identified.\textsuperscript{31} In August 1997, the results of the project demonstrated that evidence could be retrieved from gear levers and steering wheels, and a decision was made to bring the research forward for consideration by the Chief Scientist of the Forensic Science Service as a new forensic service.\textsuperscript{32}

The estimation of ancestral origins from DNA presented interesting opportunities for the generation of hypotheses of identity as well as the elimination from suspicion of some suspects. Persons arrested on suspicion of crime often have a sample of their DNA taken. The officer taking the DNA also estimates by means of visual observation which racial group the suspect belongs to.\textsuperscript{33} The DNA sample is then analysed and entered into the National DNA Database with a racial code marker indicated as part of that sample's database entry. Genetic markers within the sample are correlated with the particular racial code. In this manner, the frequencies of various markers associated with various racial codes can be determined and used to help estimate which particular racial group a non-matching sample belongs to. This analysis lets investigators estimate the ancestral origin of an unidentified sample donor. Emphasis here should be placed on the term "estimated", since the technique is based on the investigator's subjective assessment of which racial group a donor belongs and since the reliability of the process (which operates on profiling partial sections of the DNA molecule) has not yet been firmly established. Nevertheless, estimations can be made and these can be used as sources of hypotheses to be tested against other evidence. This can be especially important when there are limited lines of enquiry and hypotheses to follow.

\textsuperscript{31} Correspondence: Dr. P. Gill, Forensic Science Service, to author on 15 July 1997: Acknowledgement of original ideas around series linked crime.
\textsuperscript{32} Minutes of Meeting 26 August 1997 concerning the "Super-Sensitive Low Copy Number DNA Project" by R. Frazier, Forensic Science Service.
\textsuperscript{33} Subjective observation.
The research surrounding the prediction of ancestral origins and sex of suspects has received mixed reviews. On the one hand, the work was embraced because it offered new ways of obtaining knowledge useful to making more progress in investigations. On the other hand, some investigators were suspicious of the use of advanced scientific techniques to answer such questions. However, in one notable example, the technique was used to try to identify the ancestral origins of the donor of a semen sample recovered from a murder victim when all other lines of enquiry were revealing little evidence.\(^{34}\)

The frequency of certain characteristics of the DNA profiles taken from offenders whose data are included in the National DNA Database varies between ancestral groups. This allows predictions to be made about the ancestral traits of samples based on a measure of the probability of a profile being found within each of the five main British populations.\(^{35}\) The results can be interpreted as being indicative of the *relative likelihoods* that the offender comes from each population and represents new evidence that can be included with all other evidence in the case. This allows the analyst to make a prediction about the

\(^{34}\) On 31 December 1996, Nicola Dixon, 16 years of age, left her home in Sutton Coldfield, West Midlands. She was later found outside the Vicarage in the centre of the town, deceased. Her lower clothing was missing and she had sustained injuries consistent with a sexual assault. A high vaginal swab resulted in the recovery of semen / DNA. No Match was gained from the National DNA Database. Certain sections of the population were screened for potential DNA Match but no match was found. During the authors research concerning ancestral origins of donor samples of DNA, the sample recovered from the victim was tested. The resulting evidence revealed a high likelihood that the donor had ancestral origins from within the Afro-Caribbean population. This was greeted with scepticism by the investigation team—not because they expressed doubt about the validity of the technique, but rather because the screening policy had not included males from the Afro-Caribbean population. In 2002, a male of Afro-Caribbean descent, who was known to have visited Sutton Coldfield, was arrested. A DNA profile from him matched the sample taken from Nicola Dixon. In November 2003, he was convicted of murder.

\(^{35}\) IC1 = White Skinned European. IC3 = Afro-Caribbean. IC4 = Asian (Indo-Pakistani). IC5 = Oriental. IC6 = Arab. Race Code IC2 (Dark Skinned European) and was not used because it appears to be too genetically diverse.
relative likelihood of the suspect’s membership in a particular ancestral group. The test was intended purely as an "intelligence screen" that would aid investigators, and no suspect was to be either implicated or excluded on the basis of it. The goal was to help investigators to sort suspects into groups based on the relative strengths of the prediction. If there is reasonably good evidence to include a profile in or exclude a profile from any ancestral group, a statement could then be made by the analyst that included their opinion of the strength of this evidence. 36

Evidence of this type should be seen in the light of the way in which scientific understanding of the DNA molecule can be used to estimate which racial groups the ancestors of the donor emanate from. This can be crucial in deciding where in a given population searches should be concentrated in efforts to identify likely donors of a sample recovered from the victim of a crime. Work on refining this technique is ongoing. The next section will deal with the use of DNA profiling for routine crime investigation and it is stressed that this is not based upon racial or ancestral profiling. The next section deals with the general use of DNA markers (outside and distinct from any notion of racial or ancestral profiling) to gain evidence about a persons potential presence at a given location and hence the opportunity they may have had to commit the crime.

In December 1997, the author conducted an experiment to ascertain what could be learned from the amalgamation of evidence from different locations. He obtained data from all DNA

36 The main sources of concern over the test surround the fact that the ancestral origin of suspects is subjectively determined by the police when a suspect is sampled for their DNA. It is not known how accurate officers are in estimating which ancestral group a suspect belongs to, and thus, this brings into question the reliability of the results. Moreover, although "racial profiling" lies outside the confines of this thesis, it must be acknowledged that these types of issues are susceptible to misuse, abuse and prejudice inconsistent with scientific pursuits. The most appropriate way to use such systems is as part of an eliminative methodology rather than an implicative methodology. Even so the use of DNA and heredity to estimate the ancestral origin of a suspect from DNA left at the scene of a crime is bound to remain controversial.
matches for the West Midlands Police area for November 1997. This was entered into a spreadsheet the aim being to test the theory proposed by the author (Leary, 1995a and 1995b) and the neo-Wigmorean methodology proposed in this thesis.

The sample contained 324 DNA matches for the West Midlands Police area. One list represented "person to scene" matches; the other represented "scene to scene" matches. The aggregated data sample ran to several pages of spreadsheet data that, on the face of things, appeared bland and uninteresting. However, when disaggregated using the proposed neo-Wigmorean methodology, interesting patterns and sets of data appeared. For example, lists of "person to scene" details were generated that related to the offender’s identity, the location of the crime, where the offender resided, where the offender was arrested, where a DNA sample had been taken from the offender, the number of crime scenes at which matching DNA samples had been found, and whether the offender had been the subject of previously reported matches. Similar categories of information could be ascertained for "scene to scene" matches.

The spreadsheet was analysed by hand using the approach advocated in the methodology described in Appendix 1. This effort took the author 2.5 days of concentrated effort without the aid of a computer but resulted in five case studies that clearly demonstrated the benefits of an interrogative approach. The methodology involved detailed search of the spreadsheet for obvious and non-obvious links in the data:

In the next few pages, four case studies will be presented to illustrate the kind of evidence that can be collected and the patterns this evidence suggests. Case Study 1 and Case Study 4 have been selected as examples that will be illustrated to demonstrate how the methodology enables multiple cases to be linked.

Correspondence: K. Barnet to the author on 15 December 1997, supplying data for analysis.

That forensic evidence could be used to detect links between crimes and people, between crimes distributed across wide geographical areas and in connection with different crime types, and in sufficient numbers that this data would be useful in the investigation of series of linked crimes.
Case Study 1

<table>
<thead>
<tr>
<th>CRIME</th>
<th>LOCATION</th>
<th>SUSPECT</th>
<th>RESIDENT</th>
<th>DNA TAKEN FROM SUSPECT IN</th>
<th>VALUE</th>
<th>LINKED MATCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 matches: all</td>
<td>West Midlands, different</td>
<td>Previous convictions for</td>
<td>Oxford</td>
<td>Thames Valley, summer</td>
<td>£121,595.00</td>
<td>9 other crimes matched on the basis of similar facts in the West Midlands</td>
</tr>
<tr>
<td>commercial</td>
<td>boroughs</td>
<td>burglary, theft, violence</td>
<td></td>
<td>1997</td>
<td>(4 offences)</td>
<td></td>
</tr>
<tr>
<td>burglary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The suspect in Case Study 1 will be referred to by the alias "Reece" and the suspect in Case Study 4 will be referred to as "Watkins" for the purposes of the thesis. The chart in Figure 1.3 demonstrates the links between Reece, four initial crimes of burglary based on DNA evidence, and a further nine offences identified based on similar facts.

Figure 1.3: Network of Crimes Linked to Suspect Reece.
### Case Study 2

<table>
<thead>
<tr>
<th>CRIME</th>
<th>LOCATION</th>
<th>SUSPECT</th>
<th>RESIDENT</th>
<th>DNA TAKEN FROM SUSPECT IN</th>
<th>VALUE</th>
<th>LINKED MATCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 match, armed robbery</td>
<td>West Midlands</td>
<td>Previous convictions for drugs, theft, handling of stolen goods etc.</td>
<td>Birmingham</td>
<td>Birmingham</td>
<td>£15,000.00</td>
<td>None known at time of analysis</td>
</tr>
</tbody>
</table>

### Case Study 3

<table>
<thead>
<tr>
<th>CRIME</th>
<th>LOCATION</th>
<th>SUSPECT</th>
<th>RESIDENT</th>
<th>DNA TAKEN FROM SUSPECT IN</th>
<th>VALUE</th>
<th>LINKED MATCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>One match, armed robbery</td>
<td>Oldbury</td>
<td>Previous convictions for armed robbery, many known associates</td>
<td>Birmingham</td>
<td>Birmingham</td>
<td>£0</td>
<td>None known</td>
</tr>
</tbody>
</table>

### Case Study 4

<table>
<thead>
<tr>
<th>CRIME</th>
<th>LOCATION</th>
<th>SUSPECT</th>
<th>RESIDENT</th>
<th>DNA TAKEN FROM SUSPECT IN</th>
<th>VALUE</th>
<th>LINKED MATCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 matches, all commercial burglary</td>
<td>Cross-border, West Midlands and region</td>
<td>Previous convictions for burglary, theft and conspiracy</td>
<td>Not resident; travels widely</td>
<td>Birmingham</td>
<td>£50,000 re 4 offences; 10 others estimated at £100,000</td>
<td>12 others matched on the basis of similar facts; total = 26</td>
</tr>
</tbody>
</table>
Figure 1.4 demonstrates the links between Watkins, 14 initial crimes of burglary based on DNA and Fingerprint evidence, and a further 9 offences identified based on similar facts.

**Figure 1.4: Network of Crimes Linked to Suspect Watkins.**

<table>
<thead>
<tr>
<th>CRIMES</th>
<th>LOCATION</th>
<th>SUSPECT</th>
<th>RESIDENT</th>
<th>DNA TAKEN FROM SUSPECT IN</th>
<th>VALUE</th>
<th>LINKED MATCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 commercial burglaries</td>
<td>Across numerous counties</td>
<td>Previous convictions for burglary, &amp; steals computers</td>
<td>Birmingham</td>
<td>£11,000.00 re. first 5 offences: others unknown.</td>
<td>Not undertaken.</td>
<td></td>
</tr>
</tbody>
</table>
Notwithstanding the facts that only DNA evidence was used and the analysis was time-consuming, the case studies demonstrate the benefits of the methodology. Concern was created in the West Midlands region about the levels and value of crime discovered in the exercise that had gone undetected, notwithstanding the fact that evidence connecting criminals with the crimes was available. The problem was, the police service did not know that it possessed the evidence, and had no means to discover it.

Other networks of links between crimes and criminals were detected within the spreadsheet, although those presented here are sufficient to provide good indications of what could be achieved. Combining other evidence such as Fingerprints, Footwear and Toolmarks with the spreadsheet and subjecting the data to similar analysis would be the next step forward in developing the methodology. In order to do that in a timely and efficient manner, it was necessary to reproduce and automate the sequential data-processing activities so as to replace the manual labour with software capable of performing the analysis.

In January 1998, the author proposed a new policy\(^\text{39}\) to the West Midlands Police that would encompass his research methodology.\(^\text{40}\) The aim of the new policy was to improve the management and analysis of forensic DNA evidence. The proposal was agreed to in outline, and the author began production of a conceptual user requirement and operational outline for the software as described in Appendix 1. This was intended to be a semi-automated system to aid the management and analysis of all types of forensic evidence in tandem and that would be compatible with legacy systems operating in the force at the time. The Director of Technology inspected the draft user requirement and operational outline and agreed in principle with the proposal.\(^\text{41}\)

---


\(^{40}\) West Midlands Police Policy and Advisory Group minutes, 12 January 1998.

\(^{41}\) Meeting between Director of Technology R. Cranfield and the author, 24 March 1998.
In September 1998, Mark Compton, who had no previous experience or knowledge of evidence and forensic investigation, agreed to embody the ideas of the author in software code in the form of a prototype system. The author provided domain expertise and knowledge together with the user requirements, and Mark Compton provided software development expertise. This was built using Microsoft Operating Tools namely Microsoft Excel and Microsoft Access. A prototype system was developed and tested to demonstrate the neo-Wigmorean methodology in action with semi-automated functions. The author directed the production of the software to undertake functions embodied in the methodology. Mark Compton followed these directions configuring Microsoft Excel and Access to undertake the tasks.

On 9 July 1999, the author applied to the Home Office for funding to take the prototype further. The proposal to implement the methodology conveyed in a December 1996 Publication of Focus was successful, and on 15 September 1999, Compton became a funded consultant to the project. On 18 March 2000, Compton confirmed completion of the Microsoft Windows version of the software to the level required by the initial user requirement written by the author.

1.9 The Influence of Molecular Biology in Developing a Broadened Conception of Evidential Reasoning

The first source of inspiration that led the author to the development of a new approach involved the science of genetics. During the last century, new developments in biology and

---

42 See correspondence from Mark Compton to author acknowledging: author as originator and designer of the concept and FLINTS, Compton as code writer to embody those ideas in Microsoft Software.

43 The original software code has been retained by the author in "flat file format" and on CD-ROM dated 10.2.1999.

44 Correspondence: Author to M. Compton on 15 September 1999, offering a paid consultancy agreement.

45 Correspondence: Compton to the author on 18 March 2000.
increased understanding of the human genome led to a new era in scientific understanding of the origins of life. This research led to new understanding of the ability of the genome to construct new proteins, and increased understanding of the mechanisms of cell division. Most notable in the literature is the work of Watson and Crick (1953). This presented new understanding of the storage of genetic information, and of how DNA acts as an "instruction manual" for how to build a human body. Judson (1995) provides an account of the developments involved and the projects that provided the impetus for this rapid expansion in our knowledge. Central to understanding the human genome was the development of an understanding of the structure and function of deoxyribonucleic acid (DNA).

The illustrations of the structure of the DNA molecule that follow demonstrate DNA’s enormous capacity for storing information using highly variable but related combinations of only four base chemicals assembled along an enormously long molecule. The model of this molecule provided the author with inspirational ideas about how masses of information can be stored and used for useful purposes. In the case of DNA, cell division and the construction of proteins, in the case of policing, methods to aid the management, analysis and synthesis of information, hypotheses and questions. Figures 1.5 and 1.6, later in this section, will assist in explaining this.

DNA is made up of just four chemicals (purine and pyrimidine bases) arranged in "base pairs". In human DNA, there are only two possible pairings (combinations of the four bases), and these pairs are arranged in series so as to store enormous amounts of information and permit the use of this information. The genome itself, which can be seen as a template for the body, is extremely complex. It is so complex that it could be described as complexity imposed on top of complexity.

Figure 1.5 is an illustration of a cell and the component parts of the human genome. The chromosomes are located within the nucleus, and are made up of a "super-coiled" DNA molecule called a "double helix" because of the way its two component strands (the "double" part of the name) coil around each other (the "helix" part of the name). The
The double helix is composed of base pairs made from pairing adenine with thymine and cytosine with guanine (A with T, and C with G, respectively). The molecule is immensely long, and contains about 30,000 sets of genes encoded in a series of instructions estimated at more than 3000 million bases long. There is so much DNA in any one nucleated cell that molecular biologists still struggle to grasp how it manages to fit into the nucleus of the cell. When one considers that each nucleated cell within a human contains all these genes, the enormity of what the Human Genome Project has accomplished (describing the entire sequence of the human genome) becomes apparent. One explanation for the compression of all this information in each nucleated cell has been the "super-coiling" of the molecule into a double helix, which then coils around itself. This equates to data compression on computers and has important messages for information technologists designing software algorithms.

Expressed genes are those that have been transcribed into messenger RNA, which is then used to direct the synthesis of cellular proteins. Central to this task is the ability to combine  

---

46 The (4) bases of DNA are called nucleotides:(A, C, T, and G). Each base is joined to a sugar molecule (S) and a phosphate molecule (P).

47 It takes about 6 trillion cells to build a human body. Each cell contains a complete set of 22 pairs of "autosomal" chromosomes plus one pair of sex chromosomes (Y or X): A total of 23 pairs. Women have two X chromosomes (X+X), whereas men have one Y chromosome plus one X (Y+X). After staining with an appropriate dye, each human chromosome displays a unique pattern of bands and can be identified by its individual banding pattern combined with its length. Human chromosomes range in size from 50 million to 250 million DNA base pairs.

48 Ribonucleic acid (RNA) is also found in the nucleus and cytoplasm of the cell. It plays an important role in protein synthesis. The structure of RNA is similar to that of DNA, but the sugar molecule (ribose) that forms part of the skeleton of the molecule has an additional oxygen atom compared with the deoxyribose in DNA. Moreover, in place of the thymine that occurs in DNA, RNA uses uracil as one of its four bases. There are several classes of RNA, which differ based on their function: messenger RNA (referred to as mRNA), transfer RNA (referred to as tRNA), and ribosomal RNA (referred to as rRNA or, more simply, as RNA).
the base chemicals in different ways that code for different complex expressions. The process of combining simple base chemicals into more complex sets of expressions that become functioning genes provided the author with ideas about ways in which we can re-think concepts surrounding the combination of single items of evidence so as to provide "evidential expressions"—or put another way, to construct arguments or case theories.

Figure 1.5: Cells and Genetic Materials.

In DNA, these four base chemicals are linked in specific ways. The base chemicals can thus be thought of as entities and the component parts of each chemical as attributes. These chemicals can only bond in certain ways, but what results is a highly complex pattern of

49 It is useful to think about the term "expression" as synonymous with "argument".
repeating chemical types. This provides for the genetic expressions discussed earlier and the unique features of a particular genotype.

Figure 1.6 is an illustration of this pairing of bases and provides valuable insights into the construction of networks of information: the manner in which information is encapsulated in a genome has implications for how information can be modelled in more general networks. Examples of networks of information in Chapter 3 and Chapter 5 bear very similar characteristics to those in Figure 1.6.

**Figure 1.6: Base Pairing that Occurs Between Nucleotides in DNA**

![Base Pairing Illustration]

1.10 Parallels between DNA and Systems of Evidence

The relevance of DNA to the development of the ideas underpinning the present thesis is that DNA acts as a codified set of instructions to construct, run and maintain the human
body. By the interaction of different sets of these codes (our genes), DNA serves as the controlling mechanism for the production of proteins and for cell division, as well as the code that guides the construction of all the physical structures that make a human body. The fact that DNA is a collection of seemingly static information that can be "interpreted" in many different ways says something about the ability to use large collections of information to create small sets of focused arguments. The information in a database is every bit as static as the code in DNA (i.e., the sequence of base pairs is overwhelmingly fixed), yet (as in FLINTS) it can be interpreted in many different ways (different proteins can be expressed or inhibited) depending on input from "the user" and the "context" in which that user is operating. The whole genome is the "system", and genes are the smaller sets of "arguments" that emerge when the system is used for specific purposes; in DNA, this purpose is the manifestation of physical attributes, whereas in FLINTS, the purpose is the detection of patterns. Many parallels can be drawn between DNA and a systemised approach to the management of evidence. The human genome is a complex system for storing information about how the human body should grow, develop and replicate itself. It stores this information in discrete packets called chromosomes, which are themselves made up of smaller units called "genes". Systems developed to manage evidence can also be described as complex systems for managing information about phenomena in the natural world (analogous to chromosomes), and smaller combinations of data and the instructions for how to deal with that data (analogous to genes). This analogy will become clearer in Chapter 4, where the discussion is devoted to the explanation and use of complex systems.

Dawkins (1991, p. 112), provides an interesting discussion about the way in which genetic information is stored along the strands of DNA. He demonstrates that this storage is distinctly binary (having only two values per position) because the fundamental elements of DNA (the base codes) are always found either in one state or another, and never between these two states. The molecules that make up DNA form highly complex patterns by following programs in the form of sets of instructions for how to manage and use the DNA and what information to carry around. His claim is that what lies at the heart of living DNA
molecules is simply "information". But what is special about DNA is the complex way that it directs highly complex patterns to emerge in ways that serve specific purposes.\textsuperscript{50}

In 1996 and 1997, the author's interest in DNA shaped his abstract thinking about better ways in which information could be stored in formal systems. The author was thinking about ways in which organised collections of information could make available small packets of information in much the same way that DNA expresses genes (also small packets of information) in the form of instructions to the body. From a forensic standpoint, these "expressions" could be thought of as arguments or case theories made up of "packets" of information or evidence.

The DNA code acts as a profile or indicator rather than as a definitive expression of the entire genomic code. This is similar to the way in which arguments are composed of evidential expressions rather than definitive statements of fact involving every possible item of evidence. We can never recover all the evidence available in any scenario, and because that which we do recover is always subject to some degree of doubt, we are faced with the task of assembling our evidence in the form of an argument. Carefully managed, the argument may be persuasive, but as is the case with genetic expressions, the evidence serves as indicators rather than necessary conclusions. Given further evidence, different evidence, or by taking a slightly different standpoint, we can formulate a different argument. It seemed obvious to the author that genetic expressions are similar to evidential arguments because both are "indicators of fact". In DNA, the genetic expressions manifest themselves in the form of physical attributes; evidentially, they manifest themselves in arguments or case theories.

DNA was important in developing the ideas responsible for the genesis of FLINTS because it offers a clear demonstration of the interplay of complexity and simplicity. That is, the enormous amount of information stored and the seemingly infinite number of combinations in which it could be assembled seem paradoxical in light of the simplicity of how this

\textsuperscript{50} See also Dawkins (1989, 2\textsuperscript{nd} Edn).
complexity is achieved. The four base chemicals that form DNA (technologists might call these "objects" or "nodes") are arranged in various patterns along an enormously long chain, analogous to the punched tape used to program computers early in the computer age.

In terms of the author's systems metaphor, the cell's structure can be thought of as the "hardware", whereas the nucleus containing the DNA represents both the "software" and the "data" in a very complex information system. One single cell containing DNA is in effect a 'nano-computer' ready to use the information it contains to build and sustain a human body. The analogy with software can be seen in Figure 1.7, where the double helix comprised of the four base chemicals is flattened out into a long code. The particular sequence of base pairs in this short length of DNA could be a potentially useful locus for DNA profiling purposes.

The DNA molecule provides for a systematic method to store huge amounts of information and uses this information as a set of instructions to build templates for

---

51 Note the "lock and key" mechanism that ensures definitive bonding of nucleotides. The different geometries of the four bases prevent the wrong base pairs from linking up. Adenine can only combine with cytosine (A+C or C+A), whereas thymine can only combine with guanine (T+G or G+T).

52 DNA should be used to exonerate the innocent as well as implicate the guilty. In November 1983, 15-year-old Linda Mann was found dead in a lane in Narborough, Leicestershire. She had been sexually assaulted. In July 1986, another 15 year old female Dawn Ashworth, was found dead less than a mile away. The similarities suggested that these were "serial killings" (see Wambaugh 1989, p.114). Richard Buckland confessed to the police that he had murdered Dawn Ashworth but denied any involvement in the Linda Mann murder. The police believed the deaths were connected and set about a search for evidence to connect Buckland to both crimes. Professor Jeffreys, conducting DNA research at Leicester, agreed to undertake DNA analysis of bodily fluids from both murder victims and Buckland. Multi-locus probes demonstrated that spermatozoa from both victims was from the same donor. This indicated that both Linda Mann and Dawn Ashworth had been raped and
different functions. Genes appear in the form of groups of single codes brought together to generate a more complex code and set of instructions ("networks"). This method provides some valuable insights into the way in which we can set about building better systems and techniques for collecting, storing and using vast bodies of information (in the context of this thesis, that information can be evidence). The benefits in doing so are in the investigation of serious crime like homicide (Wambaugh, J. 1989) and rape (Gill, P et al, 1993) as well as minor crime such as burglary. See Times (11 November 1986. 29 July, 1987, 1 January 1988).

In DNA, the four constituent base chemicals can be combined in various mixtures to generate codes (genes) that can be thought of as analogous to the expressions used in argumentation because the genes represent groups of base pairs with particular functions that can be "expressed". Genetic expression is the process by which this coded information is converted into the structures that are present and operating in the cell. The result of these actions generate particular physical attributes such as eye colour, hair colour, sex, height, and indeed, every physical attribute of the human body. Analogously, the copious volumes of data accessed by FLINTS can be "expressed" in the form of meaningful networks of information by means of algorithms (analogous to the instructions for gene expression) encoded in FLINTS.

murdered by this same person. However, the DNA profile of Buckland did not match that of the recovered spermatozoa, therefore he could not have been the killer. The DNA evidence was solely responsible for his exclusion. (See Times, 11 November 1986; Times, 29 July 1987; and Times, 1 January 1988). (See "Exclusion of A Man Charged With Rape & Murder by DNA Profiling"). Gill, P. and Werrett, D. (1994). In 1987 and from a mass DNA screening of males, a man called Colin Pitchfork was declared by Professor Jeffrey to be a "perfect" match to the profile of the spermatozoa recovered from both victims. Pitchfork was later convicted of both murders.

53 The first criminal case in which DNA was successfully used to both eliminate a suspect who had confessed then implicate another suspect who had engaged in subterfuge neither of whom were connected to each other. This has many lessons for investigators both as a story of a crime investigation and the application of logical principles to evidence management.
It is interesting to note that although DNA codes for potential physical attributes, it does not always follow that those attributes will be expressed and become a reality in the human body. The environment plays an important part in the process of gene expression and can modify how genetic traits are expressed. For example, fair skin may become darker if continually exposed to the sun, malnutrition may prevent a child from achieving the full physical size made possible by their genes, and human interventions such as physically altering the body through surgery can change the body's physical structure. Genetic traits are therefore subject to contextual manipulation by the environment. This is similar to the way in which combinations of items of evidence may "code" for a particular argument, yet still leave that argument susceptible to differences in the context in which the evidence is gathered, related with other evidence, and eventually be used.

**Figure 1.7: Base Pairs of DNA Represent a Binary "Program" Similar to that Used in Computer Software.**

Excepting identical twins, all humans have unique DNA at the nuclear level. That is, no person on the planet is likely to have the same genetic code as anyone else. Humans have 23 pairs of chromosomes, each of which contains part of the DNA that encodes all the materials and structures needed to make up a human body. In addition, DNA codes for all the instructions that govern how the DNA itself works. With the exception of mitochondrial DNA, which comes entirely from the mother, each human inherits half of their DNA from each parent. This pattern of inheritance accounts for the well-known similarities in family groups. The replication of chromosomes during the creation of new cells is accompanied by a slight degree of rearrangement of sections of the chromosome, and this (plus other, less
common forms of "mutation") accounts for the uniqueness of each individual compared with their parents. Every nucleated cell in your body contains a nearly identical copy of the complete set of DNA that defines you as an individual. Most DNA is remarkably similar among humans. Only about 10% of the DNA in any one human differs from that in other humans, and much of the difference lies in "non-coding" areas or "polymorphic" regions. (These areas amount to about 3 million base pairs.) Two classes of polymorphic region exist. These areas contain a great deal of the diversity that exists within an individual's genome, and are thus excellent material for differentiating between individuals. The first class is known as sequence polymorphisms, which are simple substitutions of one or a few bases within the genetic sequence. "Genes" are areas (sequences of bases) on the chromosomes that act as templates for the making of proteins. Genes make up only about 5% of the overall human genome. Although individual variations within genes rarely provide good subject matter for DNA profiling in criminal cases (with the exception of certain unusual features, such as the genes responsible for albinism), they will have application in the future for identifying physical characteristics and ancestral trends in the individual. The second class involves length polymorphisms, which are variations ("repeats" and other similar changes) in the physical length of the non-coding regions of a DNA molecule. The 95% percent of the genetic code that doesn't code for any known proteins used to be called "junk DNA" because it was believed to serve no purpose. However, it is now known that among other functions, these areas of the chromosome regulate gene expression during development; that is, they aid the machinery in a cell in reading nearby genes and making protein, or prevent this activity. They also act as physical structural "scaffolding" that shapes the chromosome itself. The analysis of DNA evidence uses a special kind of length polymorphism found in non-coding regions, in which short lengths of identical groups of bases repeat between one and thirty times in a row. This phenomenon is known as variable-number tandem repeats (VNTRs). The number of these tandem repeats varies between individuals. For any given VNTR locus in your DNA, you will have a certain number of repeats.

The combination of these base chemicals may code for a particular genetic expression or may serve another purpose entirely, as discussed previously in the context of "junk DNA".
In the context of forensic DNA profiling, the importance of this sequence is that it provides a code that is highly specific to each individual, and this therefore gives the code enormous discriminating power for identification purposes.\(^5^4\) In this case, Figure 1.8. illustrates how the code reads as:

**Figure 1.8: Sequences of Base Pairs**

```
T C C T G A G G A G
A G G A C T C C T C
```

This code can be further compressed into a binary or algebraic code. For example, let T/A=Y+, let A/T=Y-, let C/G=X+ and let G/C=X-. In this case the code would read [Y+/X+/X+/Y+/X-/Y-/X-/X-/Y-/X-]. This binary code provides a useful conceptual model for the construction of computational languages.

This code, although highly discriminating, is only a very short segment of the entire DNA molecule, and is thus provided only for the sake of an example. Even if we wanted to, we could not access the entire genome to generate a complete DNA code for a particular human. That process would be difficult, time-consuming, expensive and unnecessary for the purpose.\(^5^5\) In practice, what is done is to assemble a collection of such short DNA fragments and compare the "codes" in that collection with a reference set of codes stored (for example) in the National DNA Database. The more codes match with those of a reference sample, the greater the confidence level in any subsequent declared match.

\(^5^4\) S and P refer to sugar and phosphate, the structural elements of the DNA molecule.
\(^5^5\) DNA is recovered from places not ideal for forensic work: Once described to author as "the scrapings of a dirty kitchen floor".
However, DNA has another attribute that human collections of evidence lack. DNA is both a complex collection of information and a complex system with an in-built mechanism for automatically seeking out and linking connections within the information it contains. As the linking of base chemicals is fundamental to the ability of DNA to reveal genetic expressions, so the linking of relevant information in systems of data is fundamental to revealing evidence and knowledge important to a criminal investigation. Revealing evidence and knowledge is a prerequisite to the ability of the investigator to develop and build arguments. This metaphor was fundamentally important in thinking about better ways of organising as well as systemising evidence for use in criminal investigation and intelligence analysis.

The structure and attributes of the DNA molecule lend it to graphical modelling in ways that provide general insights into visual modelling of evidence. Studying the nature of this modelling provided the author with valuable insights into both the way in which DNA evidence can be used to discriminate between competing hypotheses and the ways in which modelling DNA attributes can help us to understand evidential arguments. The following case study provided the author with the means to study these attributes and formulate new ideas about the overall process of formalising the management and analysis of evidence and arguments. The similarity between Wigmore's charts and the DNA model will be clear.

Gill (1994, p. 130) described the use of DNA evidence to discriminate between bones purportedly belonging to the murdered Russian Royal Family and their servants. DNA analysis of chromosomal material recovered from the bones resulted in the identification of five different short tandem repeats (STR) of chromosomal DNA. By setting out clearly the questions that needed to be answered, the available evidence and then applying the appropriate analytical processes, Gill produced an impressive piece of investigative work. This illustrates the use of (DNA) evidence to draw inferences on questions of disputed identity. Modelling investigative problems by setting out propositions, evidence and questions in this way provides many opportunities for investigators to achieve their objectives.
Another important feature of the study of DNA provided the author with valuable insights into the nature and characteristics of information in the context of networks. Study of the way in which the four base chemicals used to build a DNA molecule (thymine, adenine, cytosine and guanine) link together in long chains and in patterns (the location of groups of genes along the molecule) provided new ideas about the way in which information in networks can be linked and related. If we know how one part of a network is structured and the limits of that structure, we can use it to draw inferences about what we should expect to find elsewhere. As we saw in Figure 1.6, this is precisely how DNA is used in biochemistry but it also provides insights into other forms of information networks. An important feature of understanding networks is gaining an understanding of how complex these networks can be. Managing that complexity provides investigators with a tool to gain greater understanding of how networks are structured and how they behave in the face of different types of intervention. It may be a criminal gang, a network of fraudulent financial dealings or a series of connected crimes. Despite the uniqueness that can be attributed to each of these networks, there are rules and formalisations that can be used to model them. Understanding complexity is one way of gaining an understanding of the nature of information in networks. Chapter 3 and Chapter 4 provide two examples of methods designed to model networks: FLINTS and MAVERICK.

1.11 The Recognition of Complexity

The second source of inspiration leading the author to develop this thesis involved the science of complexity. This is discussed in more detail in Chapter 4, but is introduced here because it is an important part of the genesis of this thesis.

One of the traditional scientific approaches described by Poincaré (1905, p. 147) was that although complexity is often acknowledged, it is sometimes disregarded. Furthermore, what may appear simple often hides extremely complex realities. Although these observations are recognised by most scientists, Poincaré pointed out that science had been
conspicuous for it's devotion to linear models\textsuperscript{56} of thinking that failed to deal with this complexity.

As Schum noted (1999b, p. 183), in attempting to simplify what may be complex we do not always reflect on our evidence to an extent that would reveal complex associations in our collections of information. He claims, and it is supported by Ede and Shepherd (1997, p.64), that we disregard subtleties in our evidence even when we have knowledge of their existence. Under other circumstances, we may not recognise the presence of this complexity and therefore have no hope of drawing conclusions from it.

Gaining an understanding of the characteristics of complexity presents us with opportunities to harness it and use it to our advantage. There are a number of ways in which this can be done, many of which are examined in Chapter 4 ("Policing and Complexity"). There are two important areas for discussion at this point: the first is the recognition that connections always exist within our collections of data, and that it is simply a matter of finding them;\textsuperscript{57} the second is that previously unsuspected associations with other facts should attract our attention. The fact of an association is itself a fact worthy of inquiry.\textsuperscript{58}

1.12 The Influence of John Henry Wigmore
This section of the thesis is concerned with the third influence on the author namely, that of John Henry Wigmore. This influence and inspiration has its origins in the methodology

\textsuperscript{56} Poincaré, working with mathematical models that sometimes exhibited remnants of non-linear behaviour, noted that scientists chose to ignore this behaviour rather than confront it. Evidence that does not fit the hypothesis has sometimes been ignored in criminal investigation.

\textsuperscript{57} Eco (1988, p. 225): "No piece of information is superior to any other. Power lies in having them all on file and then finding the connections. There are always connections; you only have to want to find them." Eco and Sebeok (1983) provide an interesting connection between the "backward reasoning" of Sherlock Holmes and the abductive reasoning of Peirce.

\textsuperscript{58} Poincaré (1908, p. 2042).
espoused by John Henry Wigmore early in the 20th century. However, this thesis designates the new methodology "neo-Wigmorean" for a number of reasons. Wigmore was a pioneer of evidence marshalling in that he acknowledged the importance of structuring arguments within a framework that combined logic with the assimilation of evidence. He recognised the importance of the logical and psychological processes involved in this effort and developed an abstract system for charting arguments in support of this effort. His chart method presented for the first time a formal system for marshalling evidence and relating it to propositions in arguments.

Wigmore\(^6\) divided the study of evidence into two parts: First, the Science of Proof including the logical, psychological, scientific characteristics of judicial proof; Second, the Rules of Admissibility. This thesis is concerned with developing the former (Science of Proof) and in particular the chart method. As such, this thesis is concerned with the Science of Judicial Proof. Although developed to aid advocates preparing arguments based on a mixed mass of evidence for presentation at trial, the method and the logic underpinning it, has many lessons for police investigators. Wigmore (1937, p.8) said that the chart method "enables us to lift into consciousness and to state in words the reason why a total mass of evidence does or should persuade us to a given conclusion and why our conclusions would or should have been different or identical if some part of the total mass had been different."

The logic for reasoning about questions of fact in adjudication was seen by Wigmore to be inductive logic. In this way and simply stated, the method requires the user to set about reconstructing perceived inferential relationships between each item of evidence within the argument being advanced and then representing them as a whole within a chart. In section

---

\(^5\) Twining (1985) provides an in-depth study of the intellectual history of the law of evidence. Also see Twining (1994, p.32). This is a sustained examination of the Rationalist Tradition of Evidence Scholarship. Leary, in an unpublished article (2002), studied the foundations of a rationalist empiricist science of proof.

\(^6\) John Henry Wigmore was a reformist lawyer: See Roalfe (1977).
1.13 The method is further explained. In section 1.14 it will be seen that the method has much to offer the detective as fact investigator. It will be seen as the thesis progresses that the chart method has clear links to the methodology and systems presented in this thesis. For example, Wigmore (1937, p.281) states “The Chart Method represents the evidential data by symbols signifying their probative kind and effect, and arranges these symbols in a chart, enabling the practitioner to study on a single sheet the entire mass of data.”

One important distinction needs to be made between the approach offered by Wigmore and that developed in this thesis: Wigmore aimed the chart method at single cases or single problems involving disputed questions of fact. This thesis is also concerned with developing a methodology to aid the investigation of series or multiples of cases at the same time.

Given that Wigmore developed his method almost a century ago and did not have access to the many developments we have seen since, it is important to note that the approach was narrowly defined. It focused on the trial and failed to take note of broader issues involved in reasoning based upon different forms of logic, namely abductive, deductive and probabilistic reasoning. Appendix 3 contains one of only two published examples of the chart method by Wigmore, namely Commonwealth v Umilian. Wigmore uses the judgement of Knowlton J to supply the various items of evidence in the case. His list of propositions are constructed from this judgement and run to 62 items and a complex chart of relationships reproduced in Appendix 3.

____________________

61 Umilian is a useful classroom case study for Wigmorean analysis. Distinctions between evidence, data, inferred propositions, role of generalisations, probabilistic reasoning, inductive, deductive and abductive logic can all be introduced around the case study. Wigmore’s second case study was his analysis of the decided case of Hatchett v Commonwealth 76, Va. 1026 (1882). See Wigmore (1913b, p. 759).
1.13 Wigmore's Method

Wigmore first published his theory of a method for marshalling evidence in the *Illinois Law Review* (1913a). Although narrowly focused on the standpoint of the trial advocate (Twining 1994, p.19), Wigmore's chart method (as illustrated in the *Principles* \(^{62}\)) represents the most developed version of a non-mathematical analytical approach to managing problems of forensic proof involving a mixed mass of evidence. The method is a means of representing the links and chains within an argument in support of a probandum (Wigmore's name for the hypothesis), and has two principal elements: The first is the key list of propositions, which provides the grist for the analytical function of mapping out the evidence in a systematic and hierarchical manner. The second is the chart itself, which is a plan of the relationships between propositions and evidence. Figure 1.9 is taken from the analysis by Wigmore of Umilian as described by Wigmore (1913, p.757).

**Figure 1.9. Wigmore Chart - Commonwealth v. Umilian**

Wigmore's method is a means of reducing the argument into a list of individual propositions. These are assembled in such a way to let the user set out the major hypothesis to be proven and the intermediate hypotheses that either support or negate it. The method is in effect a compilation of a list of propositions to be charted, each of which is given a unique identifying number. This list is then used to construct the chart which in turn demonstrates how the ultimate probandum is supported or negated by the intermediate probanda. Building the chart is the synthetic element of the process, but one that aids the user to determine the strengths and weaknesses in the argument. Anderson and Twining developed a modified Wigmorean analysis to aid practitioners and those studying the method (See Appendix 4). Anderson and Twining (1991a, p.120) provide a seven step methodology for developing user friendly ways of charting arguments. They deal with the basic concepts in the form of an investigation (1991b, p.12) in an easy to follow Teachers Manual.

Wigmore's method is similar to mastering any complex analytical skill. In learning it, you should try to cultivate the habit of going through a regular sequence of operations step by step. We have identified a sequence of seven steps that seem necessary and helpful:

1. Clarification of standpoint, purpose and role;
2. Formulation of potential ultimate probandum or probanda;
3. Formulation of potential penultimate probanda;
4. Formulation of theory and themes of the case: choice of strategic ultimate, penultimate, and intermediate probanda;
5. Compilation of key list;
6. Preparation of the chart(s); and
7. Completion of analysis.

The process can be summarised into three broad operation: Declaration of standpoint; compilation of Key List; constructing the Chart.
Twining notes (1991, p. 118) that the method might be adopted and adapted by other investigators involved in different kinds of factual inquiries, such as archaeologists, historians and detectives. The original approach advanced by Wigmore and the 'user-friendly' neo-Wigmorean approach developed by Anderson & Twining, influenced the methodology developed and executed into FLINTS. In particular, the seven-step approach not only helped the author develop the conceptual foundations of the method, it was also included in training investigators and intelligence analysts in preparing to use and work with FLINTS. In terms of the system discussed in Chapter 5 namely MAVERICK, the seven-step approach has perhaps even greater importance. Users of MAVERICK need to establish and keep in mind their standpoint as well as the context in which the problem is framed at the beginning of the analysis and at each step as it progresses. This is emphasised to prospective users during training. If this is not done, analysts can find themselves facing too many scenarios and too much evidence to analyse and manage. Whilst one of the objectives for the future use of MAVERICK is the automation of constructing and deconstructing networks, setting the standpoint and context for this work will remain the domain of the user.

Wigmore (1937, Part V, p. 821) describes and contrasts two methods for the analysis of a mixed mass of evidence. The first, the narrative method, "... rearranges all the evidential data under some scheme of logical sequence, narrating at each point the related evidential facts, and at each fact noting the subordinate evidence upon which it depends; concluding with a narrative summary." He also describes a second (chart) method, which "... using the same logical scheme, represents the evidential data by symbols signifying their probative kind and effect, and arranges these symbols in a chart, enabling the practitioner to study on a single sheet the entire mass of data." The difference between the two is that the chart method involves the use of symbols to "map" the logical relations between various items of evidence. The potential for creativity of thought and introspection involved in visualising

---

63 An in-depth discussion of "visualisation", in strict terms, is outside the scope of this thesis, but a brief mention is made here for the purposes of explanation. Visualisation and imagery have long been considered fundamentally important to problem solving and creative thinking. Einstein's most
inferential relations in this way should not be underestimated. In Chapter 5, the effects of recent developments by the author in visualising highly complex masses of evidence will be clear. Visualisation facilitates a greater degree of insight into the structural nature of the argument and the evidence upon which the argument rests. Strengths and weaknesses between various parts of the chart can be "teased out". These insights can then help to raise questions about and of the evidence. For example, questions about the evidence may be "what sort of evidence is that?" or "how reliable is that item of evidence?" Questions of the evidence might be "Does that evidence support the hypothesis that X is related causally to Y?" or "Does the relationship between those two items of evidence support any hypothesis other than the one we have considered?" These are all creative problem-solving activities that can be very useful in the analysis of evidence.

Wigmore did not treat the narrative method with the same degree of importance that he did the chart method. He saw the narrative method as a "set of the parts" approach, but although the chart method superseded the narrative method, the two are complimentary. Wigmore (1937, p. 821) said of the chart method that it is the "only thorough and scientific method". Furthermore, even if Wigmore was correct that "... [the chart method] may not
commend itself to some types of mind” (p. 858), Twining (1984, p. 31) noted that Wigmore’s method “… lays the foundation for a systematic approach to analysing disputed questions of fact; it sets forth a disciplined approach to charting the overall structure of a case, to digging out unstated, often dubious propositions, and to mapping all the relations between all relevant evidence.”

The chart is a construction of the relationships between the elements (propositions) of the argument and the key list, and acts like an analytical directory of the propositions. Taken together, the chart and key list account for all the major evidence items and propositions available to the investigator. The chart helps to tease out links, weaknesses and gaps in either the evidence or the propositions. The resulting chart is an inference network of links between the items on the key list. Establishing connections between the propositions and the evidence, or undermining these connections, provides the basis of the method. But why use the method? How does it assist the user? Wigmore (1937, p. 858) provides a simple but important justification: the more complex our collections of evidence become, the more important it is that we develop tools to make sense of the data.

Wigmore approached to the problem of the evaluation of evidence on the basis of a two-stage system: First, he demonstrated how the exercise of decomposition of arguments into their core elements can help to expose strengths, weaknesses and dependencies between evidence items and propositions. Second, he demonstrated that the synthesis of chains of evidence represents the process of recomposition during which previously established links can be reassessed and new items of evidence and propositions can be considered. Decomposition and recomposition can suggest new ways that evidence can fit together as

64 Wigmorean charts may appear to be linear models of relations between evidential items and propositions in support of some ultimate probanda in which the whole is equal to the sum of the parts. On the contrary, Wigmorean charts are non-linear constructs in which the whole is different from (greater or smaller than) the sum of the parts. See Chapter 4, “Policing and Complexity”.

65 This also helps to identify gaps and new potential lines of enquiry. We may produce new and useful items of evidence, or suggest new propositions and new hypotheses for testing.
well as helping to generate new propositions and new hypotheses. The decomposition of
evidence chains characterises the process of analysis, whereas their recomposition
characterises the process of synthesis.

This two-step process comprises both a holistic and an atomistic evaluation of evidence and
propositions. It can be aligned with the process of compression and decompression of
inference chains. Compressing or reducing an inference chain to the smallest possible
length (the smallest number of inferential steps) can provide valuable insights, explanations
and hypotheses about the evidence itself. Eradicating irrelevant and redundant evidence
from the chain provides a very stringent test of a hypothesis and is invaluable in simply
discovering key items of evidence within a mass of evidence that are critical to the
provision of an explanation of a sequence of events or a chain or reasoning about a
suspected sequence of events.

The utility of the method requires careful consideration. Many of the early reviews of the
chart method were unfavourable largely because the analysis required is time-consuming.
The system of symbols used to describe evidential relations, and many of the new terms
Wigmore used to describe forms of evidence, appear complex.

Although Twining (1985, p. 113) noted® that "the Principles contain the most articulate
and coherent statement of the general theory underlying all his writings on evidence", there is a lack of comment in reviews about the practical application of the Wigmorean
method in legal education (1985, p. 239). There is little evidence of any significant® impact
upon legal education, legal philosophy, and the real-world business of evidence
management and trial preparation.

---

66 For example, terms such as retrospectant, concomitant, ratiocinative and catenated.
67 Wigmore Papers, Northwestern Law School; 5 reviews were cited of the 1913 edition, 16 reviews
of the 1931 edition and 12 Reviews of the 1937 edition. See Chafee (1931, p.320), Morgan (1931,
Most copies of Wigmore's work were believed to have been sold to libraries, a fact borne out by the results of a search by the author of the present thesis for a copy of this work. In 1997, after a lengthy worldwide search, a copy was eventually located at Georgia State University. Upon receipt of this copy, it could be seen that the book had hardly ever been opened and used. Curiosity about the book led the author of this thesis to an antiquarian book collector in Hay on Wye, England. It was discovered that this was the only copy available in any form or from any commercial source worldwide at that time. Nearly 100 years old, the book remains in pristine condition—a strange fact when one considers the effect Wigmore is now beginning to have.

Twining (1994, p.19) identified strengths of Wigmore as follows:

- It is the most concrete and well-developed version of an analytical, non-mathematical approach to the problem of forensic proof.
- It integrates logic, forensic psychology and forensic science into a single coherent scheme.
- Wigmore had vocational educational objectives for the book (i.e., the training of advocates).
- It provides a coherent, if not fully argued, theory within a central tradition of English empiricism.
- Wigmore's approach attempts to deal with questions of fact seriously and systematically in the context of legal education.

Although perhaps unintended at the time he wrote the following passage, Twining made reference to some of the attributes of Wigmore's work that had clear connections with a field of science that was destined to become important in the latter part of the twentieth century: the science of chaos and complexity. Twining (1994, p. 59) said of Wigmore, "he

---

68 Sourced with assistance of William Hine & Company, Buffalo, New York.
69 Passage was originally written in 1980 and presented at an address delivered at the opening of the Begbie Building, Faculty of Law, University of Victoria, British Columbia.
was an essentially simple-minded man who combined exceptional industry with a clear mind, broad interests and a methodical approach. His unrivalled mastery of his field was attributable in large part to his simplicity of vision: the world is full of a marvellous diversity of things, but with application and a systematic approach they can be reduced to order... he reduced more material to order than any other legal scholar. Recognition of the importance of gaining an understanding of the relationship between complexity and order is given sustained treatment in Chapter 4 of the present thesis.

Like Wigmore’s method, the methodology developed in this thesis is also concerned with the process of argumentation. That is, it focuses on the creation of arguments based on evidence that can be used to persuade others about the factual validity of a particular hypothesis. This is done by relating, linking or associating items of evidence to principal questions and propositions. In pre-trial criminal fact investigations and intelligence analysis we do not always know how evidence can be related, linked to or associated with other evidence and propositions. On other occasions, we may need more information or evidence than we possess. Pre-trial fact investigation involves the creative act of thinking of possible hypotheses, theories and propositions around which an argument might be built based on evidence. As we shall see in the analysis of Wigmore’s *Appendix on the Detective’s Standpoint*, lawyers usually have a proposition or at least a range of propositions and evidence presented to them.

This thesis and the methodology developed as part of the thesis propose that the future will not be concerned with a lack of facts and evidence but rather with a lack of technique for making use of an ever-increasing mass of facts and evidence. The range of possible hypotheses can be large, but analysts still need to discriminate between them on the basis of available evidence, even if the key is often the discovery of new evidence. Formulating, conceiving and contemplating propositions using inductive and abductive logic aids the

---

70 As we shall see in Chapter 4, one of the attributes of the study of complex systems is the ability to identify "pattern" and "order". In simplistic terms, this involves reducing chaotic states into ordered states. One could argue that the administration of the law is in itself a complex system.
process of discovering new evidence. Central to this process is the analysis and synthesis of evidence, and the ability to break down and build up arguments based on evidence using a range of questions and questioning techniques. The logical and psychological processes involved are crucial to effective investigation.

The author’s claim that the methodology developed in this thesis is neo-Wigmorean is also based upon the parallels between the two approaches. Important distinctions need to be made, however, between the methodology developed in this thesis and Wigmore’s original method. First, the neo-Wigmorean methodology enables the investigator and intelligence analyst to engage in a continuous process of forming sequences of questions and to extend these questions beyond a single case. Unlike the classic Wigmorean approach, which typically proceeds from the top (the macro level) down, these questions can be designed to operate from both a macro and micro level—that is, they can be aimed at developing new hypotheses as well as uncovering new evidence. Micro analysis does not necessarily involve a narrow look at some aspect of a chart or inference network. It can involve a broad range of questions, for example: “what would happen if I had this item of data?” or, “What proposition would I like?” This process is the identification of gaps and opportunities to raise and test hypotheses in the identification of potential leads and places to go in search of new evidence.

The Wigmorean approach of progressing increasingly towards the micro level has clear parallels to the method proposed in this thesis, in which the answers to questions can act as new propositions, which in turn are subjected to new questions designed to test them and aid in the discovery of new evidence. The questioning process can involve a number of approaches, including simple pattern recognition, in which we set out to identify predetermined or novel patterns in the evidence. Questions can be designed to identify where those patterns occur as well to identify and classify newly identified patterns as we proceed. Statistical pattern recognition can also be used to identify frequencies of particular patterns of evidence or ranges within which particular conditions can be deemed acceptable rather than outside a given or agreed-upon norm. This is particularly true with crime and intelligence analysis, in which we should monitor the frequency of crime activity,
the incidence of pre-determined patterns of crime, and even the activity of some repeat offenders. Structural pattern recognition is also possible using the methodology developed in this thesis because old patterns can be used to develop templates for new patterns. An example would be particular types of fraud or sexual crimes committed in specific ways, fraudulent trading committed by criminals tempting investors on the Internet to invest in apparently attractive yet false financial schemes. Unusual patterns in the use of credit cards and banking transactions could also be monitored, as is being done by most major credit card companies right now. Some examples of applications are given in Chapter 5. Linear and logistic discrimination can be used to identify patterns and links, and questions can be used to develop partitions and classifications for the evidence within a system. In the illustration in Figure 1.10, the pattern of times and dates when burglary crimes have been committed within a geographical region aids the intelligence analyst in assessing and understanding evidential patterns. This kind of visual depiction could be used to guide the development of strategies for investigative enquiry, inform the resource allocation for forensic examinations of scenes, and assess the most effective patrol strategies.

**Figure 1.10: Visual Depiction of the Times & Dates of Burglary Crimes Used to Facilitate Pattern Detection. (The Zigzag Line Separates Two Different Populations of Data.)**

The blue dots depict burglary committed during hours of daylight and the red dots burglary committed during hours of darkness:
A final point needs to be made about the parallels between Wigmore's chart method of analysis and the neo-Wigmorean approach advocated in this thesis. It is often easier to absorb complex arguments and collections of evidence when they are presented in a visual format. As Wigmore relied on the visual benefits of a chart, so does the methodology developed in this thesis rely on visual depiction of collections of information. The difference, however, is the way that the visual representation in this thesis facilitates speedy, rational, continuous questioning of the evidence, turning the answers to questions into new questions to be asked. In this way, the questioning process becomes interrogative as well as dynamic. The development of questions and the use of answers to generate new questions and propositions supports an approach in which the investigation and the questions evolve over time. This is similar in approach to the use of genetic algorithms in machine learning and adaptive systems. (Kosko, 1994, p.2002). Fuzzy logic and the role of 'reasoning' is given sustained treatment by Haack (2003). It is worthy of note that it was not until 1965 with the work of Zadeh (1965) that rules were developed to combine fuzzy probabilities. Another is the cardinal work of Aitken (1995) in presenting formal methods (for example Bayesian Statistics) for the evaluation of evidence in forensic science. It should be borne in mind that none of these techniques were available to Wigmore.

Although Wigmore (1937, 3rd edn.) presented new approaches to the analysis and synthesis of evidence, his chart method was handicapped by its complex appearance, the time-consuming processes required to generate it, and the use of a set of symbols that lawyers found difficult to use in describing and presenting evidence. Anderson and Twining (1991a) simplified the method by reducing the number of symbols. They also supported the use of these symbols with a systematic approach for approaching the analytical process itself. Both the original and modified methods were milestones in the development of evidence handling and could provide excellent training material for investigators and intelligence analysts. What remained to be done was to introduce the method into actual investigations in a form that was usable and that would provide the means for speedy, routine investigation and analytical work. In addition, there was a need to advance the
system into the arena of multiple cases and move away from the former preoccupation with single cases. To meet these needs was the aim of the present thesis.

Wigmore is important in this thesis for his work on the science of proof. Wigmore published *the Principles of Judicial Proof As Given By Logic, Psychology, and General Experience* (hereafter, the *Principles*) containing the analytical material so important to the development of the present thesis. A revised edition appeared in 1931 and a third edition in 1937. The third edition was entitled *The Science of Judicial Proof* on the basis of advice from the publisher that it would be commercially beneficial.

Whilst Wigmore's treatise was a successful and influential work on evidence, his *Principles* were not so well received. However, that work enjoyed a revival with the varied works of Twining, Anderson, Schum and Tillers, and has been an important influence in the development of the conceptual foundations of this thesis, especially in respect of evidence, proof, argumentation and the visualisation of inferential evidence.

---

71 For an in-depth evaluation of Wigmore's method, see Twining (1985, p. 179, Appendix, "Wigmore's method: a personal evaluation"). It should be borne in mind that Wigmore developed his chart method following the debates of the nineteenth century, at a time of great expansion for science. This was a period when experimenters like Max Planck (physics, X-rays, 1900), Albert Einstein (the general theory of relativity, 1915) and Werner Heisenberg (the uncertainty principle, 1926) were producing deterministic scientific theories. Determinism, precision and the ability to describe the world by means of a set of natural rules were strong influences on thinkers of that time. In terms of promoting, extending and opening up the law of evidence in legal discourse, Wigmore ranks among them. He was perhaps misunderstood, but his analysis of evidence provides the basis for the development of new technologies to assist those charged with the responsibility of managing evidence.
Wigmore, at the beginning of the *Principles*, states that there are two distinct aspects of a lawyer's training in evidence; the first is what he called the principles of proof in a general sense\(^{72}\) and the second he called the trial rules.\(^{73}\)

Unquestionably, his work is extensive, and a detailed study is needed to discover the rich elements and principles that created a work that was far ahead of its time. Its complexity, particularly in terms of the wide array of symbols that were used, was Wigmore's attempt to drag the world of evidence scholarship into a world that should appreciate the complexities involved in evidential reasoning. His goal was to compensate for the lack of knowledge that existed in the world at that time. The experience of the author has been that only a small number of non-specialist writers and professionals have heard of Wigmore and that even fewer are familiar with his methods. Until the author began to promote the work of Wigmore in the police service in the mid 1990’s, he had never met a police officer who knew of his work, let alone who was familiar with the implications for pre-trial investigation. That is now changing. When Wigmore wrote at a time when statistical science, probability theory and information sciences did not exist. When Wigmore published his work, the relevance of his interest in inferential analysis was unclear. An example of how far ahead of his contemporaries he was can be illustrated by a detailed study of his symbols. It is interesting because modern symbolic logic was being developed shortly before Wigmore's work, and might well have informed it. He described evidence in the form of recurrent forms of evidence more in line with what they could prove about a scenario rather than their source. This has obvious parallels with the "substance-blind approach" proposed in the present thesis.

1.14 Wigmore and the Detective’s Viewpoint of Evidence

\(^{72}\) On page 1 of the Introduction, Wigmore writes "[the principle of proof in a general sense is]... the part concerned with the ratiocinative process of contentious persuasion."

\(^{73}\) The procedural rules devised by the law, based on litigation experience and tradition, to guard the jury against erroneous persuasion.
In Appendix V of his work (Wigmore 1937, p. 1016), Wigmore turns his attention to what he calls “the detective’s viewpoint of evidence”. He presents an important discussion of the role of the detective in the contemplation of evidence in pre-trial fact investigation, drawing comparisons with the role of the advocate. Wigmore’s standpoint was that of a scholar teaching advocates to manage a mixed mass of complex evidence in preparation for trial. He encouraged and schooled his students to develop the ability and capacity to be systematic and to set out their evidence and arguments in such a way that they could establish valid and persuasive arguments. His systematic approach helps to reveal where strengths and weaknesses are to be found in the evidence upon which inferred argumentation rests. This, he rightly claims, helps the advocate to deal with counter-arguments and criticisms from their opponent.

The advocate’s role is distinctly adversarial and limited in respect of the discovery of new evidence and problem definition. Usually, the hypothesis (the problem to be tried in court, called the "probandum" by Wigmore) is given to the advocate. For example, the advocate will be briefed by the client on the nature of the problem and given a summary of the evidence upon which they will rely. The advocate can only rely on the evidence presented to them and the arguments they are able to assemble based on that evidence and the relevant body of law. Further, they are limited in the extent to which they are able to engage in voyages of discovery to find new evidence. Although Wigmore said that the detective only has his evidence given to him, often only in small amounts and without a probandum, in reality investigations are more diverse. Sometimes, as in fraud cases, there may be enormous amounts of apparently relevant evidence, whereas at other times there may be little.

Sometimes the probandum is indeed given to the detective in what the police service calls “specific terms of reference”. Here, detectives are asked to investigate specific instances, hypotheses, or claims to evaluate the strength of evidence in favour of them. These kinds of investigation, though often regarded as rather routine matters because they have set limitations, are in reality quite difficult. This is because it is not easy to undertake what is essentially a creative undertaking, the discovery of evidence, from such a narrow
perspective. Evidence may be deemed irrelevant from the outset and thus eliminated, which would not otherwise be the case.

Wigmore was attempting to create a method that would allow advocates to keep in mind many things at the same time and to continually assess and reassess where strengths and weaknesses were appearing in the arguments and evidence advanced by each side. This would enable the advocate to refine the arguments advanced to a "single final idea" (Wigmore 1937, p. 858) that results in a valid and persuasive final argument.

A point that must be made is that Wigmore was ahead of his time in developing his methods for the analysis of a mixed mass of evidence for use in structuring legal arguments. He did not have the benefit of subsequent developments in probability theory, logic and technology that we have seen in the last few decades of the 20th century. His chart method in particular provided a formalisation that was beyond the comprehension of many contemporary lawyers, many of whom saw it as an overly complex method devoid of practical application.

Wigmore (1931, p.1016) conceded in the opening passage of his Appendix that the advocate has the probandum given to him, leaving him to assemble the evidence around it, whereas the detective is given only the evidence and left with his "probandum lacking". This is not always the case, because quite often the detective is given terms of reference to assist him in drawing boundaries around the investigation and defining how far the investigation will go.

Wigmore also taught his students to assess the strengths and weaknesses in an opponent's evidence and arguments and to consider ways in which these could be exposed to the opponent's disadvantage.

Students of Wigmore's method need to learn a number of important skills and techniques if they are to master the method and use it effectively. These skills and techniques offer important opportunities in training detectives, but for different reasons than those of the
advocate. We shall return to this issue as we advance our discussion on Wigmore’s method as applied to training advocates. Students studying Wigmore’s method must first gain an appreciation of why they are using it. When faced with a mixed mass of complex evidence, it is often easier to overlook difficult inferential problems or evidence that may undermine an inferential proposition that is key to the argument as a whole. Similarly, oversimplifying an inferential problem because its relevance, credibility or weight are difficult to expose or defend may produce a seemingly clear argument in a relatively short space of time that may persuade a casual onlooker in a criminal case. However, an opponent with the objective of undermining the argument and persuading third parties of errors in any aspect of the evidence can set about deconstructing the argument, thereby exposing serious flaws. Some of these flaws may actually be real, but to succeed, in practical terms an opponent need only persuade a tribunal that, on balance, there is doubt.

Second, if evidence and arguments may be acted upon or subjected to examination for their reliability, account must be taken of all evidence available that could have some influence upon the conclusion. This is somewhat easier for the advocate because the evidence available is limited. However, for the detective the problem is greater. Detectives have the theoretical ability to pursue evidence anywhere in the world, so the selection of both the available evidence and the lines of enquiry to expose that evidence can be very wide indeed. The balance in endeavour that has to be drawn between exploring all relevant possibilities and exploring "enough" possibilities requires skill and careful thought. When advocates have to take into account all evidence available to them, this not only means keeping in mind what evidence is available but also questioning the credentials of the evidence itself. That is, they must consider any evidence that can be brought to bear based on the relevance, credibility and reliability of the evidence. This entails the consideration of evidence about evidence as well as evidence of evidence. Evidence about evidence may be any material that can provide guidance as to the inferred relevance, credibility and reliability of the evidence we use. For example, the presence of broken glass on the outside of a building rather than the inside may cause the detective to question the credibility of

74 There are legal and practical constraints.
evidence offered by a victim that their house was unlawfully entered by someone breaking
the glass with a tool from the outside. Evidence of evidence may be the presence of some
inference that may lead us to evidence. As Conan Doyle pointed out in The Adventure of
the Silver Blaze (Baring-Gould, 1967, p.280), the dog that did not bark in the night may
indicate the presence of as yet unavailable evidence that can explain some event or the
lack of an expected or claimed event:

"Is there any point to which you would wish to draw my attention?" [asked
Inspector Gregory]
"To the curious incident of the dog in the night-time."
"The dog did nothing in the night-time."
"That was the curious incident."

Taking account of the absence of evidence as itself relevant and contemplating gaps in the
evidence and arguments is an important intellectual step forward for both the advocate and
the detective in evidential reasoning. It provides a valuable intellectual platform from which
to think deeply about the nature, characteristics and uses of evidence and evidential
reasoning. Despite the efforts of Wigmore and others to introduce his method in legal
training, the material and intellectual emphasis needed to adopt this type of approach has
been largely absent in detective and police training.

Structuring arguments based on evidence or investigating events to try to find explanations
for events or non-events provides the third point that students of the Wigmorean
methodology must understand. Evidential reasoning is a process of relating evidence and
arguments together within (and as part of) a process of investigation. Wigmore (1931, p.
1016) ) makes the point at the beginning of Appendix V that these principles are the same
for the detective and the advocate even though they are used in different ways, each
decided by the context within which each actor works. In terms of the process of evidential
reasoning, it is important that students of advocacy and of detection appreciate that this
form of reasoning is indeed a process.
Wigmore (1937, p. 858) talks about the logical or psychological process of consciously juxtaposing the details of related ideas for the purpose of rationally producing a single final idea. Wigmore rightly claims that the human mind is unable to contemplate and juxtapose a large number of ideas and keep them all in mind at the same time. He implies that there is not only a need to aggregate all evidence into a single final idea, but also a need to be able to disaggregate the evidence into smaller sets and groups so that the mind can indeed manage the complex nature of structuring the mixed mass of evidence. Wigmore (1937, p. 1018) claimed that "every probandum, in the sense of being composed of several details, is more or less complex."

Wigmore claims that a methodology is required to overcome these problems. Two points arise here: The first is that of process, and the second is that of methodology. Here, "process" means acting rationally, lucidly or cogently so that the user of the evidence both satisfies themselves of the relevance, credibility and weight of the evidence, and convinces others of their final conclusion. The second point, that of "method", is clearly complex because it involves the holistic as well as the atomistic treatment of the evidence. Here, "method" represents the implementation of "process" to achieve a specified end. Furthermore, the methodological approach involves both analysis and synthesis of evidence. Here, "analysis" is intended to refer to the sifting, comparing, contrasting, juxtaposing and structuring of the evidence in different ways to see what messages the results convey. The "synthetic" process is instead connected with the way the user manipulates the evidence into different types and states of arguments. Synthesis enables the user to generate and contemplate new ideas, new views of the evidence and alternative explanations that may have been previously overlooked. These processes and methods apply equally to the advocate and the detective.

Wigmore strongly believed that the difficulties encountered in adopting this process and methodology required the user to have some means of assistance to "shore up" the mental gymnastics required to organise their thoughts and the evidence in different ways. Wigmore thus developed his chart method for constructing arguments from a mixed mass of evidence.
Constructing such a chart and key list can be an arduous undertaking, but the process and methodology employed enables the user to gain an unparalleled understanding of their evidence and possible arguments that will help both to withstand scrutiny. The advocate and the detective employing such a method can claim "thoroughness" on a level that allows them to ask two questions of third parties assessing their findings:

- On the basis of the evidence known at the time and by reference to the claims made by the producers of that evidence, does this argument satisfy and account for the evidence in a way that is stronger than any other argument?
- Faced with the same evidence and claims, would you have come to a different conclusion?

Wigmore's relevance to the present thesis and the claims that the methodology developed as part of the thesis is neo-Wigmorean are borne out by two assertions: First, Wigmore personally accepted and later demonstrated that evidential reasoning requires the user of the evidence to engage and deal with complexity. This result is important in terms of managing large collections of evidence that may be intricately connected in any number of different ways to the inherent problems associated with the analysis and synthesis of the evidence in an attempt to construct a single persuasive argument. Second, Wigmore accepted and later promoted the use of a methodology and system to aid the user in this pursuit. His chart method bears a striking resemblance to modern computer-aided visualisation processes, as the chart itself is an inference network that bears features conducive to the visualisation techniques employed in such pursuits as Bayesian inference networks and acyclical graphical nets. The seven-step method advanced by Anderson & Twining has already been addressed in this Chapter. It is reiterated here to emphasise the importance it has in developing a neo-Wigmorean approach.

Directed acyclic graphs use an extension of the general Wigmorean theory. These graphs represent or model a network of relationships between objects. The relationships are based on some predetermined inferential force (the "directed" part of the name). Until recently,
they have been used in the assessment of problems represented by a set of variables, each operation, and each constraint in the problem contemplated in the form of a node of the graph. The edges represent the direction of the relationship between nodes. The success of such a method relies heavily on the quality of the range estimates computed for the functions involved. One of the strengths of directed acyclic graphs is that they are suitable both for efficient evaluation and for performing constraint propagation.

Both Bayesian inference and acyclical graphs have been successfully employed by Dawid and Evett (1997, p. 226), who made specific reference to the inherent links between their approach and Wigmore’s method. The title of their paper is worth repeating at this point because it provides a powerful reminder of the important elements in this discussion: "Using a Graphical Method to Assist the Evaluation Of Complicated Patterns of Evidence":

"An early approach of this kind was Wigmore’s chart method. Such diagrams can make it easier to appreciate the logical structure of a complex case."

Later in the paper, they observed that due to the complexity involved in applying their own method and that of Wigmore, it was unrealistic to expect people to perform it manually. They concluded that computers needed to be employed to aid the process (p. 230):

"It would be unrealistic to expect the routine use of such methods if they were to be done manually as here; however, we strongly believe, in agreement with Aitken and Gammerman [who reviewed and accepted the paper for publication on 23 April 1996], that computer methods are a realistic prospect with existing technology."

Dawid and Evett explained that forensic scientists face the task of interpreting patterns of evidence that involve a great number of items of evidence. Furthermore, they noted that combining different items of evidence in the form of variables requires logical powers of reasoning that can be assisted by formal methods. They presented a method that offered the potential for producing computerised "expert systems" that would assist in evidence
interpretation. In the example presented below (Figure 1.11), they demonstrated how diverse items of evidence could be modelled in a formal structural Bayesian inference network using an imaginary case. The following narrative description of the imaginary case shows Dawid and Evett using a Bayesian inference network:

“Narrative: A number of unknown offenders entered commercial premises late at night through a hole that they cut in a metal grille. Inside, they were confronted by a security guard who was able to set off an alarm before one of the intruders punched him in the face, causing his nose to bleed. The intruders left from the front of the building just as a police patrol car was arriving and they dispersed on foot, their getaway car having made off at the first sound of the alarm. The security guard said that there were four men but the light was too poor for him to describe them and he was confused because of the blow he had received. The police in the patrol car saw the offenders only from a considerable distance away. They searched the surrounding area and, about 10 minutes later, one of them found the suspect trying to "hot wire" a car in an alley about a quarter of a mile from the incident.”

The following illustration (Figure 1.11) of a Directed Acyclic Graph developed and presented by Dawid and Evett (1997, p.227) illustrating dependencies between various items of the evidence,. The similarities in portrayal of logical relations to that of Wigmore’s Chart Method are clear. Furthermore, the suitability of the approach for further research and development with the support of software was acknowledged: “One option would be to create a program which did all of the analysis automatically”. (1997, p. 230).
Figure 1.11: Example of a Directed Acyclic Graph Showing the Key Elements of a Robbery Description.

Key list of evidence:
- $G_1$ and $G_2$: the evidence of the security guard
- $W$: the evidence of the police officer who arrested the suspect
- $R$: the bloodstain in the form of a spray on the suspect's jumper
- $X_1$: suspect's blood type
- $X_2$: guard's blood type
- $X_3$: properties of the suspect's jumper
Yi measurements on samples of unknown origin:
Y1: fibre tuft
Y2: blood type sprayed on jumper
C: whether the suspect was or was not one of the offenders.
A: identity of the person who left the fibres on the grille.
B: identity of the person who punched the guard.
N: the number of offenders.

Dawid and Evett used their method to assess the overall weight of the evidence in the case if produced at trial. In this sense, they were assessing the case both for and against the prosecution. In an interesting exercise designed to compare directed acyclic graphs and Bayesian inference networks as used by Dawid & Evett (1997), Schum (2003a, p. 14) analysed the same fictitious case using a modified Wigmorean approach. However, Schum used the standpoint of a prosecutor organising evidence for presentation at a criminal court to show that the defendant had committed the crime. The work involved a decomposition of the evidence used by Dawid & Evett, with some licence taken to infer additional evidence. The work provides an ideal example of the way in which two different people examining the same case using different standpoints could produce different outcomes. See also: Schum (2003b).

Two important issues were raised by this comparison. Firstly, the level of decomposition involved. Dawid & Evett use twelve (12) nodes to describe and present the evidence from the standpoint of statisticians, whereas Schum used 102 nodes (Figure 1.12). Schum explains this in the following terms: "As a prosecuting attorney, the author does have to pay a great deal of attention to the individual 'trifles' or details that items of information reveal. Some of these trifles may seem relevant (directly or indirectly) but others not relevant. To use a currently popular metaphor, attorneys (as well as intelligence analysts) have lots of 'dots' to try to connect." Secondly, Schum was critical of the lack of attention paid by Dawid & Evett to the issue of evidential weight. The Key List of the evidence in this Chart is lengthy and thus can be found in Appendix 5.
Figure 1.12: Schum's Analysis of the Dawid and Evett Case.
Wigmore makes the point clearly that the detective and the advocate both use the principles of proof, and he provides important insights into the operational role of the detective as seen by an expert in evidential reasoning. However, he overlooks some important differences between the two roles. Many of these differences can be summarised fairly simply by comparing the roles directly. The advocate is engaged in direct argumentation from a given collection of evidence whereas the formation, selection and deselection of hypotheses based on evidential tests is the role of the detective.

Schum (1994, p. 460) engages the problem of hypothesis formation in great detail and describes the process as involving the use of “imaginative reasoning”. However, there is a difference between hypothesis formation and hypothesis testing. As the advocate progresses from some point of evidence in search of missing evidence or evidence to fill the gaps in an explanation being contemplated, they must engage in the selection of evidence. This is because not all material is relevant, and because some evidence may be relevant logically but too remote for its effect on the argument to make the material worth including. Investigation and discovery continue over time. In short, what may not be relevant now may become relevant in the future.

In contrast with the advocate, the detective, who must at some point arrive at a conclusion in much the same way as the advocate does, must first engage in a process of discovery, hypothesis formation, hypothesis testing and decision-making. This process is more strongly connected with the raising of good questions, "problem solving" and inductive elimination than it is with argumentation. Wigmore (1931, p. 1016) called the eliminative operation of detective work a process of "select and discard". However, the detective must also weigh the competing hypotheses involved at various points when decisions have to be made about how to proceed in constructing the case. In this way, argumentation also forms a part of the detective's work.

One difficult issue is that detectives are the only judges of their decisions. Sometimes it is impossible to recreate the circumstances that pertained at the time of the detective's decision to follow a particular line of enquiry. That decision may have meant that evidence
that would in fact have been relevant or important was not discovered because that line of enquiry was not followed. It may be possible to ask the detective a question about whether a particular line of enquiry was followed, and if not, why not, but it may never be possible to discover what evidence would have been discovered if that line of enquiry had been followed. In this way, we are reliant upon the ability of the detective to engage in inductive elimination in a way that enables the discovery of the most important and relevant evidence while at the same time eliminating irrelevant or misleading evidence.

The detective is faced with the problem of undertaking the process of discovery of evidence to determine what may be relevant to solving the problem that is the subject of the investigation. That process will inevitably involve determining where doubt lies in the evidence, why that doubt exists, and any explanation available. The detective is then responsible for the eradication of that doubt by asking good questions and discovering reliable evidence to answer those questions. As is the case for the advocate, this involves the interpretation of patterns of evidence that may involve many variables. Combining different items of evidence within a complex framework of circumstances requires powers of logical reasoning, and this skill can be assisted by the adoption of formal methods. The neo-Wigmorean method offered in this thesis offers considerable potential for creating an expert system able to assist in evidence discovery, analysis, and interpretation, as well as in solving problems. The method, which is based on the application of a general theory, enables the user to identify associations, links, relevancies and gaps between different aspects of the evidence being considered.

An interesting issue is the formalisation that Wigmore (1931, p. 1018) adopts when he attempts to provide a definitive approach to the investigation of evidence surrounding a central human act important to the investigation. He calls this the "datum solvendum". He does not give an in-depth explanation of applying the datum solvendum, nor does he provide an explanation of what he means by "complexity" other than at a superficial level. Is it merely the intricate way in which things "just happen" to be associated, or does he mean something more? He does give a clue to his meaning when he talks about the probandum being composed of many small details; this suggests that he had a very good
personal understanding of complexity, even if he did not define that understanding for his reader. Wigmore's complexity may not be the nonlinearity and emergent properties that we see in modern complexity theory, but certainly he was not prepared to overlook the complex nature of the environment in which evidence and argumentation operate.

Part 2: Systemisation of a Neo-Wigmorean Methodology
This part of Chapter 1 discusses the author's adoption and adaptation of Wigmore's original methodology to create something new: a neo-Wigmorean approach to police investigation.

2.1 Systemisation of the Management of Evidence
In Part 1 of this chapter, and particularly in the section concerning "Wigmore and the Detective's Viewpoint of Evidence", the problems associated with the management of a mixed mass of evidence were reviewed. They can be summarised here for the purposes of clarity as arising from the volume of information involved, the difficulty of categorising it, the large number of variables involved, and the explicit and implicit relationships that may be obvious or hidden within the information. Together, these add up to a very complex problem. Developing a methodology that could provide the intellectual means to manage the body of evidence and a system that can provide a manageable process would provide many opportunities to improve pre-trial fact investigation.

The neo-Wigmorean methodology developed as part of this thesis embraces the real and profound problems created by complexity. This thesis takes Wigmore's ideas about complexity to a deeper level than he did by applying modern discoveries in complexity theory and uses them to inform the development of applied methodologies.

The methodology of the FLINTS software was designed by the author to meet user requirements by helping to overcome the problems created by narrow conceptions of evidential reasoning, the lack of integration between collections of evidence, and the traditional approach of investigating crimes in isolation, on a case by case basis. The methodology and the software that was subsequently developed provide a means to ask questions of the masses of evidence routinely collected by investigators. It will be seen as
the thesis progresses that the system manages and marshals evidence generated by diverse sources, including physical and forensic evidence. Her Majesty's Inspector of Constabulary\textsuperscript{75}, David Blakey, said that "FLINTS has the capacity to link suspects with crimes that otherwise may not have been linked, e.g. linking chequebook evidence from frauds with that from vehicle crime... there is real potential for this system to be developed, possibly nationwide, in the future." Blakey et al. (2000, p. 51, sections 6.32 and 6.37) identifies one of the central themes underpinning the methodology: "It provides a very useful insight into how evidence and intelligence can be used to link what appear to be disparate crime types and scenes."

Sir Edward Crew\textsuperscript{76} (2000a, p. 53 and 2000b, p.6) highlighted the impact that the methodology and system had had in the Midlands Region of England:\textsuperscript{77} "The system has already been directly responsible for a number of convictions. FLINTS will be extended to other forces in the Midlands with the help of a Home Office grant."\textsuperscript{78} Crew acknowledged the original contribution by the author of the present thesis in developing the ideas and methodology underpinning the development of the system and software.\textsuperscript{79} Chapter 3 provides a detailed description of the system and methodology at work.

\textsuperscript{75} Her Majesty's Inspector (HMI) of Constabulary advise Home Secretary on police effectiveness and efficiency. They inspect police forces regularly.

\textsuperscript{76} Sir Edward Crew advised the Prime Minister and Cabinet about police reform. Part of that advice included the potential of FLINTS.

\textsuperscript{77} In February 2002, the Rt. Hon. Mr David Blunkett, Home Secretary, visited the Chief Constable Sir Edward Crew and reviewed the FLINTS Project in Birmingham, England, to assess the potential of extending the system to a national platform. The system is now in use in over eight force areas.

\textsuperscript{78} Home Office Grant, £500,000. (June 2001.)

\textsuperscript{79} Correspondence: Sir Edward Crew to author 2 July 2002, acknowledging original ideas, contribution and innovation of the methodology and system. "It has allowed this force to take forward many of your ideas and innovations and put them into practice. You leave the force with a legacy that is the envy of many other forces and security organisations."
This thesis provides the justifications for adopting a neo-Wigmorean methodology and developing software built upon it. The manual operation of Wigmore’s method, of Dawid and Evett’s directed acyclical graphs, and of the neo-Wigmorean method introduced in this thesis is prohibitively time-consuming for the approach to be practical outside of training exercises. Time, human error, and the limitations of human memory, speed of recall and sequential processing of information all make a manual methodology impractical. The software developed on the basis of that methodology in this thesis provides a means to undertake the operation efficiently and accurately, while enabling the intellectual elements of the methodology to be applied in a standard, repeatable, useful and practical way.

Vast amounts of evidence can now be stored in a way that provides an inventory. Everything available in this inventory can be accessed swiftly and the results provided in a consistent, useable format. The potential for evidence to get misplaced, discarded or mistaken for other evidence is reduced because everything is catalogued and processed under the guidance of carefully defined rules. Each transaction is logged and can be tracked.

The intellectual elements of the neo-Wigmorean methodology are reproduced in the form of an information store (a computer’s hard disc) combined with a set of templates for questions, queries, analytical techniques and methods of visual representation (algorithms). The necessary system and management conditions needed to perform the tasks laid down by the neo-Wigmorean methodology are built into the data-processing functions of the software. The evidence needed to answer questions and solve problems is made available immediately to the user. Applying the methodology reveals networks of links and answers to questions. Questions can be simple or complex, and can be undertaken in sequences of queries. This means that questioning can be iterative and lucid to the observer of the process. The logical and inferential exposure of obvious and non-obvious relationships and links provides the investigator and analyst with a means to undertake intense and concentrated enquiry on practical timescales that were previously unachievable. The process being applied is one of inductive elimination, but conducted under planned, controlled and managed conditions that are designed and optimised by the methodology.
The amount of evidence available and the diverse nature of the events that the evidence is linked to mean that until a question is asked, the user is never quite sure which pieces of evidence will be produced. Because the data in the system is being continually updated, a question asked tomorrow may not reveal the same answer produced by that question today. As in the real world, circumstances change, and this means that observations of those circumstances over time will reveal different results. Essentially, this means that one piece of evidence stored in the system may in fact perform many inferential tasks, depending upon the question asked and its timing.

Since the advent of the information technology revolution in the last two decades, our ability to collect and store information has far outstripped our ability to manage, analyse and make sense of it. Computers will only perform the tasks they are designed and built to perform. They cannot perform thinking tasks in the way the human mind does and they are not self-aware, so they have no powers of contemplation. However, they have two distinct advantages that humans can exploit to improve our operational effectiveness. First, computers far outstrip humans in terms of their ability to store information accurately and retrieve it speedily and reliably. Computers can also perform sequential operations such as complex arithmetic, algebra and geometry that would bore or tax the abilities of most humans, and can do so much faster without ever making a mistake (provided, of course, that their programming is free of errors). This is because they are linear digital processors rather than non-linear analogue processors like humans. However, this does not mean that computers cannot be programmed to undertake processes and tasks that humans do. Computers can indeed be programmed to emulate human activities. To do so, the programmer must possess the necessary expertise as well as knowledge of what the human activity involves; where that knowledge is lacking, it can be provided by a non-programmer expert, as was the case when the author worked with Mr. Compton to develop the FLINTS software.

Properly employed and programmed with the appropriate methodology and operating principles, computers can augment human efficiency by undertaking complex, time-consuming tasks under human guidance. This includes the management and analysis of
evidence. What needs to be in place first, however, is a properly and appropriately designed methodology and process. There has been much comment since 11 September 2001 about the overwhelming power of computers employed by the security agencies of the United States, yet despite this power, the signs of the attacks planned, practiced and perpetrated by foreign nationals on American soil were not detected before the attacks had taken place. Why was this? Super-fast, highly powerful computers alone are no substitute for the role of human analytical reasoning. Automated computers programmed to operate in support of (and in combination with) trained human analysts is a better approach.

A very powerful strategy and one that forms a key part of the neo-Wigmorean methodology described in this thesis is to create a symbiosis of humans and computers, operating jointly in the pursuit of the same goals. Each "symbiote" complements the other: the human provides the insight and control of the operation, while the computer performs the difficult sequential, repetitive tasks necessary to optimise what was previously done solely by humans. Figure 1.13 illustrates this symbiosis.

Figure 1.13: Diagram of a System Linking Humans and Computers to Take Advantage of Each Other's Strengths.

On the left is the semantic operation of encoding a methodology useful to tasks that humans must undertake into the computer. At the right, the syntax understood by the
The computer is organised in such a way that the operations and processes directed by the methodology can be performed repeatedly at high speed and with great accuracy. The task may be the retrieval of data, the preparation of answers and lists of information in response to an enquiry, or even the creation of visual representations of what the methodology has discovered within the information store.

The human formulates an interrogative question by constructing and encoding a query. That query is then submitted for the computer to answer. Upon receipt of the query, the computer decodes the query and attempts to locate the information necessary to answer the question. The answer is then fed back to the human operator, who interacts with the response and decides whether to use it or alternatively, whether to recode the answer or part of it as a new question or instruction to the computer. The method is therefore an iterative process of questions and answers. The human part of the operation is based on the processing of "observables" whereas the computer part involves the processing of data using encoded versions of the theorems that underlie the methodology. An important distinction to be made is that the computer is controlled by the human in terms of task orientation, whereas access to, processing of, and manipulation of the information is undertaken by the computer.

One of the main reasons for the concentration on building storage platforms rather than analytical platforms has been the system designer's failure to account for the range of operations that humans desire to perform using these platforms.

**Part 3: Obstacles, Barriers and Pitfalls**

In this third part of Chapter 1, some of the obstacles, barriers and pitfalls encountered during the development of the author's methodology will be discussed. These are chiefly concerned with the need for a change in the mentality of investigators and intelligence analysts and in the approach they take to obtaining and working with evidence. Part 3 will also discuss the effects of over-bureaucratisation of the process of investigation and intelligence analysis, the over-reliance on transactional computers, and the dangers
presented by over-formalisation. Finally, the training needs for investigators and intelligence analysts will be discussed, and a brief course outline will be provided that is designed to illustrate the material needed to move towards a more effective approach to investigation and analysis that encompasses the methodology developed in this thesis.

3.1 Changing the Mentality and Behaviour of Investigators and Analysts

As we have seen, investigators and intelligence analysts are concerned with the investigation of facts as well as the management and discovery of new evidence. This responsibility includes both the generation and testing of hypotheses. Asking good questions and understanding the role of inductive elimination is central to what is essentially a process of argumentation. Dealing with known or accepted facts and evidence whilst taking account of what is unknown and of missing evidence, and at the same time generating and testing hypotheses, is a highly thought-intensive process. To undertake these tasks effectively requires an understanding of the processes, a disciplined attitude and a flair for creativity. Encouraging investigators and analysts to think and behave in this way means that organisations must treat investigation and analysis as an intellectual discipline and approach it seriously. Training must also be taken seriously based on an understanding of the benefits it can bring. This thesis is concerned with developing methods and techniques that demonstrate the benefits of an intellectualised approach to investigation and intelligence analysis.

The lack of intellectual guidance on the thought process described in Part 1 of this chapter during police training is a serious impediment to change. In this context, it is worth considering how investigation is perceived as a professional pursuit. This perception provides clues about the intellectual, institutional and social barriers that need to be tackled.

Understanding the perception of investigation of crime by police officers, detectives, police managers, the public and government officials is an important prerequisite for achieving change. We have seen that the traditional approach to investigation and intelligence
analysis has, until now, involved the investigation of single, isolated crime events (for example, a single armed robbery, a single burglary, a single rape or a single sexual assault). The classic example is the "who did it?" tale of homicide investigation that has been so well illustrated by many accomplished authors of crime fiction. Conan Doyle's Sherlock Holmes is perhaps the best-known fictional detective, but there are many others. Indeed, an entire literary genre has developed around the notion of the single homicide investigated by a lone detective. Even studies of crime fiction routinely use the single isolated case as a standard for interpreting the way that crimes are investigated. Miller (1988), in his study of the novel and the police, takes this approach to be standard, as does Munt (1994) in her study of the development of crime fiction in Britain and the United States. Her work points out the "macho" role of the detective surviving in a world of crime where "machismo" is more important than intelligence. Probably the most interesting insight into perceptions of crime as single isolated events can be found in Symons' (1992) study, Bloody Murder. This work undertakes a critical historical overview of crime fiction, but again the central focus is the single isolated event, usually a homicide, investigated by a detective. A recent development has been the growing interest in the "serial killer" which of course is not concerned with isolated events of crime. It's therefore important to note that films such as "Seven", "The Silence of the Lambs", and "The Usual Suspects" all of which are in part concerned with police procedure, illustrate a growing interest in the "serial killer". Any discussion of the single isolated crime would be incomplete without at least acknowledging such films. The development of FLINTS therefore occurs at a auspicious time because of the relatively recent surge of interest in serial killers and their nemeses, the "profilers" who have become interesting enough to have spawned an American TV series, "The Profiler". The sudden popularisation of information about serial offenders provides an opportunity to harvest the energy provided by that interest to promote the implementation of FLINTS and its methodologies.

A second interesting perception about the manner in which crime is portrayed in fiction is the concentration on the process of detection. Detection, rather than investigation, is often the theme. Haycraft (1941) demonstrated this in his Murder for Pleasure when he said that "The crime in a detective story is only the means to an end which is—detection." Why are
these authors and their works mentioned in this thesis? Because they help to illustrate the popularly held assumptions about the way crime is perceived in terms of the way it is committed, who is involved in crime and the way it is investigated: The overriding perception in both professional training and literature is the single isolated case, the criminal working alone and in respect of an isolated crime, and the process of detection. Detection is very different from investigation, since the former is practiced on the basis of applied logical deduction and the latter is based on inductive and abductive reasoning. This is an important distinction that offers important insights for those involved in designing training and professional development policy.®

These perceptions of the single isolated crime and the criminal working in isolation ignore the fact that many crimes are committed by groups of criminals working or associating together in various kinds of networks. These networks act as support structures that enable criminals to operate within a semi-organised system. They can gain resources or support in the form of money, tools, people and even intelligence. This latter point is perhaps the most misunderstood feature of crime: Criminals engage in active and passive intelligence gathering primarily to commit crimes, but also to evade arrest. Much of this intelligence can originate from within their network in the form of knowledge that members of the network can gain about the environment in which they live and operate. These networks are sometimes well-organised. The Mafia, the Columbian drug gangs, and even the Chinese Tong are well-known examples of efficient, highly organised networks. Even the "biker gangs" currently plaguing Montreal, Quebec, Canada, are well organised in terms of their associations and communications networks. The investigation of these types of networks has until now been neglected. This is because investigators have been handicapped by the lack of a recognised methodology. Using the methodology presented in this thesis supported by a tool like FLINTS, could let them organise and use the enormous stores of information they posses. The same lessons are applicable to intelligence gathering in the protection of national security.

---

80 Early detective fiction was concerned with detecting who committed the crime. It is now a more sophisticated genre concerned with social commentary.
The present thesis, however, assumes that by far the most common network is a loosely affiliated group in which criminals are known to associate and on occasions commit crime together, when and as the need arises. These networks are more like "social clubs" where people associate on the basis of common interests. However, they do not always act together in an organised manner; instead, as opportunities arise, members of the group may decide to commit a crime together. These networks are usually flat structures rather than hierarchies, but taken together, are responsible for a great deal of crime. In Chapters 3 and 4, it will be seen how networks operate and the extent to which they can commit large numbers of crimes.

The greatest threat that networks present is that they are ideal mechanisms for storing information in informal ways. A group of (say) ten criminals linked in a network is able to obtain and share information from a great many sources as a matter of course. Furthermore, each of the ten members has access to other sources of their own that they may decide to share with the network. The author's experience has been that criminals use networks to aid their decisions about where crime can be committed with acceptable or minimum risk, how new types of crime can be committed and even how the police and intelligence services may be operating in a particular area. This may be information about the patrol strategy or more focused information about the activity of a criminal investigation. The author has experienced the way criminals use networks to attempt to gain knowledge about whether any member of the network is a police informant. This form of information sharing is another misunderstood activity that presents major difficulties to law enforcement and crime prevention.

Acknowledging these issues and updating professional standards of training will be crucial in developing a more effective police and intelligence service capable of protecting public safety and reducing crime.
3.2 Dangers of Bureaucratisation of the Investigation Process

It has been demonstrated in this thesis that the investigation process is a dynamic process that requires a high degree of intellectual activity. Large amounts of information are collected about crime, from many sources: victims, witnesses, offenders and public sources are examples. In England and Wales, for example, there are about 3 million crimes recorded each year. The standard crime report that must be completed for the Home Office is a form that lists 42 separate and distinct items of information that the investigator must provide. This does not include the unstructured text contained in witness statements, and other supporting reports and documents included in many of these dossiers. Even a crude calculation indicates that there are enormous amounts of information to manage and store. What is not always acknowledged is that this mountain of information also needs to be investigated and that it is potentially a "gold mine" of intelligence about issues surrounding crimes, victims, criminals and much more.

In the United Kingdom, a standard approach in law enforcement to the problem of managing information and evidence on this scale is to resort to bureaucratic systems and procedures. In terms of managing and storing information, this is both necessary and desirable. However, one of the drawbacks is that the investigation process is often affected and subsumed by the resulting bureaucracy. As stated earlier in this chapter, managing information is not synonymous with investigation and analysis.

It is common to see a crime recorded and investigated on the basis of two characteristics: the type of event involved (for example, burglary or sexual crime) and the seriousness of the event (for example, the loss of life or sum of money involved). Standard operating procedures develop around particular crime types based on assumptions about the nature

---

81 In the United States there are more than 3000 separate police or law enforcement organisations. Departments tend to be smaller than those seen in the U.K. and Europe. Although the large metropolitan services in urban areas have the resources to acquire information management systems, smaller departments use paper-based systems.
and cause of the problem. Often, this is as simple as the assumption that "those persons with convictions for burglary always commit burglary and those persons with convictions for sex crimes always commit sex crimes". This prejudice does not take account of the migration between crime types or the causal links between two different categories of crime. For example, burglary may be committed to fund a drug addiction and fraud may be perpetrated to launder money for terrorist purposes. Ultimately, this simplistic approach affects the way that cases are recorded, allocated and investigated.

For example, the case theory may narrowly define the population from which the suspect originates. This affects the likelihood of identifying the sources of evidence simply on the grounds that the original hypothesis was too narrow and biased towards a pre-determined conclusion. This problem can often be seen in homicide investigations when lines of enquiry are pre-determined by a prior situational bias towards given explanations. This does not mean that the investigation will ultimately fail, but it often results in wasted time and the danger of erosion of evidence. This "erosion" may be a result of the effects of the eroding memory of witnesses or the erosive effects of the environment on physical contact trace material awaiting recovery. Witnesses are vulnerable to forgetting key details, whereas DNA, Fingerprints and Footmarks at scenes will degrade if left too long in the open environment.

Two examples illustrate, for different reasons, how managing information is not the same as investigating and analysing information. The first involves the Stephen Lawrence (MacPherson Report, 1999) case; the second involves the murder of Jill Dando the BBC TV Presenter of CrimeWatch UK.

At 10:30 pm on 22 April 1993, Stephen Lawrence and Duwayne Brooks were walking along Well Hall Road in London to catch a bus. Stephen Lawrence walked ahead to see if the bus was approaching, whereupon he was attacked by a group of white males. As the attack was mounted, Duwayne Brooks heard the term "what, what nigger" shouted by someone in the group. Duwayne Brooks stated that he ran away shouting to Stephen Lawrence to do
the same. Stephen Lawrence sustained two serious stab wounds in fleeing from the group. He eventually fell and died in the road before an ambulance arrived.

The police arrived and began standard procedures for the investigation of a suspicious death. Despite the evidence provided by Duwayne Brooks, police carried out an initial investigation on the basis that the death was the result of a failed "drug deal", even though there was no evidence at the scene to support that particular case theory, and Duwayne Brooks was treated as a prime suspect in the ostensibly drug-related death of Stephen Lawrence. It took more than one month before the police accepted that Duwayne Brooks was not a suspect but rather an eyewitness who had tried to help his friend escape a group of attackers. The assumptions made by the police and the case theory they formed about the series of events leading to the death of Stephen Lawrence were a product of their perception of the supposed facts they were presented with. Despite the evidence of a racial attack, the police, operating in a well-known area for drug deals that was often used by persons of West Indian decent, decided that the death was the result of a drug-related incident and investigated it on that basis. Given prior intelligence, policing objectives and the performance indicators in force for that area, the police ignored alternative explanations including one (a racially motivated crime) that was obviously warranted by relevant evidence.

Until Brooks was eliminated as a suspect in the killing, the lines of enquiry and the investigation procedures were mounted on the hypothesis that the incident involved drugs and that Brooks was withholding evidence. It later transpired that the killing was racially motivated and the case turned into a racial murder investigation, with Brooks being a crucial eyewitness. Had Brooks been treated on this basis from the beginning, and the evidence he provided of a racially motivated killing treated seriously, he would have been invited into a police car to tour the area in an effort to identify anyone still in the area as a potential suspect. This was not done despite the protests of Brooks. It was later ascertained that the prime suspects for the crime, who later stood trial, were resident in the area. They were part of a network of racists who had targeted "black people" in London.
The second example illustrates how managing information is not synonymous with investigating and analysing that information. Jill Dando, a BBC presenter with CrimeWatch U.K., was gunned down on the doorstep of her home in 1999 in London. Her involvement with the CrimeWatch series suggested a number of motives, all of which involved "organised killing" (i.e., an arranged murder that resulted from her offending someone mentioned in the series) being considered as an explanation for her death. Eventually, a local man with a psychological medical condition was arrested, charged with, and convicted of the crime. The important lesson here was that evidence of this man's identity had been in the murder investigation system for more than 14 months, along with obvious inconsistencies in his alibi. This information lay dormant in the "system" until it was discovered many months later. One contributing factor in this case was the over-reliance on computer systems to manage evidence. This particular problem will now be discussed in more detail.

3.3 Overreliance on Transactional Computers, Over-formalisation and Detraction from Good Thinking

As we have seen, computers provide powerful mechanisms for the management and retrieval of information, but the systems must be designed to support an investigation rather than merely to warehouse data, and they must be used wisely. In law enforcement in the United Kingdom, computer systems have been employed to manage general collections of information as well as specific collections. The former concern information such as 999 Calls to police, and crime reporting and recording systems. The latter concern

\[82\] In an exchange of ideas about the killing of Jill Dando Murder in London in April 2003 between the author and the Investigating Officer Chief Inspector Haemish Campbell and the Commissioner of the Metropolitan Police Sir John Stevens, it was agreed that methods to extract such information would probably have resulted in an earlier arrest. Furthermore, this approach could prevent new crimes being committed if the suspect had remained at large.
computers designed to aid large investigations such as the Stephen Lawrence and Jill Dando enquiries discussed above.

An important distinction needs to be made here about the technology itself. Systems that collect and manage information for law enforcement tend to be transactional systems. That is, they concentrate on the management and processing of the data within very strict formal protocols. In this respect, they are not dissimilar to computers employed in banks, shops and restaurants. They are designed to collate, log, process, count and convey the information between interested parties for what is often called "line of business operations". Transactional computers have limitations when used for investigation and analytical purposes. They are useful in terms of their ability to store data in one place and provide auditable and statistical analyses, but they are deficient in terms of their ability to classify, link, associate and draw useful conclusions from the data. Investigation and intelligence analysis requires the support of systems that provide the latter capabilities.

The two systems described in this thesis, namely FLINTS (Chapter 3) and Maverick (Chapter 5), are both relational databases designed with an inbuilt purpose of enabling investigators and intelligence analysts to ask "good questions" so that "knowledge" can be extracted from the "data" in the system. The benefits of the human and the computer working together need to be stressed.

Overreliance on transactional systems can actively undermine the human creativity required in investigation and intelligence analysis. The computer is an essential requirement for managing large volumes of data and for accessing sections of it, but the computer must be programmed based on the knowledge of a domain expert. That is, the design must be informed by someone who understands what is required of the system, the questions that need to be asked, the best way to arrange and present the evidence, and the types of scenarios relevant to the investigation and analytical processes that are contemplated. A computer programmer can write the "code" to enable the system to operate, but the functions, objectives and processes that need to be undertaken are strictly the province of the domain expert.
In the case of both FLINTS and Maverick, the author of this thesis acted as the domain expert. He instructed and directed the programmer about the functions that he wished the computer to perform and the way that evidence should be handled and presented in visual form. Underpinning this description of user needs was the author's knowledge of and experience in the management, investigation and analysis of evidence. The important point raised here is that the system is needed to augment not replace the skills and abilities of the investigator and analyst. These skills and abilities can be identified, and need to be taught so that these people can use the system to its full potential. Even with sophisticated systems like FLINTS and MAVERICK, the system cannot be given to untrained staff to use. This will be discussed in the next section.

3.4 Training Needs for Investigators: the Logic of Enquiry in Context

It will be clear from the foregoing sections, and particularly from Part 1 of this chapter, that the logic of enquiry and the ability to ask good questions of collections of evidence underpins good investigation and intelligence analysis. We saw that police training and investigative practices have developed a framework of traditions towards the collection and use of evidence. These frameworks relate to and have been shaped by the intellectual understanding of what evidence is as well as the way it is managed and used.

The author identified six weaknesses in training with respect to evidence:

- a concentration on exclusionary rules
- evidence marshalling on the basis of source rather than meaning
- the under-use and misunderstanding of the role of inductive elimination
- a preoccupation with single, isolated cases
- assuming rather than assessing the credentials of evidence
- the systems used to manage evidence are isolated rather than integrated

Each of these areas reveals a different training need. For example, the concentration on exclusionary rules of evidence needs to be supplemented with material on the logic of
enquiry. This material should be aimed at developing problem-solving skills and should include inductive elimination. Furthermore, the ability to assess, describe, consider and discriminate between competing alternative explanations needs to be included. This would support a better understanding of and approach to investigation and analysis as a discipline. Training material and practice also needs to develop a better approach to building an overall understanding of the nature and characteristics of evidence. This entails the creation of a better understanding of a substance-blind approach in which the meaning and knowledge we can extract from evidence supersedes the importance placed on the type of evidence. Because Wigmore, FLINTS & MAVERICK Charts provide effective methodologies for anchoring narratives in complex scenarios, they offer much to the student of evidence in police investigation.

Crime and criminal activity must also be seen in a different way. There is a need to understand crime within the context of the environment in which it occurs. This means teaching students how crime emerges as a result of environmental pressures, tensions and activities. Furthermore, the nature and characteristics of an offender’s view of the environment need to be included. This means providing students with an understanding of how criminals operate, communicate and subsist in their environment as "criminals" within networks of persons. This approach has a great deal to offer investigators and intelligence analysts as well as criminologists. (Leary, R & Pease, K, 2003).

Conclusions and Context for the Remainder of the Thesis

As Chapter 1 has shown, the author identified five key weaknesses in police investigation and intelligence analysis. These were studied in detail. Three disparate sources of inspiration were discovered, studied and used to develop a neo-Wigmorean methodology that despite its origins, represents a wholly new contribution:

- This thesis updates Wigmore's original methodology to take advantage of modern tools and ideas surrounding evidence and proof unavailable to Wigmore. For example, an extended methodology, computer aided management of evidence, forensic science and evidential reasoning.
• The thesis adapts the approach to the needs of the detective and intelligence analyst as opposed to the advocate the original subject of Wigmore's methodology.

• The thesis extends the focus of the methodology from single cases to networks of cases using new conceptions about the nature, characteristics and wide use that can be made of evidence, inference and proof in police investigation.

• The thesis demonstrates how the structure of DNA embodies raw data in the form of the base pairs that form DNA, the commands for use of that data (genes), and the relationships between the data and the commands. Though starting from a simple basis of pairs of only four chemicals, the grouping of these pairs into genes and chromosomes permits the encapsulation and compression of enormous amounts of information and complexity for continual use as a template and operating system for the genome. These aspects of DNA form the basis for the methodology and subsequent software, which unites data and commands for using that data into a system that converts simple inputs (individual items of evidence) into complex outputs (linked items of evidence) including expressions of hypotheses, arguments and suggested inferences.

• The science of complexity reveals how simple rules can lead to complex consequences, and how complex systems can often be broken down into surprisingly simple rules, as is the case with DNA. This same observation is reflected in the procedure for decomposing then reconstructing arguments in the context of evidence-based reasoning in police investigation.

The remainder of this thesis will show how the author has integrated these three sources of inspiration into a single comprehensive systematic approach and a software tool called FLINTS.
CHAPTER TWO

Acknowledging & Using Evidential Diversity

Background
Chapter 1 was concerned with the development and significance of a neo-Wigmorean approach to evidential reasoning. Five key weaknesses in police investigation were identified and discussed. Three sources of inspiration were discovered, studied and used to develop a neo-Wigmorean methodology for police investigation. A key element of Chapter 1 and a specific weakness highlighted, is the way in which the police service treats evidence: Namely, on the basis of the source of the evidence rather than the diverse nature it possesses and the capacity it has for generating good questions.

Chapter 2 is therefore concerned with both acknowledging and using evidential diversity. The chapter begins by examining the need for organisations to become acquainted with the importance of diversity and the symbiosis between evidence, hypotheses and questions. The chapter then goes on to examine evidential diversity and the important issues around the collection, recovery, storage and appropriate laboratory procedures. The importance of recognising high standards in evidence management are emphasised as well as the need for a methodology to achieve and maintain those standards.

2. Evidential Diversity
Evidence in the form of physical, forensic and contact trace material comes in diverse forms and varied combinations. It can be found in places, on things and on people, in all manner of diverse ways and combinations and can be affected by human and natural conditions. The natural processes of erosion, decomposition, as well as expansion and growth over time can all affect the material we identify and recover. Biological evidence decomposes quicker in temperate damp conditions and must therefore be preserved in conditions appropriate to the delaying of decomposition. A footwear mark in soil will erode by contact with other objects or merely by the natural erosion caused by the weather, and this justifies the careful protection of a scene where evidence is discovered. Investigators and
scene examiners entering scenes can trample physical evidence,\(^1\) distort marks and contact traces, and even shed DNA in their breath and sweat. Fibres and ballistic residues on clothing can be dislodged by movement or unpacking. Any object or evidence touched by an examiner or investigator can potentially be contaminated with finger marks, amino acids and DNA as well as with foreign material being introduced to the object under consideration. The way hypotheses and questions are posed and the way answers are received, accepted or eliminated, affects the way in which evidence appears in the arguments we construct. Asking good questions, and using varied and even competing hypotheses, provides a sound basis for the production of authentic, reliable and relevant evidence in investigation.

Scientists handling and testing material in laboratories can unwittingly introduce new material or alter evidence already found merely by virtue of their interaction with materials. So quality control and assurance procedures need to be adopted to ensure that contamination is reduced as far as practicable and that the unintended exchange of material is controlled. Recording the state of evidence with photography, measurements, and observations at key stages in the investigative processes provides some safeguards and a chain of reasoned examination that can be revisited at a later stage. Forensic scientists continually develop new systems and sensing devices to improve the recovery of evidence. Developments in collection systems need to be matched by developments in our systems to protect and maintain the integrity of the evidence and in systems to help explain what our collections of evidence mean. The smaller and more sensitive evidence detection devices become, then the more care we need to take to prevent contamination and alteration of the evidence we collect.

The diversity of evidence sources is vast, hence the potential combinatorial configurations we can use are likewise vast. In the Boscombe Valley Mystery, Conan Doyle had Holmes describing the way in which "the observation of trifles"\(^2\) formed the basis of his method of

---

\(^1\) The Nicola Dixon Murder referred to in Chapter 1: It took 12 months to eliminate footwear impressions from the scene that were not those of the offender. These had been left by officials attending the scene of the crime.

\(^2\) Doyle used term "trifle" to mean detail, data, material, information, intelligence or even evidence.
investigation. Schum (2001a p. 32) describes how Doyle’s approach presents us with many opportunities to recover material useful to us but demonstrates that it also presents us with problems in deciding what to search for and what to recover. Schum (2001b, p.3) discusses the assimilation and analysis of a complicated collection of evidence intended for training intelligence analysts.

A major issue for investigators is the problem of the recovery of evidence and its relationship to events. All manner of tangible objects and traces can be used as evidence; these include the obvious, such as blood, semen stains, saliva, finger impressions, nail clippings, hair, teeth impressions, dentures, ear prints, body impressions and impressions of the feet. We have seen in the previous chapter that until now, evidence has been classified largely on the basis of what it is rather than what it can tell you.

2.1 The Symbiosis of Evidence, Hypotheses and Questions

Evidence can be described in the form of recurrent classes and categories of material and investigators need to develop skill in questioning and decomposing evidence in order to test its authenticity and credibility. A good example are the debates between fingerprint and DNA specialists about which of their evidence types provides the “best evidence.”

---

3 Collecting fingerprints began in 1901 at New Scotland Yard. Vast databases using advanced algorithms have been developed to code and collect fingerprints. However, nothing has been done to integrate them with other evidence types to inform the investigation of multiple cases. Fingerprints (a category that includes palm prints and footprints) should be used as a source of hypotheses to indicate that a person may have been at a particular location on a previous occasion rather than as a source of the ‘fact’ that not only did the person have the opportunity to commit the crime, they did commit the crime. Using fingerprints as a source of hypotheses gives the investigator a prompt (a reason to locate additional evidence to either corroborate or negate the hypothesis under consideration).

4 As Scientific Support Manager for the West Midlands Police, it became increasingly clear that many experts working in different forensic disciplines took a distinctly atomistic view of evidence in their own discipline. The benefits of viewing evidence holistically as well as atomistically were overlooked. The author introduced a new Job Description for crime scene investigators encouraging a substance blind approach. The former Job Description reinforced atomistic and narrow views.
We often hear comments that "fingerprints are unique" or "DNA statistics are so strong that they equate to virtual certainty". What this attitude misses is that evidence in any form and from any source is always context-specific, always uncertain, and totally reliant upon the circumstances under which it was discovered, preserved, recovered, analysed and presented. Evidence never arrives in our hands with its credentials stamped on it. These have to be discovered, shaped and presented as part of the process of investigation and discovery. The products of the discovery process (evidence and hypotheses) and the process itself are symbiotic because one cannot discover evidence without hypotheses and one cannot construct hypotheses without the construction of questions. Questions arise because doubt exists and doubt exists because we have gaps in our knowledge. Knowledge is the existence of facts that we have tested and can rely upon for their truthfulness.

Schum (1994 p. 115) describes the common forms of evidence we typically see: tangible physical evidence, equivocal testimonial evidence, unequivocal testimonial evidence, missing evidence and accepted facts or authoritative records. He says that any of these can fall into classifications of direct, circumstantial and ancillary evidence as well. As we shall see, FLINTS deals in each of these evidence types, but there is a predominance of tangible physical and authoritative facts at the heart of the system. These come in the form of contact and forensic traces and authoritative records kept in databases about people, events, places, vehicles, times, addresses and so forth. Schum explains that we can ask questions about our evidence as well as questions of our evidence. The former would be questions linked to the credibility, relevance and probative force of the evidence, whereas the latter would be those questions designed to elicit new evidence and hypotheses. We will deal with questioning the evidence produced from the forensic processes later in this chapter.

Imagination and curiosity may reveal less obvious evidence such as marks on clothing, scars on the body, colloquial speech traits, and physical habits such as gaits and limps, missing limbs, a tattoo, fingers and body parts. In the West Midlands Police area, a database of reference signatures for graffiti has been set up in which investigators can query particular signatures and signs in an attempt to link suspects to a crime of damage or one in which the signature has been left after the commission of some other crime such as arson or burglary. A knife found at the scene of a murder or wounding is obvious and it may reveal DNA, Fingerprints, or both to identify the offender and victim or victims if there were more than one. Single items of evidence are interesting in proving or disproving some aspect of a hypothesis, but the combination of more than one item can provide both corroboration and a new hypothesis to consider. Finding the fingerprints of “X” and the blood of “Y” on a knife might be compelling evidence to link people and crimes together.

Figure 2. The Combination of Evidence Types.
Figure 2 illustrates a blood-stained Knife. This knife may have a combination of latent finger marks and DNA on its surface that may provide hypotheses about key actors in the crime. Fingerprints in blood and blood on fingerprints are different evidential amalgamations and must be treated differently as we shall see later.

Specialised lighting techniques can be used to enhance injuries like bruising, hidden contusions and lacerations, and these can be photographed (Figure 2.1). Time can be an important consideration in the recovery of suppressed injuries so the use of specialised lighting and photography over a period of days may reveal evidence to implicate the assailant and eliminate other suspects. The injuries illustrated in Figure 2.1 are bite marks fluoresced to reveal impressions of the attackers teeth. Photography over time can reveal more detail as the injury heals. A good strategy is to take photographs of the injury at agreed timescales with medical experts.

A sample can be anything from tangible objects such as weapons, tools and stolen items abandoned by suspects, to stolen property dropped by victims and samples of body fluids, documents or even traces of data from computer hard disks. Some samples may not be visible to the naked eye due to their minute size or their opaque or translucent characteristics, and some samples may be totally invisible unless flooded with fluorescent or laser lighting or washed with a chemical reagent to highlight the substance’s chemical and compound characteristics (Figure 2.1 & 2.2 are examples).

**Figure 2.1 Revealing Evidence – Example 1. Use of Specialist Lighting Over Time for Physical Injuries.**
Figure 2.1 reveals how specialist lighting and photography can help investigators reveal Invisible Marks. A bite mark fluoresced to reveal impressions of the offender's teeth. Taking photographs over time can reveal even more detail. For example, photographs of the injury site taken on day one may not reveal detail observable with a photograph taken on day five. A good strategy is to take a photograph at agreed timescales with medical expert opinion.

**Figure 2.2. Revealing Evidence – Example 2. Footwear.**

**Figure 2.3 Revealing Evidence – Example 3. Handwriting In Shoe.**
Figure 2.2 illustrate how Laser lighting reveals a footwear impression on a car seat. A comparison with normal sunlight reveals the difference. Figure 2.3 illustrates Laser lighting directed at the inside edge of the shoe reveals the name of the potential owner. A common practice in prisons where expensive sports footwear is a prized possession.

Evidence can emanate from a range of sources, and can be found in a range of conditions. As science and technology advances and with new and more sensitive techniques and sensing devices being built the range and extent of our ability to collect evidence is likely to increase. The only restriction on our ability to collect physical and forensic evidence is our imagination, originality of thought and innovation in interpreting what may be relevant to the events or persons under investigation. Figures 2.4, 2.5 and 2.6 demonstrate how magnification can reveal the presence of non-obvious material that may be relevant evidence under certain conditions. Figure 2.4 reveals minute fibres amongst debris. This could be the contents of a pocket, a car glove box or the inside of a trouser ‘turn-up’. The important issue is the imagination needed to look where others might not.

**Figure 2.4 Magnified fragments of Glass, Debris and Fibres.**
Physical objects apparently insignificant at normal magnification can be magnified to reveal highly discriminating physical characteristics. Over time, some of these physical, forensic and trace evidence sources are matched with control samples held in collection systems whilst some remain unmatched. DNA stains, latent finger marks, footwear impressions, tool marks, ballistics residues and cartridges, handwriting, drugs, and toxicology samples are examples of the types of material recovered and compared with reference samples held in various databases and collections.

The numbers of samples generated represent a huge financial investment as well as a major commitment in personnel and time to attend and examine scenes of crime. The process of identifying potential evidence at scenes and then collecting it for analysis and comparison in a laboratory requires great care and skill as well as a wide knowledge of the techniques and methods available. By comparing scene samples with control samples held on record the police can identify people who may have had an opportunity to commit the crime and, by implication at least, begin to eliminate other people in the collection from suspicion. Each match and each elimination generated is a valuable item of evidence that investigators can use to rationalise their search for suspects.

Figure 2.5 Debris from pockets of garments. (Red arrow indicates a computer chip)
Figure 2.5. reveals how minute debris from pockets can be compared with control samples or samples later recovered from other locations in search of physical fits and chemical matches. Note the red computer chip mixed in with debris. Analysis of the chip might provide surprisingly detailed evidence, yet it emanates from debris and a very small object; its relevance could be very powerful.

**Figure 2.6 Magnification & identification of micro objects.**
Figure 2.6 illustrates how the use of magnification techniques can reveal minute items whose presence could not have been detected without a microscopic view. Not only can their presence and potential relevance be considered, but their relationship to other objects can also be considered and compared. Different light and different angles can provide new perspectives on the objects being studied. Note the shadows cast by the light falling on the objects from the upper section of the photograph. By selecting a higher degree of magnification and rotating the plate, those areas under shadow could be examined. This may reveal new material or, potentially, physical fits between these objects.

**Figure 2.7 Chemical treatment of suspected blood stains.**
Figure 2.7. illustrates how Diamino Benzidine has been applied to an area of floor to test for the presence of blood. In the top frame, little transfer evidence is visible, whereas in the bottom frame, evidence of transfer of shoe marks can be seen. The chemical reaction enhances and visualises blood-stains. However, questions "of" and "about" the evidence need to be asked. Evidence may not always be what it seems on first sight. For example, an interesting question to ask here would be "Was the mark made by a transfer of blood already on the sole of the shoe from a different location or, was the sole of the shoe placed into a pool of blood already on the floor?" The former is a transfer of material from outside the scene (blood on the shoe's sole) into the scene, whereas the latter is the result of stepping into blood already inside the scene. This could be crucial in determining a sequence of events concerning the transfer of material.

2.2 Testing the Authenticity and Reliability of Evidence — Asking Questions About Evidence

We can ask questions of and about evidence (Schum 1994, pp. 71 and 93 respectively). FLINTS operates largely on the basis of asking questions of evidence. However, there is also a need to ask questions about our evidence to ensure that the credibility, reliability and authenticity of the evidence is not in doubt. If it is, we will have to reassess the confidence levels we place in it. In this section, we will discuss two broad areas of questions we might ask of our evidence. The first will be the collection, recovery and storage of evidence from crime scenes; the second will be questions of our evidence produced as a result of a laboratory process. These questions can be used by investigators or analysts as well as by advocates charged with defending suspects. The questions are essentially the same; only the context will differ.

2.3 Evidence Collection

Any material collected at a scene of crime should be itemised and described carefully, and the location noted in detail. Photographic evidence should be taken to illustrate the location and the condition of each item on recovery. Items and material should be packaged in accordance with standards laid down by the Forensic Science Service (2000a). In respect of DNA, see Forensic Science Service (2000b. This process includes labelling and assigning
a unique reference number to each item, as well as recording the time and date of the recovery.

2.4 Recovery and Storage

Any material moved from or within the scene of crime should be recorded. It is important that the "chain of custody" of evidence can be referred to in future testimony and for the purposes of proving the authenticity of the material and its presence or absence at any other locations. This can be important in terms of proving that the material was kept away from other material that could contaminate it. Any movements to and from storage or to and from any laboratory and court, as well as the material's return to storage, must also be proven by documentary means. This is an area where a consideration of evidence about evidence and, evidence of evidence is important. Imagine any of the items of physical evidence recovered in the case study. The evidence must first be identified or recognised as evidence at the scene. Its position, condition and proximity to other evidence at the scene may be crucial, therefore a permanent record must be made. Ideally, this should be a photographic record combined with some form of measurement, a written description and a label identifying the object. A log of the evidence recovered should also be made. This log represents a permanent written record of all material recovered. It should include a description of the object, identifying mark, and the name of the investigator recovering it, along with the time, date and place of recovery. The object may then be removed to a safe place of storage. This removal must be recorded in the log, and any movement of the object from the place of storage must also be recorded. That record will include the time, date and name of the person removing the object, where it was transported to, and the time, date and person who returned the object. This record provides a mechanism to prove that the evidence is the original material recovered and a proof of each location and time the material was handled or moved. Standard Operating Protocols dealing with the recovery and handling of evidence were prepared as part of this thesis. See Leary (1999).

2.5 Questions About Laboratory Procedures and Actions

Any material going into a laboratory should be recorded as it is handed to the forensic scientist. A unique reference number should be recorded on the document and the packaging should be checked for correct packing and the presence of any damage. Any
incorrect packaging and damage will render the material useless because the results of any tests will have to weighed against the likelihood of contamination. A description of the material and its unique reference numbers should be recorded to ensure that the chain of custody is maintained. Any break in this chain may subsequently affect the ability of the user to prove authenticity. Diagrams and photographs as well as any movement of the material should be communicated to the laboratory. Any previous testing or requested testing needs to be communicated to the scientist because this may influence future tests conducted with the material. For example, where material (say a suitcase suspected of having been used to conceal and transport a consignment of illegal drugs) is to be analysed for traces of heroin or cocaine and the evidence obtained from the reading is to be used as a profile of the chemical makeup of the substance for comparisons with other recovered samples elsewhere, it is vital to indicate whether any other form of chemical- or reagent-based testing has been undertaken. Analysis of the material using gas chromatography is a common confirmation test. Among its uses are drug testing and identification, as well as the detection of environmental contamination. Gas chromatography separates the components in a sample and gives a representative spectral output. The technician injects the sample into the injection port of the gas chromatography device. This instrument vaporises the sample, then separates and analyses the range of components. Each component produces a spectral peak that can be recorded on a chart in the form of a graph. The size of the peaks is proportional to the quantity of the matching substances in the sample being analysed. The peak is measured from its baseline to its tip. The tests undertaken within the laboratory should be recorded and the condition of the sample noted. If there has been any other form of chemical analysis, it may interfere with the chromatographic analysis and distort the results.

Where material is submitted for forensic examination and that material has previously been subjected to tests, details of the previous tests need to be given and considered as part of the second procedure. They need to be described in detail. If the suitcase in the abovementioned drugs example had been subjected to specialised fingerprinting treatments, new reagents used in the second series of tests (say blood or gas chromatography) could produce false positives.

6 The time that elapses between injection and elution is called the "retention time". The retention time can help to differentiate between some compounds.
The results of forensic analysis should be "Peer Reviewed" by competent experts to ensure that the work carried out was fit for its intended purpose and that the results obtained are consistent with those expected from the tests and the materials used. In addition, do the formulae used withstand tests for accuracy and could they be repeated again with the same result?

Much of the evidence relied upon in the burglary case was tangible, physical and forensic contact trace material. Some of the evidence adduced from the process was self-serving and only had to be produced by a witness to prove its physical presence, where it was found and in what circumstances. Photographs of the window, the door, the writing on the mirror and the debris in the scuff marks where the offender had climbed into and entered the premises would be this type of evidence. Other evidence such as the blood, the fibre on the fence, the footprint, the debris from pockets in the denims, the blood on the denims and the trainer shoe would have been processed by means of scientific tests and procedures. DNA evidence is produced by a complex process that uses gene scanners to extract the cell's nuclear material, uses PCR procedures to amplify this material, then profiles it and logs it in the database for comparison. These categories have undergone complex and potentially damaging processes in which they are treated with reagents to enhance or expose physical and chemical characteristics of the material. Evidence produced under these circumstances has often been changed beyond its original state, therefore questions arise about how it was treated, why it was treated, and whether the results are reliable. At one level we might ask "is it the same material or evidence recovered from the scene?" At another, we might ask "is the PCR result reliable, bearing in mind the efficiency of the machine used to amplify it?"

One way we can test the authenticity of evidence is to ask questions of it with a view to confirming or contradicting the inferences we draw from it. Any processes developed for the purposes of managing and handling evidence can also be subjected to the same process of questioning to establish whether the results obtained are consistent with the

---

7 Polymerase chain reaction. This process amplifies small amounts of DNA into quantities suitable for DNA profiling. The material can be amplified up to 32 times to gain sufficient material.
tests carried out, the way the tests were carried out, and the persons who carried them out. This takes the questioning process further and amounts to asking questions of processes and protocols to establish evidence about those processes that have been designed to generate evidence.

An example here would be protocols produced within a Fingerprint Development Bureau for the receipt, analysis and examination of latent finger marks recovered from scenes and control samples kept for reference and comparison by experts. The underlying purpose is to establish whether the systems and protocols in place have been applied and whether the results are consistent with those expected. Another area for consideration would be the type and ratio of false-positive results achieved over given time periods and the number and type of those false positives.

### 2.6 Standards in Evidence Management – Applying a Methodology

Where evidence has been produced following analysis in a forensic laboratory, there are, in most jurisdictions in the United Kingdom, United States, Canada and Australia, Laboratory Quality Control and Assurance Manuals that provide and lay down procedures for the handling and management of evidence. These manuals extend to overall procedures in the laboratory at the case and individual-test level. Laboratory procedures will usually specify that a case file, with records of the movements and the notes of the scientist carrying out the tests in the laboratory, must be maintained and logged. The fact that standard operating protocols do not exist in a laboratory would be a fruitful line of questioning in cross-examination, so these protocols should be questioned as part of the investigative process.

In normal circumstances, the case file should precisely follow the procedures laid down in the manual. Often there will be proficiency tests published in the laboratory for the use of

---

8 Standard Operating Protocols for Fingerprint Examinations.

9 Standard Operating Procedures lay down procedures for undertaking various tests and performing various processes. They lay down the methodology, equipment to be used, and reagents to be used, and provide "best practices" guidelines. One interesting point is that they invariably approach this goal by reference to the typology of the test, process or scientific discipline: For example, how to undertake DNA extraction from recovered material.
scientists in conducting tests and providing evidence for courts. These can be accessed and compared with the results attained in the tests. Defence lawyers can also access these test papers and data by discovery processes and may cross-examine witnesses on any discrepancies encountered. These discrepancies can be brought to the attention of the scientist by investigators for verification, and even for re-testing to confirm or negate the results. On occasion, the ability to undertake new tests will depend on whether sufficient material has been left over from the original test. For example, blood and other bodily fluids recovered from a scene may be minute samples and may need to be used in their entirety during the process. If this is the case, and a person has been charged or is openly suspected in reports, forensic scientists should invite defence lawyers to appoint an expert to attend the testing process.

Laboratory technicians and those charged with the responsibility for handling and managing evidence and material connected with it, such as reagents and equipment used for storing samples, on behalf of scientists are responsible for adhering to the standard laboratory procedures. Their training, experience and general proficiency are fertile areas that defence lawyers may choose to challenge and explore, so it is important to ensure their training, backgrounds and *curriculum vitae* meet required standards if they are to successfully meet the challenges that may beset them if they are cross-examined in court.

Often, laboratories carry out blind trials as part of their general approach to maintaining quality standards, and results of proficiency tests for the laboratory technician can be made available. The data underlying a laboratory technician’s proficiency tests can reveal important insights into their general levels of proficiency. Managing these standards maintains a high standard of reliability as a product of the process. Material specific to the case, such as the scientist’s and technician’s original notes, can provide valuable ancillary evidence upon which to satisfy oneself [or not] of the standards applied during the handling and testing of the material itself. There may be drawings, diagrams, charts and even spreadsheets, as well as reference databases to bear in mind when considering the relative quality of the evidence.

For example, was the evidence photographed before it was altered, tested and unpacked? An example in which it is crucial that photographs be taken at every point in the handling and testing process is suspected mixtures of finger marks, footmarks, and smudges and
blood. This question would also apply to things such as semen splashes and other bodily fluids. In cases of this type, the combination of a finger mark in the blood of the victim in a murder would potentially provide not only cogent evidence of opportunity and physical contact but also an indication that the suspect was at the scene of the crime at a particular time as well, when the victim was attacked. However, the question may arise in such a case as to whether the finger mark was left prior to the attack and then blood was splashed onto it or whether the blood was splashed and then the finger mark was placed into it.

It is important to be able to demonstrate to third parties that the appropriate test was carried out correctly and in accordance with procedural guidelines. In these types of cases, it is common for the Scene of Crime examiner as well as the scientist to swab the location of the combined finger mark and blood for DNA testing, but the swabbing process will inevitably change the scene mark in some material way. For this reason, it would be crucial to photograph the mark before and after the swabbing to document the chain of events for future reference. Failure to do so would render the investigator unable to satisfy himself, let alone any other person, that the material was handled in a particular manner which resulted in a particular outcome.

A similar area for consideration involves secondary contacts between evidential materials collected from scenes and the tools and equipment used to process and test the material. This consideration may apply to packaging materials as well because they too may cause the contents to alter upon contact. In these circumstances, it is always necessary to take a control sample from a surface where (say) a blood or saliva or semen stain has been swabbed to provide a control mechanism (a basis for comparison) in subsequent tests. A second swab should be taken from the same surface, but away from the evidence being recovered, as this will provide a permanent record of the state and condition of the surface being swabbed as well as any latent material present thereupon.

Photographic evidence provides a powerful record of the condition of material and the surrounding location. It can be used for the recording of positive and negative controls, of the state of equipment before and after tests, as well as of gels and filters used for the processing of material. These are all good examples of the way in which evidence needs to be carefully handled.
Validation studies are sometimes available from a forensic laboratory. The study results are useful for testing and measuring the relative worth of the results obtained and the possibility of false positives. In addition, documents relied upon or referred to by the scientist and technician in reaching conclusions can also be useful for assessing the relative weight to be attached to a finding – *either positive or negative*.

**Conclusion**

This chapter has been concerned with acknowledging and using evidential diversity. We have seen how evidence comes in diverse forms and varied combinations. Furthermore, that it can be found in places, on things and on people in varied ways and combinations. These can be affected by human and natural conditions. Questions therefore need to be asked of and about evidence to ensure that it is reliable. In the next chapter, we will examine the FLINTS 1 technology, then the FLINTS 2 technology, to determine how the software has been designed and built to meet the needs of a modified form of Wigmorean analysis. That is, how it has been designed to manage, analyse and synthesise masses of evidence.

---

10 Membership in professional associations and bodies can also assist the user of the evidence by providing ideal material for assessing the credibility, reliability and veracity of the expert's evidence, as well as for checking the validity of laboratory protocols. Some professional bodies, particularly the medical profession, also require members to adhere to codes of ethics and these or like requirements for membership in professional bodies can provide evidence to support or negate a witness' testimony.
CHAPTER THREE
FLINTS 1 and 2

Background
As we saw in Chapters 1 and 2, the traditional approach to the management of evidence in policing has involved narrow conceptions of the way evidence is managed, analysed and used. The author’s experience demonstrated that practitioners\(^1\) adopted narrow views as well as uninspired approaches\(^2\) towards the study and use of evidence. This included the way that evidence should be collected and the many uses to which it could be put. A common experience was that whilst cases may appear to be overwhelmingly proven "on paper", by simply adopting another standpoint or considering an alternative explanation about some aspect of the case, an alternative view could be deemed not only plausible, but often persuasive. Often, this was the result of investigators treating and interpreting evidence only in the light of the hypothesis they were pursuing. Evidence is too often seen in light of the support it can give to a narrow or single hypothesis.\(^3\) Alternatives are not considered, or, if they are,

\(^1\) This includes police officers, Crime Scene Investigators and lawyers.
\(^2\) The author found that some police officers failed to search for evidence that was against a favoured hypothesis. Evidence is usually available, in some form, somewhere, and it is only a question of determination, ingenuity and patience that is needed in finding it. The need for evidence to be tested by others was an issue often overlooked. These reviewers of evidence may be Crown Lawyers, Defence Lawyers, a Jury or a Judge, and any suspect; therefore, the author felt a responsibility not only to satisfy his own perception of the evidence, but also to demonstrate that arguments in favour of some hypothesis, as well as those counter to it, had been considered. Balance in listening to both sides of a story paid off. Generating new lines of enquiry or the development of sources of covert information from the public and from within the criminal fraternity. Anticipating the opposing view, seeing evidence from different perspectives and demonstrating that evidence had been collected in support as well as negation of a hypothesis was crucial. Whilst it is never possible to overturn every possible stone, it is possible to demonstrate that one has overturned every reasonable stone, bearing in mind the available evidence and the issues under investigation.

\(^3\) Schum (1987) was commissioned to provide training material for a federal agency in the United States responsible for intelligence assessments. The material was ahead of the times and like Wigmore, failed to make the impact it deserved. However, like Wigmore, his work is now demanding the attention it deserved two decades ago. His failing was to under-estimate the
they are dismissed too readily. Narrow or single hypotheses often appear in the form of a case theory. For example, the theory may propose that a particular act had been perpetrated by a particular individual, or that an event took place "in the following way", thereby favouring a particular explanation. This narrow view has implications not only for single cases, such as the investigation of historical events or crimes, but also for intelligence analysis and predictive enquiry. In terms of single cases, it creates barriers to the consideration of alternative explanations. Evidence that may support an alternative theory may be ignored, resulting in the wrong conclusion being drawn. In terms of intelligence analysis, the narrow focus can prevent users of evidence from considering fruitful lines of enquiry that would potentially prevent a threat from becoming a reality. Simple explanations or those that appear obvious are considered at the expense of those more difficult to uncover. Collections of evidence often contain many layers of information in which indirect links and associations may not be immediately obvious. Accessing and testing these areas of our collections of evidence present many opportunities for the discovery of new knowledge. For example, see Schum (1986).

This insight provided valuable lessons about the way evidence is sought, collected and used, and seemed crucial to developing a better approach. What seemed to be missing was the development of a truly systematic forensic attitude towards the management and use of evidence.

3. FLINTS 1

FLINTS is a modernised neo-Wigmorean approach to the management, analysis and use of evidence in pre-trial criminal fact investigations. It was designed on the basis of the methodology in this thesis to model the relationships between people, crime, locations, times and evidence in ways useful to analysts, investigators and policy makers. Wigmorean evidence modelling serves a number of purposes in the generation of intransigent nature of the profession and to assume that logical, common sense approaches would be recognised. See also Schum & Tillers (1988) and (1991a) and (1991b).

"Forensic" is intended to convey an interrogative, questioning approach. The Shorter Oxford English Dictionary defines the term as "pertaining to, connected with, or used in courts of law; suitable or analogous to pleadings in court; or a speech or written thesis maintaining one side or the other of a given question."
and discovery of knowledge. However, there are two principal purposes it is concerned with: first, the provision of understanding of the attributes of evidence we already possess about events that have already take place, and second, the provision of insights into evidence we do not yet possess, but need, and into events that may yet take place. At the end of this chapter, a case study in "linked burglary crime" is described, and the methodology and use of FLINTS are demonstrated.

In Chapter 1, the argument was put forward that policing has suffered from a lack of knowledge about the structural and intellectual questions surrounding the collection and use of evidence as a discipline and has therefore been unable to construct a conceptual framework and a set of operating principles that would allow police organisations to gain maximum knowledge from their collection of evidence.

The mechanisms put forward in this thesis to aid the modelling of relationships within networks of evidence are achieved by organising the systems and structures under which evidence is discovered, collected, considered and stored so that links and connections inherent in the evidence can be speedily established. This in turn aids the formation of new hypotheses and the elimination of old hypotheses. Questions can be asked of the system to draw on the complex combinations of evidence that already exist, but that are perhaps not readily known, as well as those combinations and connections not known to exist but that are strongly suspected to exist.

This demonstrates that although we may be in possession of information, we are often unaware of the evidence's existence, or, if we are aware of its existence, we are sometimes oblivious to its meaning and the links that exist within the information. The contribution that approaches like this can make to developing our understanding of the environment in which we operate is underestimated. What we "possess" and what we "know" are often very different. Establishing the difference between what we possess and what we know provides the ability to establish what we "do not possess" and "do not know". Optimising systems to undertake this function is crucial in getting the most benefit from the evidence collections we have. Applications for use of this approach are numerous.
Identifying links and connections between crimes and events that we know\(^5\) have taken place and people that we believe are connected to these occurrences helps us to identify links and connections with other crimes, events and people that *may* be linked, but for which evidence is currently not available to justify, negate or sustain that belief.\(^6\) Investigators can set out to establish whether sufficient evidence, even if not presently available, does exist in some form, somewhere, to justify or negate the hypothesis. This helps us to investigate crime not only on the basis of single events in time, but also on the basis of chains of events in time and space, and thus represents a whole new way of thinking about crime investigation and intelligence analysis. Let us imagine a series of ten crimes of burglary linked on the basis of DNA evidence.

**Figure 3 Hypothetical Series of 10 Crimes Linked by a Single DNA Profile.**

\(^5\) Here, the term "know" does not mean a fact that has been established beyond challenge. It means "that which we are prepared to accept on the basis of reliable evidence currently in our possession".

\(^6\) Challenge may come in the form of counter-arguments put forward by our adversaries or, just as importantly, counter-arguments we construct ourselves to test some argument that we are persuaded by. The former is simple; adversaries or colleagues may favour another argument or explanation that they put to us in the form of a challenge, and we can deal with it on that basis.

The latter is sometimes difficult because it involves constructing counter-assertions ourselves, often in the knowledge that we are already satisfied with the current explanation. The approach may go something like this: "Is this explanation or argument sustainable if new evidence were to be made available?" Alternatively, it may go like this: "Is my explanation or argument sustainable in the light of the following alternative hypothesis?" This thought process may involve considering a range of possible explanations or arguments ranging from that which is highly probable to that which is highly improbable. It may also involve considering that which is impossible. The reason for this is simple: that which is impossible on the basis of evidence currently available may become possible in the light of new evidence or some other explanation.

The process may instead be as simple as viewing the evidence we currently have in a different light or from a different standpoint.
Figure 3 illustrates that at each of the 10 crimes, DNA evidence in the form of a crime stain was recovered. The hypothesis is formulated that these 10 events are linked because DNA recovered at each crime scene has produced the same genetic profile, namely that of suspect "A.

We can formulate a hypothesis that the donor of the DNA at each of the scenes of crime is the same person, even though we do not yet know their name. In an effort to identify the donor of the DNA, we might search for any matching DNA profiles from former suspects and convicted persons stored in the National DNA Database. However, it's possible that after the search, despite our establishing that the crimes appear to be linked, no profiles from suspects and convicted persons matched Profile A. We would then be left with the task of identifying the offender by other means.

3.1 Identifying "Unknown" Offenders

How can we set about identifying "unknown" offenders? We could sit around and hope that we "get lucky" or we could appeal for witnesses to the events in the hope that someone, somewhere, might have the evidence we need. One effective approach is to explore methods that reduce the level of uncertainty associated with the number of people in the database that could account for the DNA profile.

We can create a "virtual offender" to account for the presence of DNA Profile A at the scene of each of the crimes and await other evidence that might indicate a legal identity. This can be done by systematically exploring the information we already

7 A "crime stain" means DNA recovered in some form from a crime scene and awaits matching against reference samples stored in a database. A match with one of these samples would enable the investigator or analyst to formulate a hypothesis that the individual may have had the "opportunity" to commit the crime. It does not necessarily mean that they did commit the crime.

8 In addition to the problem of false positives and adventitious matches, investigators and analysts should also keep in mind that identical twins share the same DNA code. The hypothesis that a suspect may be an identical twin must always be considered.

9 The ideal position is to be able to eliminate (reduce uncertainty) all persons except one. Once we have reduced the uncertainty to a single individual, we can then use other evidential tests to challenge the reliability of the analysis and conclusion.
possess to ascertain whether there are any indications anywhere in our systems as to the possible identity of the individual who possesses DNA Profile A. Not only might this produce a suggestion of their identity, it might also lead us to search for additional information in areas where we are likely to find useful indicators of the offender's true identity.

So far we have only considered DNA evidence recovered from each of the 10 crimes. There may be other evidence available that we have not considered. Fingerprints, footwear, tool marks, handwriting, hairs, fibres, witness evidence and other clues may provide a suggestion about the likely identity of the suspect if we consider this evidence alongside the DNA.

Imagine that a fingerprint found at burglary 4 is identified as the index finger on the right hand of a known former burglar called Mr. George Smith. The question then arises: "Does George Smith have DNA profile A?" If he does, fingerprint evidence has suggested a method to establish the identity of the original donor of DNA profile A—possibly Mr. George Smith. If the answer affirms this, then Mr. George Smith may be asked to provide a DNA sample for comparison and, if matched to DNA recovered from one or more burglary scenes, asked to account for the presence of his DNA at each of the 10 scenes. Other evidence types can also be used in this way.

Many types of evidence can help us to identify people that we know exist in the population but for whom we have no means of distinguishing them as individuals. Used in combination, these sources of evidence present us with a range of possibilities to identify individuals uniquely. Some involve direct and some involve indirect chains of reasoning.

3.2 Systemising the Identification of Unknown Offenders

Policing and intelligence work has for too long approached the identification and elimination of suspects in a conceptually narrow way. The focus of attention has been on the use of names rather than a wider concept involving the use of "indicators of
"identity". Intelligence systems employed in law enforcement use names as the key identifier. The same is true of evidence systems used in fingerprint and other forensic databases.

The ability to systematically (and routinely) identify "persistent offenders" has great potential for decision-making and for optimising investigative effectiveness. Identifying those persons who commit most of the crimes in our systems offers greater returns on the investments we make in the deployment of staff and financial resources.

The use of a wide range of indicators of identity can be used rather than narrow, single indicators (typically only a name) to provide a more inquisitive methodology for identification. Rather than simply referring to offenders by either their name or as simply "unknown", they can be referred to as "virtual unknowns". They can be classified and catalogued in a database alongside indicators of the characteristics we do know. As the investigation of crime continues over time, we can explore different combinations and different inferential chains of links by using these indicators in combination to help us set about filling in the gaps in our knowledge. Researching direct and indirect chains of links may eventually produce or suggest a possible indicator as a means of identification.

Let us consider this approach in detail. If we are satisfied from the available evidence that a crime has been committed, we can infer that someone who may (as yet) be unknown committed the crime. Unknown persons can be classified as "virtual suspects" simply by giving them a unique number to act as an identifier until their true identity is discovered. Once we have allocated a unique number to the "unknown", we can then think about them as a "virtual unknown" person. This provides us with a whole new way of thinking about the problem of identification. We can use a range of indicators about their characteristics, their identity or their personal circumstances to do so. Taken

---

10 This concentration on the use of a name as a means to identify people is surprising bearing in mind the large proportion of the population that share the same name. Some with the same name even share the same date of birth.
together, these indicators can provide the means to link different aspects of identity until one or more of those indicators provide a suggestion of a name.\textsuperscript{11}

It is the ability to develop and navigate direct and indirect chains of inference between indicators that presents the opportunity to identity individuals. This is an example of a broader use of the concept of evidence and the wider uses to which it can be put. Figure 3.1 is a "multidimensional identification index" designed to present a systematic approach to the use of a range of indicators to identify people.

**Figure 3.1 Range of Indicators of Identity**

<table>
<thead>
<tr>
<th>Evidential indicators of identity</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Birth date or age</td>
<td></td>
<td>#</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Address zip code</td>
<td></td>
<td></td>
<td>#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. E-mail address, number</td>
<td></td>
<td></td>
<td></td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>5. Father's reference number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>6. Mother's reference number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>7. Male siblings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>8. Female siblings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>9. Height</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>10. Eye colour</td>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Hair colour</td>
<td></td>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>12. Ethnic origin</td>
<td></td>
<td></td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>13. Shoe size</td>
<td></td>
<td></td>
<td>#</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>14. Biometric identifiers:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Eyes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Facial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Fingerprints (10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. DNA profile</td>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Genetic characteristics:</td>
<td></td>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>(a) Hair colour</td>
<td></td>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>(b) Eye colour</td>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Sex</td>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Ethnic ancestry</td>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Height</td>
<td></td>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>17. Body marks; tattoos/scars</td>
<td></td>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>18. Vehicle number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>19. Electoral roll number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>20. Nationality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>21. Passport number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>22. National Insurance Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>23. Driving licence number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>24. Credit card number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>25. Taxation number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>26. Telephone number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>27. Cell phone number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>28. National Identification Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29. Associates with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>30. Employed by</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>31. Educated at</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>32. Related to</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>33. Criminal convictions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>34. Occupation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
<tr>
<td>35. Name (legal/accepted)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>#</td>
</tr>
</tbody>
</table>

\textsuperscript{11} A "virtual suspect or offender" is a person who is known to exist because evidence of their presence at a scene of crime has been discovered, but whose identity is yet to be established.
Referring to Figure 3, let us imagine that Event 2 was a burglary in which the offender shed hair. Subsequent DNA analysis of the hair produced a DNA profile. However, no reference sample of the offender existed in the National DNA Database, therefore the offender cannot be immediately identified by name. Genetic information gained from DNA profiling of the hair provided further information about the person's physical characteristics: their hair colour, eye colour, ethnic ancestry and height. These additional indicators are used to begin to fill gaps in the "virtual persons record" that may become useful to us.

The same DNA profile is found at Event 4, the theft of a motor vehicle. A witness to Event 4 states that the offender was seen to have a distinctive tattoo on his right forearm: an eagle and sword. He was aged between 30 and 40 years, was a white European and had brown to red hair.

Because Event 4 revealed the same DNA profile as Event 2, we can begin to cross-reference specific details of "indicators" from Event 4 to Event 2.\textsuperscript{12} The index demonstrates how we can use a method of cross-referencing evidence from one event to another so as to provide us with a system to navigate inferential links, gaining clues to the identification of individuals and even groups of individuals as we progress. In this example, it can be seen that the DNA recovered in Events 2 and 4 provided us with genetic information about the offender's physical characteristics and ancestral ethnicity, and these become a part of the index.

A search of the tattoo file in the "multidimensional index" reveals that two people are known to have a tattoo of this description: a male aged 65 years, of West Indian appearance and with a recorded name of Charles, and a 32-year-old male of White European appearance called Finney. Neither had previously provided DNA profiles. The system could be automated to check for those persons within the population with

\textsuperscript{12} For example, the original Indicators (DNA, tattoo, age and hair colour) that we discovered from Event 4 are marked with a red (#) sign. Because the same DNA profile was found at Events 2 and 4, we can infer that all details for Event 4 should also apply to Event 2. These inferred indicators are marked with a blue (#).
indicators that match a tattoo as well as any other indicators available. This narrows down those in the system that could potentially match with the available information.

Computers can be used to manage and track the chains of connections produced by this kind of cross-referencing. Although the methodology is simple, the potential links involved soon become complex and require an efficient means of tracking and cross-referencing. This process helps us to eventually establish an identity using the conventional method of a legal name, ultimately reducing the uncertainty about the legal identity of the person of interest to us. Another useful attribute of this method is that the indicators of identity can be searched in predetermined ways involving one indicator or a combination of indicators to "cleave out" of the system configurations of information of interest to us. We may need to identify a white male, aged 50 to 55 years, with brown hair and blue eyes, and who drives a white BMW car. This may produce a range of potential suspects, some with known legal names and others still classified as "virtual unknowns". Again, the process of cross-referencing indicators, combining indicators and exploring inferential routes between records may produce an indicator of interest in determining a true identity.

Let us consider another aspect to this process. The evidence we have does not mean that the "virtual suspect or offender" was alone when the crimes were committed; they may have committed any one or any combination of these crimes with any number of other individuals. The index may provide evidence of links between individuals and hence their potential identity. Even the notion of "virtual criminal networks" can be handled by means of this approach. For example, we may have evidence in our system to suggest that a number of crimes have been committed, and by means of a range of indirectly linked indicators, a complex network of links between a group of people may be suggested. These groups can be used as sources of suggested names for elimination purposes. As with the fingerprint evidence at burglary 4 in Figure 3, if we can establish an accomplice of our "virtual offender" acting in concert at (say) burglary 6, that evidence (whatever it may be\textsuperscript{13}) may suggest a potential name for the donor of the DNA found at each of the 10 crimes.

\textsuperscript{13} Evidence should always be subjected to questions about its reliability, relevance and probative force.
Chapter 4 explores and demonstrates how modelling networks of offenders can assist in the identification of suspects and groups of suspects for crimes that may already have occurred and for crimes that are yet to occur if action is not taken. For the moment, let us consider how this can be done and how FLINTS can assist in this.

Searching each of the 10 crimes for additional evidence types such as a fingerprint or tool mark or footwear impressions may give rise to suspicion about a group of suspects or even an additional single suspect who may also have been involved.

Figure 3.2 demonstrates how a multidimensional approach to evidence management and analysis can aid in the detection of links between series of crime evidence and people. The same approach can be used to detect links between groups of people, geographic locations and chronologies using different mixtures of evidence. Figure 3.2 is an illustration of a database of crimes that can be examined for linkages on the basis of different evidence types. Each square in the illustration represents one crime. Each blue square is a crime scene from which DNA of type A has been recovered. As already stated, these 10 crimes are potentially linked.

A useful question might concern which of the remaining crimes in the database are linked based on an analysis of a variety of evidence types and, importantly, which are linked on the basis of combined evidence types. If any other evidence type (for example, those listed in the illustration) can provide a suggestion of a linked suspect, then we can set out to implicate or eliminate that suspect based on the DNA evidence.
Inferential links may be discovered on the basis of high frequencies of offending in particular geographic areas or where a crime bears a particular *modus operandi*. These observations may reveal interesting patterns to consider as hypothetical links within the original linked series. This may reveal evidence that suggests suspects for consideration in the original series linked by means of DNA.\(^\text{15}\) Using this idea, a search of the FLINTS system may reveal potential suspects on the basis of the frequency of crimes bearing striking similarities to the series of 10 that are believed to be linked.

Investigators and analysts can begin to discover and understand complex networks and connections between people, events, locations, times and evidence in ways not previously possible. FLINTS not only allows this to be done—it allows it to be done speedily, efficiently and with reliable and actionable results. In *Foucault's Pendulum*,

\(^{14}\) A Finger mark at linked crime 6 suggests the name "George Smith" as a suspect. Smith may possess DNA profile type A. If so, we can connect him with the series of 10 linked crimes. If he does not, one of his associates may. Other evidence types may indicate additional links between other crimes and Smith as well as other series of crimes and other suspects. Some of the new suspects may be connected to Smith as associates.

\(^{15}\) One of those crimes may have been detected or there may be an item of evidence at any one of the crime scenes that may provide an insight into the identity of the "virtual suspect or offender".
Eco (1988, p. 225) describes an innate characteristic that exists in databases of information. This description could well have been a description of FLINTS:

"No piece of information is superior to any other. Power lies in having them all on file and then finding connections. There are always connections; you have only to want to find them."

FLINTS is designed to act as an evidence integrator that brings together collections of evidence and arranges them in such a way that users can formulate questions. The principal objectives are to enable the marshalling of substance-blind sources of evidence that enable links between people, events, locations, times and evidence to be discovered by the process of analysis and questioning.

Figure 3.2 demonstrates the fundamental principle of integration, management and analysis of evidence around the key attractors of people, events, locations, times and evidence. If we begin from the lefthand side and work through the chart, we see that evidence is put into the system from various sources. These may be sources such as fingerprints and DNA, but in fact can be any class of information that we determine as reliable. "Accepted fact", a concept well understood in law, has great potential in intelligence analysis. There are many facts about the way we live, work, behave and communicate that are generally available. These characteristics can be used as evidence in the form of "accepted fact" and treated in much the same way as DNA, fingerprints and other forensic evidence types.

Evidence of many kinds is integrated in the FLINTS database around the key attractors of people, events, locations, times and evidence so that links, associations and connectivity within the data can be detected. The system allows questions to be formulated in a structured way by investigators and analysts using a conventional computer that runs Microsoft Windows supported by a graphical user interface.

Figure 3.3 is an illustration of the flow of evidence.
3.3 First Generation of FLINTS

The prototype FLINTS system began managing forensic evidence matches for the Midland Police in April 1999 following a request from the Chief Officer of the service to use the system. The system had been designed to demonstrate the benefits of its underlying concept and used fingerprint and DNA evidence to do so. Evidence based on footwear, handwriting, tool marks and drugs were soon to follow. The system provided for the integration, management, analysis and performance measurement assessments as well as for the systematic allocation and management of enquiry work. Protocols designed for key managers and key analytical tasks became part of the West Midlands Police strategic policy.

Forensic matches reported by departments for specific evidence types are input into FLINTS by means of a standard formula. For example, DNA matches reported by the National DNA Database, fingerprint matches reported by the West Midlands Fingerprint

---

1 This system was the prototype version of FLINTS.
2 FLINTS was designed an executable computer programme for use in forensic investigation. Other applications were not pursued as computer programmes at this stage.
3 The enquiry work referred to is often called an "action package". This package is a file of evidence produced by FLINTS that contains all the necessary evidence, photographs, plans and ancillary intelligence necessary to carry out an enquiry.
Bureau\textsuperscript{19} and physical evidence matches such as footwear and tool marks reported by forensic laboratories are brought together in the FLINTS Bureau for entry into the underlying databases.

Strategic and analytical management tasks can be undertaken for a wide variety of purposes. Some of the tasks undertaken: maintaining a "tracking system" for the enquiry work allocated, assessing the performance of operational police areas by individual evidence types as well as by individual scene examiners, comparing evidence yields by operational areas and individuals, managing information about suspects identified, and comparing operational areas for trends.

3.4 Integration, Linking and Analysis Tools

From the initial implementation, it became apparent that FLINTS gives the user access to ranges and classifications of intelligence data about people, events, locations, times and evidence. The system enables the user to "visualise" the evidence in a number of ways that provides a range of perspectives on the data. Geographical visualisation, network visualisation and spreadsheets of varying kinds can be requested and presented in user-friendly ways. Wigmore (1913b. p.751) in his "Explanation of Apparatus for Charting And Listing The Details Of A Mixed Mass of Evidence" was a clear recognition of the power of visualising the use of evidence and argumentation. FLINTS is partly based upon this methodology and therefore represents a neo-Wigmorean approach.

Conan Doyle gave Sherlock Holmes a number of attributes important to his task that are rarely all seen at once in analysts and investigators in real life: keen curiosity, high native intelligence, a fertile imagination, powers of perception, a good stock of knowledge and extreme ingenuity. Holmes explains to Watson the difference between some of these attributes in \textit{A Study in Scarlet}: (Baring-Gould 1967; Vol. 1, p. 231).

"I have already explained to you that what is out of the common is usually a guide rather than a hindrance. In solving a problem of this sort, the grand thing is to be able to reason backwards. That is a very useful accomplishment, and a very easy one, but people do not practice it much. In the every-day affairs of life it is more useful to reason forwards, and so the other comes to be neglected. There are fifty who can reason synthetically for one who can reason analytically."

\textsuperscript{19} Fingerprint matches are input automatically, but their quality must be checked by the intelligence system's manager.
In *The Five Orange Pips*, Conan Doyle has Holmes explain to Watson the importance of understanding how chains of events can be studied and reasoned about. He says (Baring-Gould 1967; Vol. 1, p. 398).

"The ideal reasoner would, when he has once been shown a single fact in all its bearings, deduce from it not only all the chain of events which led up to it, but also all the results which would follow from it."

There are no formal rules in existence for "reasoning" and, if they did exist, they would represent a logic of discovery. Schum (1994, p. 479) believes that this illustrates what he calls "bottom up and top down" reasoning.\(^{20}\) These are useful metaphors because they can aid investigators and analysts in understanding the frame of thinking in which they are operating.

FLINTS goes some of the way towards helping analysts and investigators develop their curiosity; because they are provided with high-quality data, and the system operates on the basis of questions, the user's imagination and perception of events, people, locations and times are important. This mass of knowledge and data is stocked, awaiting enquiry by users. Although FLINTS can never replace human powers of reasoning, it does provide a foundation and system from which users can access evidence, analyse it, synthesise questions and hypotheses, and visualise results in ways that are easily understood. In addition, the system then allows the results of those queries to be entered into the system as new inputs in the form of new questions in a iterative and continuous quest for new knowledge. The analyst and investigator can access substance-blind evidence about series of crimes, networks of active criminals, crime patterns, and areas where the frequency of crime is high. It can also identify travelling criminals. The system concentrates the mind of the user on using the weight of the evidence to link nodes rather than on the type of evidence involved.

Although the Home Office is considering the potential of FLINTS and the approach underpinning the software to enhance the use and management of forensic evidence

\(^{20}\) Schum provides a diagram illustrating how these processes aid the generation and testing of hypotheses.
and intelligence nationally (Home Office 2001, p. 3), it acknowledges that much more could be done to train users to get the best from the system.21

"The FLINTS system has the potential to support substantial improvements in police efficiency and effectiveness in West Midlands. However, the force is far from using the system to its full capability. This includes the as yet untapped potential for FLINTS [to be used] as a senior strategic management information tool. West Midlands should therefore refine its FLINTS Project Plan so as to maximise its beneficial impact... This national potential includes the opportunity for forces to improve detection of crimes22 committed by offenders across policing boundaries."23

3.5 Expanding FLINTS to Other Police Areas
In April 2001, following a recommendation from the Regional Forensic Science Group,24 FLINTS began to manage forensic matches for West Mercia, Warwickshire and Staffordshire by means of a wide-area computer network linking the forces together. FLINTS gave the forces access to all West Midlands databases dealing with crime, incident handling25 and custody data via FLINTS computer terminals of the type described towards the end of this chapter. In the future, it is predicted that each of

21 FLINTS had been adopted by the West Midlands Police, the Warwickshire Constabulary, the West Mercia Constabulary, the Staffordshire Police and the Hampshire Constabulary. Many others are considering adopting it. The system was recommended as a "best practice" by two of Her Majesty’s Inspectors of Constabulary. The first, Keith Povey, is now Her Majesty’s Chief Inspector of Constabulary; the second is Sir David Blakey.

22 It should be noted that the reference is plural. This is an important feature of the rationale and design behind the FLINTS approach. FLINTS manages evidence and information about volumes of crime as well as single crimes. The traditional approach is based on managing evidence and information as single cases.

23 There are 43 police forces in England and Wales. There is a natural tendency in each force area to concentrate on crime committed within the force's boundaries, and crimes committed elsewhere attract less attention. This provides the opportunity to criminals to travel to commit crime. Criminals who reside in one police area and who travel to commit crime in other police areas are difficult to track and detect, and pose a serious threat to the community. National Criminal Intelligence Service provides support to forces nationally in dealing with travelling criminals, yet no national system to monitor criminals. FLINTS could fill that gap.

24 Forensic science and best practice is monitored jointly by a number of police and Forensic Science Service Regional User Boards.

25 The system is called "Command and Control Data". This includes access to the emergency (999) system.
these forces will also integrate all their current non-forensic databases of police information into FLINTS so as to realise the benefits that the West Midlands region is seeing. At present, the Midland region of police forces communicates using high-bandwidth networking technology and shares all forensic intelligence data. It is the first Region to have adopted this approach. In the illustration (Figure 3.4), the current FLINTS communication channels are indicated by red lines: these represent the present flow of data. However, note that these lines do not yet make for a complex system whereby each force can communicate with any other force or combination of forces as needs arise.\textsuperscript{26} In the future, there will be an expanded capacity whereby each force will effectively input its data into one system, communicate in complex ways and make thorough use of feedback looping (the blue lines in Figure 3.4).

**Figure 3.4 Current and Future Communication Channels.**

In addition to these police services, a number of others expressed an interest in inputting their forensic match data into the system so that it can be shared in exchange for the improved analytical capability they would obtain.\textsuperscript{27} This will enlarge the network and database, and will extend the system’s analytical capability. The benefits of extending the system to other police forces will be the wide-scale integration of

\textsuperscript{26} Feedback loops involving an iterative process of hypothesis generation, testing and regeneration are limited. Chapter 4 discusses the importance of this type of process in the search for new knowledge in systems.

\textsuperscript{27} Hampshire began using FLINTS in 2002. Two national Home Office projects, CRISP and VALLIANT, are studying the potential to link the databases of every police force. On 10 April 2002, the CRISP Project Team met with the author, and subsequently reported that CRISP is considering using FLINTS as the central analytical tool for managing and interpreting the information.
evidence managed in those force areas. As of April 2002, with the exception of the Midland Region and Hampshire, each evidence type was managed within isolated systems. The benefits of a substance-blind integration and treatment of evidence has yet to be realised in those areas. For example, police forces outside the Midland Region cannot manage matches from their diverse evidence types within one system, they cannot access management information about matches with other evidence collections and they have yet to automate the preparation of Evidence and Intelligence “action packages”. In short, Wigmorean approaches have yet to be adopted, but the tide is beginning to turn and FLINTS, with its ancestral foundations in Wigmorean analysis, is proving to be the catalyst for this change.

Access to accurate intelligence is central to being able to exercise good decision-making in policing. FLINTS achieves this “good decision-making” by providing access through the integrated management of evidence as well as through a structured approach to the asking of questions of and about the evidence itself. Wigmore knew even in 1913, when he published his first edition of the Principles of Judicial Proof (Wigmore 1913b) that the visualisation of evidence is crucial to gaining an understanding of the complex relationships and dependencies that exist in evidence. The ability to visualise links and networks is central to the ability to generate new knowledge about the evidence we possess and the hypotheses we are constructing by asking questions.

3.6 Volume^{28} Crimes and Volume Suspects: Not Single Events and Single Suspects

Police forces in the United Kingdom are based on geographical and political boundaries. Though there are benefits to the geographic organisation of the 43 police services in England and Wales, one drawback is the fragmentation of intelligence. Criminals often travel from one geographical area to another to commit crime, often intent on frustrating intelligence strategies to detect them. By identifying series of linked crimes by the gathering and linking of provable evidence across wide geographical areas by means of intelligence networks enables the police service to operate in a target-rich environment and mitigate the problems brought on by geographical boundaries. Instead of second-guessing where crime is emerging, FLINTS can give up-to-date and reliable

^{28} "Volume" may not be the best word: the logical counterpart of "single" would be "multiple". However, this term is in common use in policing and so it has been used here to reflect that.
indications of areas where activity is likely to be most prolific and of those persons who are likely to be most active. FLINTS can also give its users specific as well as linked cases in which evidence exists to arrest offenders and often charge them with crimes. It can also be used to analyse, disrupt, fragment and control organised networks of criminals. FLINTS is proving to be a useful tool not only for crime detection in the Midlands but also nationally, serving as a targeting tool for the identification and disruption of criminal networks. Her Majesty's Inspector of Constabulary reported that nationally (Blakey, 2000).

“FLINTS has the capacity to link suspects with crimes that would not otherwise have been linked, for example, linking chequebook evidence from frauds with that from stolen vehicle crime... there is real potential for this system to be developed nationwide in the future... As FLINTS is developed it should be possible to utilise it to help identify series of offences which can then help to inform the tasking process. Potentially this database provides an exciting tool for crime investigation...”

3.7 Performance Monitoring and System Identification

Identifying the outcomes of those processes by which evidence is managed and generated provides insights into new methods of generating and using evidence. As well as identifying outcomes of evidence generation processes such as fingerprint collection and DNA swabbing at scenes and classifying these outcomes by evidence type, FLINTS enables more complex configurations to be identified.

In 1999, as part of developing the treatment of evidence as a complex substance-blind commodity (Schum, 1994, Pg. 4-5 and 508) it became apparent that if DNA could be extracted from objects merely touched by humans,\(^{29}\) it could also be extracted from objects merely touched by persons committing crimes. This minute trace evidence had traditionally been thought to be beyond the ability of forensic science, but possible application areas now include crimes such as thefts of motor vehicles, deception, and fraud against elderly victims, in which offenders produce false identification papers and DNA profiling has developed rapidly in recent years to become more and more sensitive and discriminating. DNA Low Copy Number (DNA LCN) is an extension of the routine FSS SGM Plus™ profiling technique that enables scientists to produce DNA profiles from samples that contain very few cells, such as a single flake of dandruff or the residue left in a fingerprint. These profiles are fully compatible with those in the National DNA Database.

\(^{29}\) DNA profiling has developed rapidly in recent years to become more and more sensitive and discriminating. DNA Low Copy Number (DNA LCN) is an extension of the routine FSS SGM Plus™ profiling technique that enables scientists to produce DNA profiles from samples that contain very few cells, such as a single flake of dandruff or the residue left in a fingerprint. These profiles are fully compatible with those in the National DNA Database.
pose as government or public utility officials to gain access to the victim's home\(^\text{30}\) to steal.

If DNA could be extracted from minute sources,\(^\text{31}\) in this case faint and smudged fingerprints, it was proposed to the Forensic Science Service that in partnership with the West Midlands Police, an experiment should be run to recover minute traces by swabbing objects at crime scenes for DNA. These swabs would include DNA from objects merely touched by humans. For example, vehicle crimes would provide sources such as gear levers and steering wheels touched by the thieves. Thirty cases of burglary were targeted for the use of the Low Copy Number DNA technique and each involved elements of distraction tactics exercised against elderly victims.\(^\text{32}\) National covert intelligence sources indicated\(^\text{33}\) that a number of active individuals were involved. As a result of using the Low Copy Number technique, DNA profiles were recovered from objects merely touched by the offenders that had committed the crimes. These were places such as door handles, door knockers, bells and so forth. As a result, 80% of the identified suspects were matched against DNA traces and later convicted and given prison sentences.\(^\text{34}\)

### 3.8 Using FLINTS: A Tour of the System as the User Sees It

Here are three simple examples of the questions we might ask the system to deal with at the start of an exploration of the evidence. The precise nature of the question is a matter for the user to define, and will be determined by the type of problem and

\(^\text{30}\) Elderly people are chosen as victims on the premise that they may experience difficulties in the recollection of evidence of identity.

\(^\text{31}\) “Low Copy Number DNA” is sometimes called “supersensitive DNA”.

\(^\text{32}\) A typical technique is to visit the victim with false identification and claim to be a member of one of the public utilities. Once inside the premises, the offender has expertise in locating the victim’s cash savings. Many elderly victims do not use bank accounts. It is not unusual for several thousands of pounds to be stolen in cases of this sort. Many victims later die, but “proximity” in terms of causation of death is almost impossible to prove.

\(^\text{33}\) Classified source.

\(^\text{34}\) The idea to use Low Copy Number DNA to find small traces of DNA left at scenes was raised at a meeting of Crime Scene Examiners in 1999 in the West Midlands Region. A national operation called “Operation Liberal” now employs similar forensic techniques to target and identify burglary offenders where elderly victims are involved.
enquiry they face. This problem or enquiry might be very focussed and might search of particular items of information about specific people, events or locations. However, it might also be quite broad and search for masses of data that could be used to formulate more focussed questions.

1. "Show me any links between suspect Mark Smith and any crimes."

2. "Show me robbery events over three months in Wolverhampton along with any links between those events and people."

3. "Show me a list of prolific offenders—that is, a list of people who have been linked by evidence to crimes on more than one occasion—and list them alphabetically."

The first two questions allow us to simply link people with crimes on the basis of evidence that we can prove to high standards of reliability, and the latter question enables the identification of those persons who repeatedly offend. Faced with answers to questions like these, we can set about deciding the most appropriate response to take in a rational and reliable way. The options may be to arrest the suspect, use covert surveillance, investigate the crimes or the people involved in detail, or engage in ampliative discovery by asking further questions to expand our field of knowledge around the people, events, locations, times and evidence itself. Let us look at the results of the questions we have posed above by accessing the FLINTS system. The illustrations below (Figures 3.5 and 3.6) are taken from real questions asked of the database.
Figure 3.5 An Example of Framing a Question in FLINTS.

**QUESTION 1** "Show me any links between suspect Mark Smith and any crimes."

FLINTS has answered the question by presenting us with a modified Wigmorean chart illustrating the inferential dependencies by means of simple nodes and lines ("arcs"). We can see a node ("Smith") in the centre of the chart surrounded by seven other nodes around the outside of the chart that depict links to events (crimes) and other people (suspects). The arcs depict the inferential evidence—in this case, fingerprints and DNA. The dotted line depicts a partial fingerprint match. The space on the right of the screen is called a Tree Builder and enables the user to keep track of links navigated in the left hand screen. The Red Lines in the FLINTS Captures that follow depicts a DNA link and the Blue Line depicts a Fingerprint Match.
Figure 3.6 A Second Example of Framing a Question in FLINTS.

**QUESTION 2.** "Show me all the robbery events in the last three months in Wolverhampton, along with any links between those events and people."

Figure 3.7 Links Being Formed in FLINTS.
Two charts result from this question. In Figure 3.6 we see that an individual called "James" has been selected by the database as the centre of an interesting network of four robbery offences and one burglary at a factory. Furthermore, one of the links is between the node for James, currently the centre of the network, and another individual node with a target sign adjacent to it. This indicates that there is a second network of links to be investigated in addition to those in the first chart. By asking the database for further information, we see in the second chart (Figure 3.7) two other nodes: one bearing the name Massey, and another bearing the name Ferguson. This tells us that James, Massey and Ferguson are implicated in yet another robbery.

The detection of volume offending is greater than expected. In another chart (Figure 3.8), we can see that the node "Ford" has been identified by the system as a volume offender on the basis of forensic fingerprint evidence and DNA. He has been linked to twelve burglary offences at houses based on fingerprint evidence, to one offence of theft of a car based on fingerprint evidence, to three offences of burglary at houses based on DNA evidence, and to one offence of burglary at a dwelling house based on fingerprint and DNA evidence. If other evidence types such as footwear, tool marks, drugs, handwriting and so forth were added to the list, the volume and frequency might be even higher. Without FLINTS, it would not be possible to detect such complex linkages over time and geography by different evidence types.

**Figure 3.8 The Network of Links Around Ford.**
The information contained in the charts presented thus far has been detailed at a micro level, with illustrations of links between certain sets of nodes. However, it is useful to be able to switch between a macro and micro view in the same way that we read a text—sometimes quickly, by scanning the text looking for key areas of interest, then slowly, reading the same text carefully, noting detailed meanings, relationships, connotations and implications. In Figure 3.9, we see a depiction of a "syllogistic tree" of all links in the database involving the node "Smith". This chart can help the analyst and investigator to understand networks of links that we should know already exist and networks of links that may exist but that have not yet been discovered. It can act as a prompt for asking further and better questions. For example, we can now ask ourselves a question such as: "Faced with the following tree of links, and based on my knowledge of the prevalence and geography of crime elsewhere in the system (Figure 3.10), what other links may exist between these nodes for which we do not yet have evidence?"

Searching our database may begin with a simple question such as the one depicted for the node "Smith". The scenarios around Smith and other nodes of interest may begin to develop as we begin to ask further questions and receive answers to them that we can in turn use to formulate further questions. From this process, we begin to see emerging items and combinations of evidence.

Figure 3.9 Confirmed and Rejected Links in FLINTS.
The locations of events and crimes, as well as the locations that suspects and victims habitually go to or reside at (Figure 3.10) should be regarded as prime material for intelligence generation. In this chart, the yellow dots refer to scenes of crimes and the red dot refers to the location or last known residence of the suspect for those crimes. Adding the dimensions of space and time to the range of tools provided by FLINTS has enabled analysts to examine crimes from the standpoint of the geographer. Clustering events by their locations begins to give us insights into the movements and activities of suspects and thus lets us synthesise potential as well as real links, raise propositions about events that suspects may have been involved in as well as events that are still emerging, look for crimes where there is available forensic evidence which we may use to either implicate or eliminate our sets of currently interesting suspects, and even identify vulnerable areas where victims are at greater risk. The chart containing the map (Figure 3.10, above) illustrates these points.

In the illustrations in Figures 3.10 and 3.11, we can see how we can adopt macro and micro views of geography to help us gain a better understanding of the characteristics and prevalence of the events and suspects we are currently interested in, or perhaps
that we should be interested in given the emergence of new and interesting networks. Here, in our quest to gain insights into the activities of a node called "Miller", we learn that the suspect's links to crime span almost the length of the United Kingdom, notwithstanding the fact that his residence is in Liverpool. In this case, the events are burglary offences at factory premises from Liverpool in the northwest to the Midlands and on to London in the southeast. From this we may infer that the suspect has been using either the motorway network or the rail system to travel between events and crimes. Interestingly, one of the events in the series involves the theft of a car, so we may also infer that Miller has been stealing vehicles to undertake the journeys. Our next enquiry may be about vehicles stolen at or near the crimes in and around Liverpool, the Midlands and London.

Figure 3.11 Geo-referenced View of Forensic Links to a Suspect.

One specific function the system undertakes is performance management by using various measures and indicators. In the following illustration (Figure 3.12) we can see the way in which a variety of categories of data can be drawn together to allow managers to assess the relative performance of police departments. On the lefthand
side can be seen a series of preformatted questions from "Unresolved Actions By OCU" to "Crime Type Distribution by OCU." The dates between the times of interest can be selected for the analysis and the resulting chart will reflect these dates.

**Figure 3.12 Sample Performance Reports that can be Generated by FLINTS.**

![Sample Performance Reports](image)

The chart below (Figure 3.13) is the result of asking the system to measure and present the number of crime scenes, by operational area, in which matches have been successfully achieved. Differences between areas can be evaluated, the way that scenes of crime examiners are used between different areas can be assessed, and the relative efficiency of staff in recovering evidence between different areas can also be assessed. If one area is achieving a high success rate, the others can examine the practices being adopted and try to emulate those achievements.

**Figure 3.13 Histogram of Hit OCUs, by Evidence Type.**

---

35 OCU is a police area called an Operational Command Unit.
36 Police Forces use the term "hit" instead of "match."
Other questions can be formulated to identify repeat offenders, and these questions can be used for strategic analysis and offender targeting. Offender targeting can be the concentration of both overt and covert means of monitoring the activities of key suspects within a population strongly suspected of involvement in series crime. One of the benefits of this function in FLINTS is the auditing and tracking capability that results from the analysis. This can help to justify decisions to third parties in later debates. In Figure 3.14 we can see the answer to a question: "Show me the evidential hits [matches] in FLINTS for suspects with more than one hit."

**Figure 3.14 Answers to a Question Concerning Evidential Hits in FLINTS.**

<table>
<thead>
<tr>
<th>Surname</th>
<th>Forename</th>
<th>Birth date</th>
<th>Crime</th>
<th>Crime no.</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adams</td>
<td>Paul</td>
<td>12.3.77</td>
<td>Burglary</td>
<td>101010</td>
<td>DNA</td>
</tr>
<tr>
<td>Adams</td>
<td>Paul</td>
<td>12.3.77</td>
<td>Rape</td>
<td>1111010</td>
<td>DNA</td>
</tr>
<tr>
<td>Adams</td>
<td>Paul</td>
<td>12.3.77</td>
<td>Auto Theft</td>
<td>1011010</td>
<td>Fingerprint</td>
</tr>
<tr>
<td>Jones</td>
<td>David</td>
<td>17.11.52</td>
<td>Burglary</td>
<td>11010001</td>
<td>Handwriting</td>
</tr>
<tr>
<td>Jones</td>
<td>David</td>
<td>17.11.52</td>
<td>Theft</td>
<td>1001111</td>
<td>Fingerprint</td>
</tr>
<tr>
<td>Jones</td>
<td>David</td>
<td>17.11.52</td>
<td>Theft</td>
<td>10010110</td>
<td>Tool mark</td>
</tr>
<tr>
<td>Jones</td>
<td>David</td>
<td>17.11.52</td>
<td>Theft</td>
<td>1001111</td>
<td>Footwear</td>
</tr>
<tr>
<td>Jones</td>
<td>David</td>
<td>17.11.52</td>
<td>Possess A</td>
<td>10010101</td>
<td>Drugs</td>
</tr>
<tr>
<td>Kelly</td>
<td>Bart</td>
<td>18.4.58</td>
<td>Burglary</td>
<td>11100001</td>
<td>DNA</td>
</tr>
<tr>
<td>Kelly</td>
<td>Bart</td>
<td>17.4.58</td>
<td>Burglary</td>
<td>11010001</td>
<td>Fingerprint</td>
</tr>
<tr>
<td>Kelly</td>
<td>Bart</td>
<td>18.4.58</td>
<td>Burglary</td>
<td>10110001</td>
<td>Footwear</td>
</tr>
<tr>
<td>Kelly</td>
<td>Bart</td>
<td>18.4.58</td>
<td>Burglary</td>
<td>11000001</td>
<td>DNA</td>
</tr>
</tbody>
</table>

In reality, the list in Figure 3.14 would run to many pages. Lists can be prepared for different police areas and over different time spans, thereby giving different
perspectives on the evidence. Note the squares filled in blue: for these squares, the crime reference numbers are the same, therefore Kelly and Jones may have committed this crime as accomplices. Figure 3.15 illustrates how this correlation can be identified and brought to the attention of investigators.

**Figure 3.15 Conclusion Generated by FLINTS that Calls a Key Finding (Correlation) to the Investigator’s Attention.**

In Figure 3.16, we can see the result of asking the system to prepare a list of those scenes of crime that have been matched against suspects and list them by operational area. In this case, we can see a list of persons identified as being suspects for single crimes as well series-linked crimes, along with the evidence type involved for the Sutton Coldfield area. The list has been abbreviated for illustration purposes.
## Figure 3.16 Listing of Suspects with More Than One Hit.

For Suspects with more than one hit

<table>
<thead>
<tr>
<th>Surname</th>
<th>Fore Name(s)</th>
<th>DOB</th>
<th>Crime Number</th>
<th>Offence</th>
<th>Ev. Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOW</td>
<td>SHERMAN</td>
<td>02/1151/89</td>
<td>BDW</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>BOW</td>
<td>SHERMAN</td>
<td>01/13283/98</td>
<td>BDW</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>BRAD</td>
<td>ANTHONY</td>
<td>K1/1880/98</td>
<td>BOT</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>BRAD</td>
<td>ANTHONY</td>
<td>K1/4808/98</td>
<td>BOT</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>BRAD</td>
<td>ANTHONY</td>
<td>K1/1286/98</td>
<td>BOT</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>CARR</td>
<td>EDWARD</td>
<td>CH/874/98</td>
<td>Deception</td>
<td>FP</td>
<td></td>
</tr>
<tr>
<td>CARR</td>
<td>EDWARD</td>
<td>CH/1041/98</td>
<td>Deception</td>
<td>FP</td>
<td></td>
</tr>
<tr>
<td>ELM</td>
<td>JAMES</td>
<td>D2/795/98</td>
<td>BDW</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>ELM</td>
<td>JAMES</td>
<td>D2/495/98</td>
<td>BDW</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>FIN</td>
<td>MICHAEL</td>
<td>S1/4265/97</td>
<td>BOT</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>FIN</td>
<td>MICHAEL</td>
<td>S1/4283/97</td>
<td>BOT</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>FRA</td>
<td>DONALD</td>
<td>E1/5019/99</td>
<td>BOT</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>FRA</td>
<td>DONALD</td>
<td>F1/6926D/97</td>
<td>Criminal Damage</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>FRA</td>
<td>DONALD</td>
<td>F1/6926D/97</td>
<td>Criminal Damage</td>
<td>DNA</td>
<td></td>
</tr>
<tr>
<td>HAY</td>
<td>MARK</td>
<td>D3/375/98</td>
<td>Theft</td>
<td>FP</td>
<td></td>
</tr>
<tr>
<td>HAY</td>
<td>MARK</td>
<td>D0/19413/95</td>
<td>BDW</td>
<td>DNA</td>
<td></td>
</tr>
</tbody>
</table>

Analysts, investigators and scene examiners can access their own reports as well as those of other areas to help formulate hypotheses about active offenders, crime types and the prevalence of particular suspects by area, crime type and density of offending.

The integrated approach to the management, analysis and synthesis of evidence now seen in the FLINTS system is enabling the police service to take a more sophisticated yet still pragmatic approach to the management and use of the evidence contained in police data systems. This approach permits analysts to solve problems that were known to exist yet that were too complex to tackle in the past.
A good example is the relationship between the incidence of crime and the illegal use of drugs, which has until now been assumed rather than proven. No reliable evidence has been produced to date to demonstrate this relationship, although intuitively many governments and police sources have claimed it to exist. Whilst there is evidence that many persons arriving in police custody are under the influence of drugs, the evidence to explain the networks of people and crimes involved has been too complex to even bring together let alone to analyse. FLINTS treats evidence and crimes in a substance-blind way. It is thus as applicable to the investigation of drug offences as it is to the investigation of burglary, rape, theft or homicide. Likewise, the evidence types it draws on are treated as “fuzzy” categories rather than “strictly deterministic” categories, and are equally applicable to DNA, fingerprints, footwear and a whole range of other forensic evidence types. Persuading the police service to treat evidence generically, in a substance-blind way, would pave the way to accessing a rich matrix of linked networks of people, events, times, locations and evidence.

A joint Government and Police Committee\(^37\) chaired by a Minister asked early in 2001 that FLINTS be used to assist in identifying markets for the distribution of illegal drugs in the United Kingdom. Identifying those who travel across boundaries to commit a crime and who deal in drugs will aid the identification of travelling networks of criminals involved in drug trafficking or related offences. For example, at present there is no evidence available about those persons who engage in the illegal trafficking of drugs between the coastal towns of Sussex and the middle counties of England and Wales, yet there are data available that drug importation does take place on the southern coast and that the drugs arrive in the Midlands Region in smaller consignments. One way to tackle the problem of gaining a better understanding and real knowledge about this would be to apply the methods embodied in FLINTS.\(^38\)

We can see how FLINTS, using a substance-blind approach to evidence, enables the system to be used for the analysis of drug networks. In this example (Figure 3.17) we can see that the node "Castle" is linked to one offence of illegal possession of drugs on

\(^{37}\) The approach was made by Mr. Peter Hampson, QPM, Chief Constable, West Mercia Police, in February 2001.

\(^{38}\) A substantial data set is being compiled to enter into FLINTS to establish the extent and weight of illegal drugs that reach markets and the magnitude of their people networks. .
the basis of fingerprint evidence rather than a chemical drug analysis. Using fingerprint evidence in this way is an example of the substance-blind approach, and serves to illustrate how the use of one evidence type can inform the use of another. The fingerprint evidence involved came from the examination of paper wraps used to store the individual packs of drugs. The imaginative decision to use fingerprint analysis in this way was central to the ability to create a link to the networks.

**Figure 3.17 Link Between One Suspect and Evidence.**

![Figure 3.17 Link Between One Suspect and Evidence](image)

However, we should also note from the chart that another network is operating behind the one visualised here. It is depicted by the "target" appearing against the crime node on the right of the screen. The system is telling us to look further because there are additional interesting links. In Figure 3.18, the result of asking the system to present us with those additional links is illustrated. What we then see is that the node "Castle" is also linked to a node called "Kosko" and another node called "Castle". This latter node is in fact a brother of the first Castle. Probably the most interesting aspect of this analysis is not that we have fingerprint evidence presenting us with a scenario linking three formerly unknown associates but rather proving that none of the people involved in the network reside in the West Midlands Police area, where the drugs offence was committed.
An overview of the links between these nodes quickly demonstrates the extent of the network based solely on fingerprint evidence. Chemical analysis of the drug may reveal evidence of its source and original consignment. The use of evidence about telephone traffic among Castle, Kosko and Castle may reveal evidence of linked communications before, during and immediately after the events involving the handling of illegal drugs.

Figure 3.19 demonstrates how complex links between different people and different crimes can be identified using different but integrated evidence types and by using FLINTS in this way. These links would take very long periods of time to identify using conventional investigations. In this illustration, Williams has been linked to two offences of burglary at factory premises, three burglary crimes at domestic dwellings, one robbery and one theft of a car. It can also be seen that Kennedy and Tennison have been linked to the node marked with a large "X". This is, in fact, the same crime as the node marked with a "Y". This visual approach is thus a method to indicate quickly that Williams, Kennedy and Tennison may have committed at least one crime together whilst Williams has been implicated in another six crimes. The hypothesis prompts the analyst to suspect that all three may have been operating together. Further links can then be explored by pressing the target icons depicted next to certain nodes. These indicate further lines of immediate enquiry available to the analyst. In this way, FLINTS allows the user to "surf" the connections and links inherent in the evidence.
Figure 3.19 Identification of Complex Links by FLINTS.

Figure 3.20 Intelligence Picture Generated by FLINTS.
3.9 The Intellectual Foundations of FLINTS

Large corporate bodies such as police forces have become far better at generating, transmitting, storing, and retrieving information than they have at making use of it to expose useful configurations and scenarios that can withstand repeated challenges and tests about the data's credibility and legality. Storing masses of data is *in itself* an unproductive pursuit because this does not automatically translate into masses of knowledge. Strategies and tools are needed to help the investigator and analyst make use of the evidence known to exist in order to discover evidence that may exist but that has not yet been discovered. One useful tool that will be described in detail later in this chapter is the ability to formulate useful questions. Good questions aid in the discovery of interesting configurations of evidence and chains of inferential reasoning from which useful conclusions can be drawn. Another useful tool that I will deal with later in this chapter is the formulation of stories to act as a mechanism for providing a structure in which configurations of evidence can be presented in a useful way. No matter how far-ranging and how thorough our search for evidence is, there will always be gaps and there will always be a degree of doubt. That doubt may be small and unpersuasive, but it will always be there to some degree.

In addition, strategies and tools are needed to aid us in the identification of known or suspected gaps in our knowledge as well as areas of weakness in our chains of reasoning. Circumstances often exist in which it is useful to be able to corroborate or negate an inference that we have drawn or are preparing to draw based upon evidence we currently possess. In this regard, we may see the following simple chains of reasoning (Figure 3.21) depicted with black nodes and arcs that need to be tested by the search for evidence that will either corroborate or negate the node or arc. Corroborative evidence is depicted by red nodes and arcs, an approach borrowed from Schum (1994, p.124). Here, in Figure 3.21, two sources of evidence (one source is a red dot and the other black) infer the occurrence of the same event.
A number of the problems that policing faces in terms of the analysis and synthesis of evidence involve the manner in which evidence is managed and organised. How well an organisation manages its evidence will ultimately influence how well the organisation is placed to generate or discover new thoughts and new evidence that will prove useful to the problems they face. The strategies an organisation adopts in evidence management play a key role in its ability to discover new evidence, new scenarios and new explanations. In addition, drawing defensible conclusions from databases will depend upon the quality of the information, its inherent credibility and the probative force it delivers. Dealing with evidence in systems for multiple-case analysis, as depicted so far, is subject to the same tests as dealing with evidence handled in single cases in a traditional way. Successful investigation and discovery depends not only upon strategies and methods designed to marshal our information in ways useful and meaningful to solving our problems (as stated here), but also upon the ability of the user of the evidence to keep in mind and continually test for the evidence's credibility, relevance and reliability. Inference chains are only as strong as their weakest link.

FLINTS symbolises a new approach for marshalling evidence in pre-trial criminal investigations. The opportunity to exploit complex relationships and networks of links between people suspected of involvement in criminal activity allows the investigator at a tactical level and the police manager at a strategic level to identify threats and marshal finite resources more effectively and in direct response to identified problems.
Identifying the problems we face is the first step in solving them. The deployment of resources and time is evidence-led and directed to specific needs. Events can be connected or associated by virtue of their characteristics and typology, which allow investigators to link events into chronological series. This is not simply a matter of macro-level linking of high volumes of events over extended time periods; it also enables investigators to undertake the micro-level analysis of single events in the search for evidence. An item of evidence in one case may fill a gap or even a series of gaps or part of a chronology in another case.

3.10 What is it About FLINTS that Makes it Different?

As discussed in Chapter 1, FLINTS uses a modified form of Wigmore's method for the analysis and synthesis of evidence in pre-trial investigations. The aim of the FLINTS approach and software is to introduce and develop a systematic method for the management of facts.

A frequent observation by practitioners using FLINTS for the first time is that it makes great use of “hard” evidence as opposed to the traditional approach in intelligence work, which relies more on the use of “soft” evidence. Though this description is useful, it can be misleading and problematic. The FLINTS approach and software was designed to make a distinction between tangible evidence such as fingerprints, blood samples, DNA profiles, footprints, drugs, firearms, and so on, and testimonial evidence from human witnesses. Examples here would be witnesses observing events and intelligence reports from informant agents.

This distinction is an important feature of the FLINTS approach. It draws on the differences between the attributes of the credibility of tangible evidence that differ from the attributes of the credibility of testimonial evidence in a number of ways important to this thesis. In the case of tangible evidence, we can draw on its authenticity and chain of custody as well as on the accuracy and reliability of the collection and sensing devices we use. Examples here might be DNA swabbing kits, electronic sensors, cameras, electrostatic lifting devices and sound recordings. In addition, we have the competence of those persons who operate and interpret these devices to draw upon. For testimonial assertions, we have to keep in mind the difficulties that surround the veracity, objectivity and observational sensitivity of human sources of evidence.
Although this distinction is important, it does not mean that one form of evidence is naturally superior to another.

In its present form, FLINTS overcomes many of the investigative difficulties associated with attempts to link together different criminal activities, different people and different sources of evidence. One way of describing the utility of FLINTS is to say that it provides an elegant means for forming audit trails of related criminal activities.

3.11 A Case Study in Linked Burglary

In Chapter 1, we saw the importance of developing the capacity to ask good questions and how this differs from a protocol for asking good questions. Checklists for questions in the form of a protocol provide a good method of checking that certain things have been done, but investigators and analysts cannot operate effectively without basic training in good thinking. In Chapter 2, we saw how evidence arrives in our hands from diverse sources, in diverse conditions and with varying levels of reliability. In Chapter 3, we have been introduced to the modernised neo-Wigmorean approach in the form of computer software called FLINTS. Now let us explore a real-world scenario and the investigation of a series of burglary crimes using the methodology and software developed in this thesis.

This example is a real case of burglary, but with some fictional and additional hypotheses and evidential scenarios used to illustrate the potential of the methodology and of the use of FLINTS. The burglary scene depicted in the photograph (Figure 3.22) presents many opportunities to recover physical, forensic and trace evidence. The scene examination reveals that the door is open, having previously been left locked and secured by the victim earlier that day. There is also clear physical evidence of damage on the inside of the door, where some kind of tool appears to have been used. The lock has been forced open, which would allow an intruder to exit the premises. This evidence raises a hypothesis that the door could have been used as a point of exit and is therefore an ideal location for seeking contact trace material, but the question arises early on as to where the alleged offender entered the premises.

This question is central to our ability to investigate the crime, because when people enter and leave premises, especially by the use of force, they may leave contact trace material behind as a result of their physical contact and proximity with objects that
make up the fabric of the building. Windows, doors, furniture and objects that the intruder has touched provide excellent opportunities to recover evidence. Opportunities are presented to target searches for contact trace material that could provide evidence of the identity of the intruder, the clothes they were wearing and the kind of contact they had with the premises.

In the case subject of Figure 3.22, a search of the premises and grounds was made and the lower ground-floor casement window in the foreground of the photograph was found open and damaged. This raised a hypothesis that entry was gained by means of the open casement window. The hypothesis was supported by evidence that the owner of the property had left the premises locked and secured when she left for work earlier that day. There was no damage to the window locks when she had left home earlier that day and her jewellery and cash was now missing from a bedroom. Damage had been caused to furniture inside and a message in lipstick had been left on the dresser mirror that read “It is not over yet—we'll be back.” Footwear marks were apparent in the soil below the window. On the kitchen work surface near the window that was believed to be the point of entry, there was a small smudge of reddish-brown fluid that appeared to be blood. The fluid was located on the glass close to the forced lock. Another red fluid that may be blood was apparent on the kitchen work surface. A red fibre was snagged on the window ledge alongside some scuff marks, and was thought by the Scene of Crime Examiner to have been made by gravel embedded in the sole of a shoe when the intruder(s) entered.

Initially, the geography and extent of the scene of crime were thought to be the boundary of the premises. However, there was circumstantial evidence that the intruder(s) must have left the garden area by some means. On the pathway in the garden, a metal pole was found that the victim said was foreign to the scene. A hypothesis was raised that this might have been delivered into the scene by the intruder(s) as a tool to assist their entry into the building; as a result, the pole was recovered for examination at a laboratory.
The intruder(s) were not within the boundary of the property at the time the search was undertaken, and the gate remained locked and secure. It was hypothesised that they left by climbing the fence. A damaged shrub pointed out by the victim revealed a damaged fence panel. Directly above the panel, a fibre was found snagged on the top of the fence, but this time it was blue in colour. This gave rise to a series of new hypotheses: were there one, two or more offenders? If a single offender, were they wearing a red and a blue garment? Where did they go after climbing the fence?

Our observations of the scene should not be restricted to the house and garden. We can infer from the evidence available that the intruders probably left by climbing the fence. The scene now needs to be extended to encompass further pathways outside the perimeter of the garden. A "scene" can incorporate any place, any person or any "thing" that has been party to the events prior to, at the time of and even after the event under
The combination of events and times serves a number of purposes. One of them is the construction of stories to assist us in gluing together the events we know about in a meaningful way that helps us to explain the events we do not know about but need to understand. The construction of stories such as these helps us to search for evidence to either confirm or negate the evidence we will produce to fill in our knowledge gaps. In addition to helping us tell stories and discover new evidence, stories provide an ideal form of classifying our search for and interpretation of evidence.

**Figure 3.23 Chronological Sequence of Events.**

A whole series of events can go into making up a "scene." People suspected of involvement in the crime can and should be treated as potential crime scenes in themselves, especially if they're a suspect or a victim, because they may have played star roles as "actors" in the theatre of the crime. Victims in particular can provide good evidence from their direct knowledge for two reasons: First, they have knowledge of events either before the crime was committed, at the time the crime was committed, or some time after the crime was committed. Second, they often have domain knowledge of the place, the time, the prevailing circumstances and even the people who may have been involved and those who may not have been involved. Victims often have a stock of ancillary knowledge useful to the provision of contextual evidence about the commission.

---

39 Wigmore (1913, p. 149) dealt with "time and place" as a means of proof. "Proximity, on the part of the accused, as thus presented for consideration, may be, in itself, of various degrees, from mere vicinity, up to actual juxtaposition or contact. It may also be of various kinds, such as proximity to the person of the deceased, or to the scene of the crime, or both; and it may exist at different stages; as before the commission of the crime, or afterwards, or both before and after. The strongest form in which this circumstance can be presented, and the one which requires the least reasoning to give it effect, is undoubtedly that of the juxtaposition of the persons of the accused and deceased, proved, by actual observation to have existed both immediately before and immediately after the crime is perpetrated. These show presence at the moment of actual perpetration, with the greatest effect possible, short of direct evidence."
of the crime. Sometimes this knowledge will be small, but often it will be more extensive than one might expect.

In the case we are investigating in the present example, the victim provided important evidence about the condition of the premises before the crime was committed, and about how an intrusion and entry had changed the physical condition of the building. She had also pointed out that the metal pole was foreign to the premises and thought to have possibly been used as a tool to effect entry and discarded when the intruders left. It is crucial that investigators and Scene of Crime Examiners fully understand that the relevance, credibility and weight of any physical, forensic and contact trace material will be directly conditioned by this type of evidence from a victim or a witness. If a suspect is arrested as a result of fingerprints being identified on the tool, that suspect might find it difficult to persuade us that the tool did not belong to them but rather belonged to the owner of the premises or the victim.

It was decided that residents in houses opposite the "scene" may have witnessed activity before, during or after the crime was committed. Perhaps they saw strangers to the area loitering or climbing the fence, or heard the sounds of the window and door being forced. We formed a hypothesis that the offender(s) had at some point climbed the fence, and that asking questions of residents near the scene could provide additional evidence. Who could have seen the offender(s) leaving or even entering the premises?

As a result of asking residents opposite the scene about the events of that day, we discovered an elderly lady who claimed to have seen two men climbing the fence and leaving the garden during the afternoon. She had been suspicious, so had watched them run, walk, then run again along the street towards a car parked nearby. One of them was carrying a black bag and she saw one of the men drop something. When he returned to pick it up, the other man forced him to carry on and leave the object. He threw it over the fence into the garden he had climbed out of, and that object appeared to be the pole found in the garden. The witness pointed out in the garden the direction in which the "pole" had been thrown and identified the metal tool in the garden on the pathway as being similar to the object she had seen thrown.
The object was recovered for forensic analysis, with emphasis placed on DNA and fingerprints in an attempt to identify the persons in possession of it earlier that day. Evidence was sought about the credibility of the witness. She said she had never experienced serious difficulties with her sight other than short-sightedness, but felt she could be sure of what she had seen. She did wear glasses for myopia and had been wearing them at the time of the incident. The investigator might have chosen to question and confirm the credibility of the witness's evidence by asking her to repeat a car registration plate or some other unique object in the street under similar conditions to those under which the events were seen to unfold.

Control and elimination samples of DNA and of fingerprints were taken from the elderly witness and the victim to distinguish them from any foreign DNA and finger marks found on any of the exhibits recovered from the scene. During this exercise, the witness said that she had subsequently thought about the incident and now thought that she recognised the car the men had got into as one very similar to the car owned by the previous owner of the house. Also, one of the men appeared familiar in appearance, as if she had seen him before in the area. On being asked why she had not said so earlier, she replied that she had been concerned that she might have been wrong. This provides us with a good example of Schum's equivocation testimony.

Schum (1994, p. 107) provides a detailed methodology for assessing the relative strengths and weaknesses inherent in testimonial evidence provided by an eyewitness. The methodology serves to illustrate how important it is for investigators to bear in mind the attributes of evidence and the way in which reliability has to be assessed and not merely accepted. Schum's method is based on a non-statistical approach and involves asking a variety of questions about the behaviour of the witness relevant to assessing their credibility as well as other factors that might influence a person's credibility. Schum believes that most credibility-related questions fall into three main classifications or, as he calls them, "major attributes": veracity, objectivity and observational sensitivity. Let us assume that a witness "W" provides us with evidence that event "E" occurred. Let us further assume that the event did in fact take place and that "W" obtained evidence from his own senses causing "W" to believe that the event occurred—therefore, "W" knows that "E" occurred. We did not observe the event "E", so how are we to verify the account given by "W"? Because "W" claims to have witnessed the event with his own senses, are we also to say we know that event "E" occurred?
What we have really discovered is that "W" claims to know that event "E" occurred, not that event "E" actually did occur. In considering the testimony of "W" we are faced with a chain of inferences about what "W" believes, what "W" sensed and whether event "E" did occur. Schum demonstrates the decomposition of evidence when he tells us that we can also consider our own credibility in receiving the evidence from "W" because we are not passive in the receipt of evidence. If we question our own credibility, all we can really say is that we believe witness "W" told us that event "E" occurred. Let us examine this in detail to see what he means. Let us assume that "W" believes that "E" occurred based on the evidence of his senses, and we treat this as a form of a chain of inferences. Each piece of evidence in the chain indicates a point of uncertainty about what "W" tells us. If we include an assessment of our own ability to receive and convey the evidence of "W", then the inferential chain becomes much longer. Not only must we consider veracity, objectivity and observational sensitivity in respect of witness "W", we must also consider our own major attributes in the receipt and management of that evidence. This becomes increasingly important when dealing with evidence from questionable sources or when there are competing accounts of events from witnesses. Take, for example, intelligence sources where information is offered in return for favour or reward. The recruitment of intelligence sources from the criminal fraternity or from foreign countries for the receipt of intelligence should not be based simply on the ability of the source to provide information. A well-placed source in a criminal network of offenders or a foreign diplomat working as a defence attaché in a host country may well be in a position to provide timely, high-quality information. However, they may also be in a position to provide false or misleading information to undermine operations they have been recruited to oppose. Take, for example, a drug dealer providing the police with information. Though he may indeed have valuable information, he may also have a motive for "informing" on competing drug dealers who pose a threat to his own trade in illegal drugs. He may also provide the information to arrest many smaller drug dealers as a means of providing himself with a more open and exploitable market. In intelligence scenarios, a foreign source may provide valuable information about international negotiations concerning a new military capability. However, what is really being practised is a deception designed to distract attention away from new technology being developed in another area and that is of greater importance to that power. Schum (1994, p. 115) also provides a schematic diagram for depicting his classification of recurrent forms of evidence.
This gives rise to another hypothesis: that one of the offenders may have been the previous owner returning to the house to commit the crime. An enquiry with the victim reveals that she was involved in a dispute with the former owner about an outstanding sale of some of the contents that she had refused to pay for because they were substandard and faulty. She said that the dispute had become acrimonious, but did not believe that the former owner would burgle her home, even though she had been threatened on a previous occasion when she refused to withdraw her legal action. Instead, she had put this down to frustration about the legal action. However, as a precaution, she had reported it to her lawyer and he had written a letter to the former owner warning him about the consequences of any further actions involving threats and intimidation. This might provide important evidence about "motive".

Enquiries revealed that the former owner of the premises had a number of convictions for burglary of dwelling houses, two of which were offences similar in nature to the present crime—lower ground-floor windows had been forced open, escape was by means of a door to the rear, and there had been episodes of climbing on both occasions. He also had other convictions for violence and damage to property.

The items of physical, forensic and contact trace material recovered included photographs of the suspected point of entry (the lower ground-floor window), the work surfaces in the kitchen (with suspected blood stains present), the footwear scuff mark to the window-sill, damage inside the premises and the writing on the dresser mirror, the damage to the door suspected to be the point of exit, the garden area (including the metal pole on the pathway) and the fence suspected to have been climbed as an escape route. A photograph was also taken of the place at which the elderly witness said she saw the people climbing out of the garden. This provided evidence that she could indeed have seen what she claimed to have seen. Other items recovered included the suspected blood stains, the debris from the scuff marks, the metal tool, the fibre snagged on the window and the fibre snagged on top of the fence. A single footmark was found in the soil outside the casement window, and this was identified by the victim as a foreign mark. It was photographed and cast to reveal the size and weight of the shoe that created it to serve as evidence for comparison with any shoes later recovered from suspects. All the victim's shoes were examined for the presence of similar patterns to those in the flower bed in an attempt to eliminate extraneous evidence and reduce the potential number of sources of the mark.
Control samples were taken from all surfaces from which items had been recovered. For example, a control sample of soil from near the footmark, a sample of debris from the path, a control sample swab from the kitchen surface and glass (where the suspected blood was recovered) and a sample of wood from the window and fence for comparison with any clothing taken from suspects.

3.12 Forensic Decision-making

The objective of the investigation was to discover the identity of the person(s) who committed the crime as well as the identity of the people seen climbing out of the garden. This was done to try to reduce the suspect population to as small a number as possible. From the available items of evidence the following hypotheses were constructed:

1. The premises had been entered by force, possibly via the casement window and by use of the metal tool recovered on the garden path.
2. One or both of the intruders had cut themselves in forcing the casement window, had bled onto the work surface inside the premises, and had scuffed the window sill with a shoe and grit from outside.
3. The premises had been searched and the mirror had been written on by the intruders with a message bearing relevance to an ongoing dispute.
4. The intruders had left by the open but now damaged door and climbed the fence to escape.
5. One of the intruders had thrown the metal tool away; it landed in the garden on the path.

Of prime interest was the identity of the former owner of the premises and whether he had both a motive\(^{40}\) and the opportunity to commit the crime. In addition, it was important to determine whether there was any physical, forensic or contact trace material available to connect him to the enquiry or eliminate him. He was identified by the victim and her lawyer, and from this information his convictions were found, including the fact that he was already registered in the National DNA Database following a conviction three years previously for violence. This meant that simply submitting the suspected blood from the scene to the National DNA Database for profiling and

\(^{40}\) Evidence of motive is distinctly different from evidence of opportunity. Detectives sometimes mistake the two because motive and opportunity may on occasions converge, providing some additional probative force.
comparison would provide valuable evidence about whether he had had an opportunity to commit the crime. Also, the elimination sample of the victim, who lived alone, would also have to be submitted to ensure that the suspected blood did not originate from her, however unlikely that might seem. Also of concern was the fact that a false positive might result in linking the former owner of the premises to the crime solely because he had lived there previously.

The DNA profiling process is very sensitive, and it could potentially pick up old genetic material from when the suspect was resident there. In an attempt to clear up this point, the victim reported that she had cleaned the surfaces almost daily with a surface cleaner and that the previous owner had not been present for 18 months.

Whilst DNA profiling was being undertaken, including a comparison of the scene stains and the control samples from the witness and victim, enquiries were conducted into the background of the former owner of the burgled premises. Intelligence was received and later confirmed that at the time when the crime had been committed, the previous owner of the premises had been in police custody and then remanded to prison to await trial for a theft that was not connected with the burglary. This effectively provided an alibi for him and challenged the basis of the enquiry. There was no reason to question the honesty and credibility of the victim and the elderly witness, so the police were left with the task of identifying (from the population) who else might have committed the crime.

It was decided not to interview the former owner in prison on the following grounds. A hypothesis was considered that although he could not have committed the crime personally, he might know who had and might have been involved as a conspirator in arranging the crime. If questioned, then, he might forewarn the intruders so they could dispose of valuable forensic and trace evidence. No evidence was available to indicate who might have committed the crime, but blood recovered from the scene might link to someone already in the DNA database.

Five days after the submission of the suspected blood to the National DNA Database, the initial results were received by the police. The suspected blood from the kitchen work surface was confirmed to be blood, and wholly different from the victim's and witness's control samples, but it did not match with any person in the Database,
including the former owner of the premises (the prime suspect). However, the FLINTS Coordinator contacted the officer and informed him that one of the blood stains, although not matched to any person in the National DNA Database, did match with seven other DNA samples submitted from seven other crimes of burglary in the last two years as well as with samples from an offence of car crime.

Whilst no person had been matched, FLINTS now gave grounds for believing that the offender was a serial burglar responsible not only for this crime but for seven others. The problem now was to identify the offender. The National DNA Database was contacted and asked to confirm the sex of the donor of the scene's blood samples and whether the two stains emanated from different donors. The Database confirmed that the donors were both male and were different people.

FLINTS was consulted in an effort to assist in identifying potential suspects for the series of nine crimes (eight burglary crimes and a car crime). In the mind of the investigator, the previous owner still had reason to be involved in the main burglary, so it was decided to begin the enquiry by identifying his network of associates. The investigator asked the system to follow five lines of enquiry and constructed the following questions:

1. Show me the links between the former suspect and any other known criminals in the system: what is the extent of his criminal network and who is in it?
2. Show me the geography of the nine crimes: where were they committed?
3. Show me a time line of the crimes: what is their chronology?
4. Show me all the burglary crimes committed in the area of the main crime: is any physical, forensic and contact trace evidence available in any of them?
5. Show me the current keeper of the car formerly owned by the former suspect: who has it now?

\[41\] The presence of X and Y chromosomes reveals that the genomic material comes from a man; the absence of a Y chromosome reveals that the donor was a woman. DNA markers used for criminal investigation routinely test for sex, but in the experience of the author this eliminative test is not widely used despite its enormous value. For example, if a DNA profile is gained from material left at the scene of the crime, the gender test eliminates 50% of the suspect population from suspicion.
6. Show me the most prolific offender for burglary [in cases bearing the following features] in the area of... and over the time period of...

The answers to the questions provided the investigator with new evidence and emergent lines of enquiry. In answer to question 1, it was revealed that the former suspect had a primary network of ten links to other criminals, all of whom he had been arrested with on previous occasions. In answer to Question 2, FLINTS told the investigator that the nine crimes fell within a radius of a spate of burglary crimes extending to 35 offences, all of which bore distinctive signatures in terms of the modus operandi. The answer to Question 3 was that all 35 offences had a regular pattern in that each was committed between 3.15 and 5 pm on a Tuesday or Thursday afternoon. The answer to Question 4 was that eleven of the crimes had various items of available physical, forensic and trace evidence that could be submitted for analysis and comparison with reference databases of people. Blood and finger marks were also available.

The answer to Question 5 gave the hoped-for breakthrough: the car was now registered to one of the associates in the primary network of the former suspect. He had incurred a Fixed Penalty Ticket for a parking violation on the day the main crime had been committed, and only three streets away near a shopping precinct. The payment of the Fixed Penalty Ticket had been made in the name of the current keeper of the car and via a bank account in the shopping precinct three streets away from the scene of the burglary. His DNA profile was not present in the National DNA Database. Two days before the burglary crime being investigated, he had visited the former suspect in prison.

Tangible grounds now existed to formulate a hypothesis that the current keeper of the car had committed the crime. This conclusion was reached on the basis of his former convictions for burglary in houses, his presence in the vicinity at the time the crime had been committed, the fact that he was the keeper of the vehicle seen by the witness in the same street the crime had been committed, and that he had no legitimate reasons for being inside the premises. The vehicle was now parked regularly outside his home address and used by him in the area. The decision was made to arrest the suspect (the current keeper of the car) in an attempt to recover evidence that would either eliminate or incriminate him. On arrest, his wardrobe was searched and a pair of blue denim
trousers was found. These were bloodstained (Figure 3.24); moreover, he had a cut to his right hand, and a red jumper was found along with a pair of shoes similar in pattern to that in the foot mark found in the soil outside the window.

Figure 3.24 Bloodstained Denim Trousers

Are these consistent with having bled after climbing through a casement window?
At interview, he denied being involved in any burglary crimes at any time other than those of the crimes for which he had been convicted. He agreed to supply a DNA sample in the form of a mouth swab to eliminate him from the enquiry. The DNA process would take 5 days, so it was important whilst he was in custody to use other evidence available to either eliminate him or implicate him.

**Figure 3.25 Footwear Mark In Blood**

The blue denim jeans were sent to the laboratory, and under microscopic analysis the fibres appeared similar to the fibre recovered from the fence, but because denim is a common fabric in clothing, a definitive conclusion of identity would be unlikely. The red fibre also resembled that recovered from the scene, but was a rare fibre and thus more discriminating than the denim. However, one pair of shoes was examined by a forensic scientist and compared with the shoe mark recovered from the soil bed (Figure 3.22). The scientist reported that it was very similar (a close match), that there appeared to be blood on the shoes and that there were traces of debris in the sole. The scientist made a detailed examination and produced a statement identifying points of similarity in the pattern and distinguishing damaged sections that she said made the shoes unique.
Footwear mark in blood suitable for DNA swabbing and profiling. This may reveal the identity of a victim or the attacker who bled during the crime. The question arises whether the shoe was placed into the blood already present or blood was delivered to the floor from traces already on
Those same damage marks on the sole were present in the soil cast taken at the scene. The suspect was later charged with the burglary on the basis of his presence in the area at the time the crime was committed as well as the fact that his shoes matched the foot mark outside the casement window at the point of entry. He continued to deny involvement, although he admitted that he had knowledge of the dispute between his associate (as former owner of the property) and the victim. Faced with this evidence, he still declined to state who he had been with the day the crime had been committed and had no alibi evidence to offer.

His car was examined by a Scene of Crime Examiner, who revealed a number of finger marks in the front passenger area. These were sent for fingerprint examination with a suggestion that they be searched against the marks of the ten associates identified by FLINTS. One set of marks was identified as those of a third male. These in turn matched some outstanding finger marks at one of the linked burglary crimes. The third man was also arrested, and admitted his involvement in the original crime, saying that he had been recruited to settle a dispute between the former owner and the current owner of the premises.

**Figure 3.27 & 3.28 Tool Mark From the Point of Entry at the Burglary Scene**

**Tool Mark From the Point of Entry at the Burglary Scene**

Microscopic comparison used to compare the tool mark in the paint with the tool recovered from the garden at the scene.
Five days later, the National DNA Database reported that the DNA taken from the first man arrested and in custody matched that in all nine linked burglary crimes, including (based on the blood found on the kitchen work surface) the main crime and an additional theft of a motor vehicle. Furthermore, FLINTS now reported an additional link by means of fingerprint and handwriting evidence to a deception practised in a department store, where a cheque from a stolen book of 25 cheques had been used and presented fraudulently. The cheque book had been stolen during a car theft. The damage to the door in the main crime that was believed to have been the point of exit matched the edge of the metal pipe recovered from the garden path (Figure 3.22).

The chart below (Figure 3.29) illustrates the crimes linked by forensic evidence to the suspect. The burglary and theft of the motor vehicle are linked by DNA evidence and the deception is linked by handwriting and fingerprint evidence. This chart demonstrates the links to those crimes that were the subject of a forensic link as well as links to an additional 35 potential offences of burglary that may have been linked to the suspect, depending upon the available evidence. Each of these crimes may have available forensic material available for comparison with reference evidence against the main suspect as well as his associates. These could be DNA, fingerprints, footwear, tool marks, firearms, handwriting, drugs, or, indeed, any forensic or physical contact trace material.

Analysis of the damage to the casement window and the door used to escape the premises revealed that the damage matched with the tip of the metal tool recovered from the path. A similar length of pipe was found in the boot of the car belonging to the suspect, and a comparison of the cut end sections of the two pieces revealed that they had once been a single pipe.
Figure 3.29 Chart of Links for the Linked Crimes and Offender\textsuperscript{42}

\textsuperscript{42} This chart represents a Bayesian Belief Network. The characteristics of these charts is explained in the section of the thesis entitled "Policing and complexity."
3.13 Second-generation FLINTS

The discussion so far has centred on the conceptual ideas underpinning FLINTS and the prototype version built to prove those concepts in practice. The remainder of the chapter will be devoted to developments and a description of the latest version, now called FLINTS 2. The author's aim was to have FLINTS 1 installed on every desktop computer in West Midlands Police area\(^1\) so that all staff could avail themselves of better evidence marshalling capabilities and, better evidence marshalling skills from training and use. FLINTS 2 was built for this purpose.

FLINTS 2 utilised the conceptual foundations of FLINTS 1, namely the systematic integration, analysis and use of information to inform the investigation and intelligence process along with access to information from an even wider range of sources. For example, tables of information about arrested persons, about persons stopped and searched, and about vehicles. The new version also allows access to Command and Control\(^2\) logs, and this enables information about incidents and crimes to be directly viewed and read on the screen.

FLINTS 2 was also built to incorporate more advanced mapping software\(^3\) so that geographical analysis could be undertaken at a more atomistic level. Geographical analysis provides useful insights into the way in which information about events, people and time can be marshalled.

Two specific features of FLINTS 1 were enhanced\(^4\) because they have great potential for the future. The first, a "prolific offender search", offers the ability to analyse the activity of persistent offenders. The second, a crime "hot spot search", allows us to monitor the frequency with which crime occurs in different geographic areas. These functions allow the investigator or analyst to generate hypotheses about who in the known criminal population may be offending repeatedly and about the locations where crime seems to happen most. By combining these functions, the investigator or analyst

---

\(^1\) By 2002, FLINTS had been installed on over 300 desktop computers in West Midlands alone. By 2004, FLINTS had been installed on a further 180 desktop computers in West Midlands Police and other forces.

\(^2\) The Command and Control System is computer that manages information about incidents and crimes reported to or attended by police.

\(^3\) FLINTS 1 had mapping software but it was rudimentary. FLINTS 2 upgraded this.

\(^4\) Both exist in FLINTS 1 but were enhanced in FLINTS 2 to make them available to greater number of staff using the system.
can contemplate both detection and prevention strategies. Interventions can then be targeted more accurately and the results measured over time.

Two new search and analysis functions were added. The first allows a search to be made for addresses of interest, and the second allows searches to be conducted for vehicle license numbers and partial numbers. These searches can be used to answer obvious questions about people, addresses and vehicles, but they can also be used to answer less-obvious questions. For example, if we want to know the name of a man but all we have is a partial registration number of what is believed to be his brother’s car, we can set about identifying the car, then the owner, then the owner’s family members. We could use the address search to provide lines of enquiry to establish which family members live where and whether any of those addresses are of interest to us. Using these search functions together or in chains of questions, we are able to navigate around the data warehouse in search of information to substantiate or negate hypotheses or to open up and test new hypotheses. It is the interplay of good questions and thoughtful analysis that allows the system to be used to best effect.

Figure 3.30 is an illustration of the main functions of FLINTS 2. Another new feature is the ability to use electronic mail (e-mail) to communicate intelligence findings to other personnel. Actioning forensic matches between people and crimes can be done instantaneously, thereby informing staff of a developing hot spot or the identify of a prolific offender in real time. Just as importantly, the results of this communication can be received in real time.

**Figure 3.30 Main Functions Offered by the FLINTS Toolbar.**

<table>
<thead>
<tr>
<th>Key List:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = Exit system.</td>
<td>8 = Address search.</td>
</tr>
<tr>
<td>2 = Management information.</td>
<td>9 = View management information.</td>
</tr>
<tr>
<td>3 = View graphical links</td>
<td>10 = Mail system.</td>
</tr>
<tr>
<td>4 = Prolific offender search.</td>
<td>11 = View history.</td>
</tr>
<tr>
<td>5 = Names search.</td>
<td>12 = Enter hit results.</td>
</tr>
<tr>
<td>6 = Hot spot search.</td>
<td>13 = Set-up options.</td>
</tr>
<tr>
<td>7 = Vehicle search.</td>
<td></td>
</tr>
</tbody>
</table>
FLINTS 2 is a "tailor made" system designed to support the West Midlands Police in undertaking their investigations and intelligence work. It is built on the same conceptual foundations as FLINTS 1, but uses wider sources of information. Links between people, crimes, locations and times are primarily based on forensic evidence, but incorporated into FLINTS 2 is the ability to use "accepted fact". Here, the term "accepted fact" refers to information that is collected in the course of routine work and that would not normally be challenged. For example, the following are examples of accepted facts: that Frederick James owns a Ford Fiesta with license number X123 GHF, and that Hugh Flannery was arrested with Frederick Prosser on 15 November 1999. Another accepted fact might be the details about a "stop and search" conducted by a police officer under the Police and Criminal Evidence Act. The fact that these events happened at a particular place, at a particular time, and involved particular people is not normally challenged. These sorts of facts therefore provide important links in chains of reasoning and seemed ideal for inclusion in the system. Introducing the term "accepted fact", which has been borrowed from the terminology of law, into intelligence work is an important step forward for law enforcement. It allows us to explain to intelligence personnel that the collection, analysis and use of everyday information can be extremely effective if the information is systemised and managed carefully; this is especially true where there is a mixed mass of information. However, the terminology also allows us to but remind personnel that information of any kind is always subject to tests of credibility, relevancy and probative force.

3.14 Access to the System: Searching or Surfing?
The traditional approach taken by intelligence organisations in Europe and North America has been based on a policy of a "need to know". This means that only those persons who "need to know" are allowed access to intelligence information. This has been an openly accepted policy, but one might ask "how do you know if you need to know before you have access to the information?" Evidence is only as good as the uses found for it, so giving wider and more open information access to staff offers a greater potential for the evidence contained in a database to be put to good use. That is, staff accessing the system will potentially discover new scenarios and combinations of evidence that in turn can be fed back into the system as new inputs. Wide-ranging and open access offers high-quality feedback benefits, but has to be balanced against the risks of misuse.
FLINTS may thus create a measure of tension because the very opportunity and ability to access the complexity inherent in combinations of evidence will nearly always justify the user in claiming that they have a “need to know”. The nature of the policy currently operating in the West Midlands Region is currently classified as “sensitive”, so it is not possible to publish it in this thesis. However, what can be said is that success was gained by applying for a policy of very wide-ranging access for users in order to ensure sufficient access to the complexity of linkages in the system. FLINTS now presents so many opportunities for linking that it is feasible to literally “surf” the system to discover links between crimes and suspects based on evidence that can be immediately acted upon. This is compatible with what Peirce (1955, p.150 & 305). See also Peirce (1958, p.218) termed "abductive reasoning" and equates to acting on the basis of hypotheses that are mere hunches or insights, then recognising evidential opportunities presented as tests of their justification. The ability to formulate and ask questions speedily, then bring together the answers equally speedily while bearing in mind both what we have learnt and what we may want to learn if the opportunity presents itself is an example of Peirce’s reasoning. The process is similar to the asking of questions followed by seeking evidence to either refute or confirm the hypothesis embedded in the questions.

Sir Edward Crew, the Chief Constable of the West Midlands region, recently commented that “the system is beginning to produce so many cases that a wholesale re-evaluation needs to be taken about deployment of staff across the West Midlands. In some areas so many evidence leads and cases are being produced that there are insufficient staff in current structures to manage the arrests.”

Inappropriate access could present opportunities for corrupt practices and illegitimate use of the evidence. This problem has to be balanced against the need for wide-ranging and (as far as possible) open access to the system by investigators and analysts. The philosophy of this thesis and the design of the access system is therefore intended to support broad access but with security levels and passwords incorporated to prevent misuse.

Access to the FLINTS system cannot be gained until the user completes a log-in procedure, as shown in Figure 3.31.

---

5 Peirce (1958, p.304) "Abductive suggestio comes to us like a flash. It is an act of insight.”
Having negotiated the log-in procedure, users enter the system and gain access by negotiating a unique (individualised) password screen (Figure 3.32). Passwords can be changed at regular intervals by the user or by system administrators to protect against security breaches. All changes are logged and tracked by means of audit trails. The toolbar at the top left corner of Figure 25 is used to navigate through the system and to select the relevant options.

Once the user has negotiated the password and security system, they see the basic operating desktop (Figure 3.32). This desktop gives the user the tools to undertake searches, analyse results and navigate the system.
3.15 Asking Questions About People and Suspects

Figure 3.34 illustrates the results of entering a suspect's name (here, "Tyler") into the system. Tyler may be of interest as part of an enquiry or in response to a request for intelligence information as part of another investigator’s enquiry.

In terms of suspects, any single field or combination of fields can be used to construct a search. Searches can be made by reference to surname, forenames, date of birth, criminal record number and DNA sample reference number. Names or identifying
features (in any of the fields) can be selected and analysed further as the user's interest is raised.

3.16 Asking Questions About Crimes and Events

Crime types are coded into the system for ease of retrieval. Figure 3.35 illustrates the result of a search for burglary dwelling crimes. (These are coded as crime type "B.D.W".) Once found, crimes on the list can be selected, viewed, cross-referenced and searched again to provide more details about each crime as progress is made. This search could result from trying to locate a crime of particular interest based on its modus operandi or other discriminating features.

Figure 3.35 Results of Searching by Code (Burglary Dwelling Crimes.)

<table>
<thead>
<tr>
<th>Search For</th>
<th>Crime No.</th>
<th>Crime Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspect</td>
<td></td>
<td>BDW</td>
</tr>
<tr>
<td>Scene</td>
<td></td>
<td>BDW</td>
</tr>
<tr>
<td>HIT</td>
<td></td>
<td>BDW</td>
</tr>
</tbody>
</table>

Searches can also be done by geographic police area, such as a town, village, city or the whole of a police area. Geographic criteria entered into a search can change the results enormously. Figure 3.36 illustrates a search of a police area called 20L2. Again, crimes can be selected and analysed further as the user's interest is raised.

In terms of crimes, any single field or combination of fields can be used to construct a search. Searches can be made by reference to crime reference numbers, crime types, geographic locations and even laboratory references for forensic samples.

---

6 This area is a suburb of the West Midlands called Solihull.
3.17 Displaying Modified Wigmorean Charts: Graphical Results in FLINTS

One of the most powerful intellectual tools that FLINTS 1 possessed was the ability to visually display links within the evidence stored in the system. This feature has been retained and enhanced in FLINTS 2. Having obtained a list of search results, the user can select the required entry, and the links within the evidence in the system will be illustrated. Figure 3.37 demonstrates this feature.

Prior to FLINTS, the task of bringing together the evidence to construct such a chart would have been very time-consuming. It would involve accessing many systems, as well as the arduous task of drawing a chart encompassing all the nodes and all the arcs. Apart from being time-consuming, the many actions required of the user to obtain the information and then construct the chart would involve the risk of error. The automated system in FLINTS 1 and 2 speeds this process up and reduces the risk of error. In addition, the process can be repeated time and time again as new and interesting scenarios or links are discovered. This means that immense amounts of information can be marshalled and tested in different ways as the process of discovery unfolds. Users can combine different strategies and different functions\(^7\) to analyse, synthesise and hypothesise about relationships, links and networks of people and crimes of interest to the investigator's particular tasks. This process is unique to FLINTS 1 and 2.

Figure 3.37 provides an example of a search of the system and a graphical display of the result. Let us imagine that we have decided that a suspect called "Tyler" is of interest to us. In the top portion of the chart, we can see links between Tyler and his

\(^7\) Here, "function" simply means "questions".
former associates. These are people he has previously been arrested with or prosecuted with as a co-accused person. In the lower portion of the screen, we can see links to crimes based on inferences from forensic evidence. These present us with hypotheses about opportunity and will need to be tested alongside additional evidence. The different coloured lines refer to different evidence types or links.

**Figure 3.37 Graphical Display of the Results of a Search.**

The upper part of the FLINTS screen (user interface) displays networks of people and the lower part of the screen displays links between crimes. In this case, Tyler is the subject of the enquiry. He has thirteen direct links to former co-offenders called Brett, Adrian, Anthony, Bill, Andrew, Stewart 1, Stewart 2, Clay, Gareth, Kar, David, Craig and Martin. Tyler is also linked to fifteen crimes on the basis of different forms of evidence. Although Tyler is in the centre of the chart presently, any one of the other people or crimes could be placed into the centre and a whole new set of links would develop. This is because a new name or criminal event would become the central focus of the overall network. This demonstrates that asking new questions of some given initial condition
will often provide new answers, in this case, a new network. Figure 3.37 demonstrates the application of the general methodology described and discussed in Chapter 1. It should be noted that in Figure 3.37, Tyler is the central link between two sets of links or networks: one involves a network of multiples of people and the other a network of multiples of crimes.

Throughout this thesis, it is claimed that the ability to manage, juxtapose and ask questions of evidence in a variety of ways provides valuable insights into interesting scenarios and possibilities. In Figure 3.37, each forensic link is colour-coded and can be identified by placing the cursor on top of a line linking two objects or nodes together. Further information about each crime scene or person may be obtained by placing the cursor on top of the relevant icon. Additional information will appear that can then be presented in another graphical view.

On the left side of Figure 3.37, the user can make use of a series of functions on a toolbar. This has been designed to display the evidence in a number of ways and to reveal interesting combinations of the evidence. Figure 3.38 is an expanded illustration of the toolbar itself.

**Figure 3.38 Enlarged View of the Results Toolbar.**

![Toolbar Diagram]

**Key list:**

1 = Graphical chart function – people and events.
The presence of evidence is not always the same as evidence of the validity of the inference one can draw from it. Checking evidence for authenticity is as important in FLINTS as it is in the management of evidence in single cases. Figure 3.39 is an illustration of the warning system that instructs the user to check the validity of the evidence before acting upon it.

**Figure 3.39 Sample Warning to Confirm the Validity of Links.**

This approach helps to eliminate errors in recording and in evidence interpretation, as well as false positives. Imagine the presence of a DNA match demonstrated visually to an investigator on a chart. Before the investigator decides to take action, they are prompted to check on the validity of the match by checking secondary systems such as the National DNA Database or the Custody Records System in an attempt to uncover corroborative evidence.
Available photographs of suspects appearing in a chart can be viewed instantaneously. If there are a number of photographs available, they can be viewed chronologically. This has many uses, but one important one is the identification of unknown suspects.

Figure 3.40 FLINTS Provides Immediate Access to Photographs of Suspects in its Database.
3.18 Geographical Analysis

Figure 3.41 provides an enlarged view of the toolbar icons in Figure 3.37, plus explanations of the features. Figure 3.42 provides an example of the map that can be generated by clicking the second map icon in Figure 3.41.

Figure 3.41 (1) Icon for Selecting Geographic Overview. (2) Icon for Selecting a Subset Area. (3) Icon for Displaying the Results for a Selected View.

(1) Select to view a network of suspects geographically. Links between suspects and crimes across England and Wales can be identified. The links are then presented in the graphics screen.

(2) This icon can be selected to view the West Midlands Region and surrounding areas.

(3) This icon can be selected to view the graphics screen.

Figure 3.42 Map of Locations Within the West Midlands Region.
Figure 3.43 is a map of the West Midlands Region and surrounding county police forces of Staffordshire, West Mercia and Warwickshire. Crimes committed by a network of linked offenders are plotted on the map to give an impression of the distribution of the crimes. This display can give analysts insights into the places where suspects and their associates habitually offend, and compare these locations with each person's place of residence. This chart could then be compared with and indeed overlaid by another chart dealing with crimes whose perpetrators have not yet been identified crimes. There may be some correlation between those crimes known to have been committed by the identified network of persons and those crimes as yet undetected.

**Figure 3.43 Crimes that have been recorded across two police areas.**

This map display presents an opportunity to identify travelling criminals. Cylinders of various heights are used to give an impression of the number of crimes in each area. In this illustration, we have a hypothesis that a known offender, identified by means of DNA evidence, has been linked by forensic evidence to one crime in the West Midlands Region and another crime on the southern coast of England. Without FLINTS technology, these links could not be speedily identified during routine analytical work.

### 3.19 Temporal Analysis

FLINTS results can also be subjected to temporal analysis using the toolbar icon in Figure 3.44.
The use of temporal analysis in intelligence work can provide useful evidence to infer "opportunity" and assess how groups of crimes may be connected with each other. This assists in the provision of hypotheses and ranges of questions that can be explored elsewhere in the system.

Linking these types of hypotheses with those connected with “virtual offenders and suspects” provides additional insights into the identification of those in the population who ought to be considered as more likely offenders and those who perhaps should not be so considered. Reducing the certainty attached to some suspects in the database is a useful method of indicating those who should be considered for further inductive eliminative exercises.

Figure 3.45 illustrates a chronology of crime for the suspect Tyler identified earlier in this chapter.

Figure 3.45 Example of a Typical Chronology of Crime for a Suspect.
3.20 Prolific (Volume) Offenders Search

The prolific offender search function (Figure 3.46) allows the user to ask the system questions designed to elicit information about persons who repeatedly commit crimes—that is, persons identified by evidence as doing so. The police, acting under Home Office instructions, classify these as "detections" and refer to them in a number of ways. Figure 3.47 illustrates the various ways in which these classifications are listed. These ways are called "disposal types."

Figure 3.46 Searching for Prolific (Volume) Offenders.

![FLINTS Prolific Offender Search](image)

Figure 3.47 Disposal Types Used by FLINTS.

![Disposal Reason](image)
Prolific offenders can be identified by crime type, geography, and disposal type, as well as by reference to time. The results of searching under these criteria can be presented graphically in the form of a chart. This view has many uses in the construction and testing of hypotheses about crime and offenders.

### 3.21 Using Geography to Identify Prolific Offenders

In the West Midlands Region, operational areas are known as Operational Command Units (OCUs). These OCUs are listed in groups or clusters called Divisions, and coded from A to M. Any one or a number of these areas can be selected to provide the basis for a geographic query. Figure 3.48 illustrates this.

**Figure 3.48 List of Available Operational Command Units (OCUs).**

In addition, a single description or group of descriptions of crime can be selected to provide the offence type within 180 days, as shown in Figure 3.49.

**Figure 3.49 List of Available Offence Types.**
For example, looking at Figures 3.48 and 3.49 shows that we can select the E Division, the E2 OCU, and burglary crime during the last 180 days, by reference to where the crime was committed. This query (Figure 3.50) would give us information about burglary crimes committed in E Division's E2 OCU during the last 180 days and let us view the information graphically. We could also select any one of the crimes to view the original report on screen directly to access additional information.

**Figure 3.50 Query Definition Dialog Box.**
Figure 3.50 demonstrates the way in which the user is presented with a narrative of the question. This approach reminds the analyst at regular intervals about the question they are asking.

Figure 3.51 shows the results of a search. This screen allows the user to select items of interest from the results of the search for further searching or viewing in the graphical viewer.

**Figure 3.51 Results of Specifying a Date Range in a Query.**

![Figure 3.51 Results of Specifying a Date Range in a Query.](image)

Figure 3.52 is an example of the type of report that can be accessed using FLINTS 2 technology. The first illustration is a report concerning a crime included in the Crimes System and the second is a report concerning a Command and Control entry.
A map can be presented to display the relationships between crimes committed and events (indicated by black crosses) and the offender’s address (indicated as a red cross). See Figure 3.53 for an example.
By integrating searches between functions, detailed information about individuals and crimes can be accessed speedily. This feature can again include photographic details, as shown in Figure 3.54.
All the links to this individual can displayed using the graphical viewer along with information on their geography, chronology and associates.

### 3.22 Hot Spot Searches

As illustrated in Figure 3.55, the hot spot search function allows users to identify geographic areas where the frequency of crime is high. This can be done by reference to times, locations, and crime types, and can be compared with address details for
prolific offenders. This provides a powerful analytical tool for strategic analysis of crime frequencies as well as a briefing tool for patrolling officers and investigators.

**Figure 3.55 The FLINTS Search Function for Identifying Hot Spots.**

![FLINTS Hot Spot Search](image)

Figure 3.56 illustrates an example of using the hot spot feature to search for incidents rather than crimes. The address, the day, the date, the time, the reference number of the incident, the type of incident and any notes made by the reporting office can be accessed remotely by the analyst.
Figure 3.56 Results of a Hot Spot Search Based on Incidents Rather Than Crimes.

3.23 Vehicle Searching

FLINTS also offers a powerful mechanism for searching registration numbers of vehicles. Figure 3.57 and 3.58 illustrate the range of options. This is an example of the methodology designed by the author for the combination of different forms of evidence to aid the capacity for asking good questions. In this case, accepted facts from standard collections of data about vehicles and evidence gained from the investigation of multiple crimes. For both full and partial vehicle registration numbers to be searched as well as the make, model and colour of the vehicle. This gives investigators the ability to use what may appear to be trivial items of information to be entered into the system for searching against other information of interest.

For example, if a green Vauxhall Cavalier had been seen driving away from a number of crime scenes by victims and witnesses, and this information was entered into the system as a question, then it may give rise to the realisation of new information useful to the identification of the vehicle, the owner and the user. If an owner is identified in this way, new information is gained that can in turn be searched in FLINTS. This may involve a name query, an address query and a query to ascertain whether the subject has matched to any evidence recovered from crime scenes. This may realise more information about the owner. The result of this may realise yet further information that again may be subject of another query. As the process proceeds, investigative discovery
unfolds. Discovery of hypotheses, evidence and explanations (arguments) are all exercises in imaginative reasoning. (Schum, 1999a, p.409).

This iterative querying process provides the initial conditions necessary to undertake useful investigative discovery. Note in Figure 3.58 how only a partial vehicle registration number (called a VRM in FLINTS) namely “B6” has been entered for search. This has resulted in twelve possible matches of Vauxhall vehicles. We know that the vehicle of interest to the investigation is green and so that information can be used to select from the list of matches the green Vauxhall Cavalier.

Figure 3.57 The FLINTS Vehicle Search Dialog Box.
Searches can be conducted on the basis of partial information, such as partial vehicle numbers, makes, models and colours.

The results of vehicle searches appear in the form of lists from which the analyst can select those vehicles that appear to be of interest (Figure 3.59).

From the results list you can view details of the HIT. These will be displayed in the right hand screen.

Click on name with the other mouse and this will put the offender details into a names search.

If there are more than 20 HITS in the list you can browse though each list using the NEXT & PREVIOUS buttons.
3.24 Analytical Audit Trails

Using FLINTS 1 and 2 can involve navigating many inferential links between people, crimes, events, places and times. For example, a user may begin by searching for a suspect for a series of crimes but soon find themselves navigating links that change their priorities or produce unexpected opportunities to discover new issues of interest. The speed with which the system searches, retrieves information and then presents graphical charts can result in users "losing their way". Users can navigate so many links and find so many opportunities within charts that it can be difficult to know where the evidence trail started and how they arrived at a particular conclusion.

An audit trail has been built into the system to help users manage this potential confusion. This function can be activated by the user and will record as well as present audit trails. Figure 3.61 is an illustration of a simple audit trail or an aid to others checking the validity of evidence. Audit trails can become long lists of links, depending on the analysis.

The function serves two purposes: First, it helps the analyst to maintain a log of analytical activity that allows the user to "backtrack" through the analysis. The analysis can also be repeated by following the audit trail if the occasion arises. Second, the function can aid others in checking how a particular conclusion was arrived at. For ease of interpretation, the example presented here is a simple one—but is nonetheless a real audit trail from FLINTS. In Figure 3.60 we can see an example of a complex network of links between 37 suspects. The suspect at the centre of the chart is called "Barker". The chart represents a series of links beginning with Arnold, Chance and finally Barker. The original search began with Arnold, but by navigating only three more steps the analysis ended with an extensive network of linked criminals and crimes. This is an example of the methodology introduced in Chapter 1. The investigator and analyst is given access to a mixed mass of evidence about "networks" of links between people, crimes and evidence. The use of "networks" of links is an important feature of the approach. It allows the investigator and analyst to contemplate a multitude of both obvious and non-obvious evidence of links between the components of the "network." Furthermore, the iterative questioning process enables the analysis to become dynamic. Many opportunities are presented to ask new questions and gain new evidence. This would otherwise be beyond the ability of the investigator and analyst.
A valid question at this point might be, "what benefit has been gained by this approach?" The answer is that at each level of search, a different chart was viewed (similar to the one in Figure 3.60). This approach can give many different perspectives and insights into many networks involving suspects, crimes, locations and chronologies. Each of the five suspects from Hudson to Barker was viewed as a separate step in an analytical chain of reasoning. Each suspect, from Hudson through to Barker, became a central node at each stage in the process. That is, they became a central focus of the analysis, and all links known to exist between crimes and suspects were displayed in a chart.

Those charts also appear similar to the one illustrated in Figure 3.60. At each stage, therefore, the analyst can decide where the analysis will journey next, and by which route. Different routes will provide different results and different links. Many unknown features and characteristics of networks between suspects and crimes could be discovered in this manner.

Another answer to the question would be that Figure 3.60 has four links between suspects and burglary crimes (indicated by arrows). The suspects linked to these crimes have been linked by means of forensic evidence and are thus liable to be arrested on suspicion of committing those crimes. The hypothesis is that they had the "opportunity" to commit those crimes. However, there are indirect links between other suspects and the same crimes that may indicate different hypotheses. The investigator could, for example, draw inferences about which suspects might be acting together in crime and which may not be. These hypotheses can then be tested by performing other analytical work. This is an example of the way in which the system acts as a generator and tester of hypotheses. Some may be substantiated and some may not, but the important thing is the ability to ask the question. In this example (Figure 3.60), we could formulate a hypothesis that Barker, Chance and Arnold have been acting together as burglars. There is direct evidence of a link between Chance and Arnold and one burglary. Other hypotheses of equal validity could also be formulated, but from even this brief analysis, Barker has already become a suspect of great interest to us.

There are seven links to crimes of burglary in this chart, of which three are linked directly to Barker and four are linked indirectly via another suspect. The chart presents many hypotheses for testing the possible involvement of Barker and others in crime as well as many opportunities for intelligence generation. Recording the way in which the
chart was navigated might prove important to those we seek to persuade subsequently of the validity of our logic.

**Figure 3.60 List of Links and Hypothesis Summary.**

**Hypothesis:** Barker, Chance and Arnold have been acting together as burglary accomplices. There is direct evidence of a link between Chance, Arnold and one burglary.
Figure 3.61 Audit Trail - Hierarchy of Links in a Network of Associates.

Conclusion

This chapter has demonstrated that a neo-Wigmorean approach to the management, analysis and use of a mixed mass of complex evidence has much to offer police investigation. The ability to manage and navigate complex layers of information and follow direct and indirect links using the powerful visualisation techniques demonstrated provides great potential for the development of future systems. In the next chapter, the complex nature of the policing environment together with some of the problems and opportunities presented by gaining an understanding of the impact of complex systems and the science of complexity will be examined.
Chapter 4 Policing and Complexity

"He that will not apply new remedies must expect new evils, for time is the greatest innovator." (Bacon 1625)

Background

This thesis has been concerned with examining the case for a neo-Wigmorean approach to the management and analysis of a mixed mass of evidence in police investigation. The importance of acknowledging evidential diversity including the symbiosis between evidence, hypotheses and questions has been examined. Chapter 3 was a case study of a formal neo-Wigmorean system (FLINTS) designed to aid investigators and analysts ask good questions. FLINTS enables them to access huge amounts of evidence about events and observations taken from the policing environment. Due to the amount of information involved, the vast number of variables and the huge number of hypotheses that could be created for testing, the methodology described in this thesis including FLINTS, presents new and unique opportunities to police investigators and analysts. A continued source of concern for the author has been assumptions that abound in 'policing circles' about the nature, characteristics and diversity of the policing environment. For an enlightening study on complex environments and the role of human reasoning within it see Schum, D. (2002, p.4). Investigators and analysts can now gain unique levels of insight and understanding of the policing environment previously beyond contemplation.¹ FLINTS has a unique property not possessed by traditional approaches: Not only will it allow users to ask 'linear' or obvious questions that will often produce 'linear' or obvious results, the system will also allow users to engage in asking series of complex non-linear questions that often produce unexpected or non-obvious results. This often facilitates discovery of new knowledge to an investigation. This capacity is based on the neo-Wigmorean method described in this thesis and the opportunities presented by fast computers to store, compare, contrast and

¹ In April 2004, the Home Office and the Metropolitan Police approached the author to create an evidence based 'data-model' to assist in gaining an understanding of crimes of theft and robbery involving mobile telephones. This follows a massive rise in thefts of mobile telephones in London. Conventional analysis has not thus far provided evidence able to explain probable causes. The variables involved and the numbers of crimes is extremely large covering many Boroughs of London.
juxtapose evidence ways and at speeds that far exceed the capacity of the human mind. Many thousands of different combinations of evidence can be juxtaposed in an effort to find a chain of evidence that may provide a relevant answer. Many of these combinations are based on the testing of non-obvious and non-linear relationships between the items of evidence stored. The 'real' policing environment is stocked with non-linear relationships between events, people, places and times that are difficult to understand. The sheer number, and the complex issues surround causal relations, presents many problems for the observer, investigator and analyst. This non-linear environment is extremely difficult to work with unless aided by appropriate strategies, methodologies and a means to raise and test hypotheses. A discipline that allows us to gain insights into complex non-linear dynamic systems is the 'science of complexity'. By non-linear systems, the author here means the arrangement of nature, life and its complicated patterns and variables that go to make up our social and to some extent physical environment.

Chapter 4 is thus concerned with complexity: that is, investigating the properties and behaviour of the dynamics of non-linear systems, in this case, the policing environment. This allows a better understanding of the environment in which policing must operate to be gained.

The first part of Chapter 4 examines complexity theory and the second examines the complex police environment. The objectives of the chapter are twofold: firstly, gaining an understanding of the complex and dynamic nature of the policing environment; secondly, to introduce ways in which gaining an understanding of complex systems can aid investigators and analysts contemplate and ask better questions.

4.1. Introducing Complexity To Policing

Policing in the 21st century faces a multitude of complex problems. One of the most pressing is the management of the mass of information now routinely collected within many policing processes. As we have seen thus far, organizations have become proficient at the collection of information, but this has not been matched with a corresponding proficiency in the analysis of data and evidence to draw knowledge from it. This chapter
deals with the problem of policing in the context of complexity, and the opportunities offered by the emerging sciences of chaos and complexity theory. It is concerned with gaining a better understanding of the nature of our social environment and how this new understanding can be used to explain the many conditions we experience. Highly complex interactions between variables in the social environment cause different states to emerge, subside and reappear in ways that sometimes seem random and out of control. At other times, conditions seem static, immoveable and not in need of control. Designing strategies to manage social complexity from a policing perspective requires us to understand systems in which we work.

One of the claims in this thesis is that the role of the policy-makers in policing should be to deeply understand the environment in which they operate so that appropriate assessments can be made that in turn justify appropriate strategies to combat and deal with problems. This enables the policy-maker to take action now that will result in desirable outcomes and minimize undesirable outcomes in the future. To achieve this goal requires contemplation and reasoning about the potential outcomes of particular courses of action and policy-making. Prediction is a key component of this process, and can be achieved by extrapolating knowledge of a current "system" to a future state. The ability to do so depends upon the ability to gain an understanding of both the current system and the environment in which it operates.

The impact of science, technology and socio-political change has resulted in a new environment for policing. Sir Edward Crew said that "change is the only constant and complexity is the only apt description of the environment in which we operate." How can we respond to this, how can we operate in this complex environment, and what are the challenges that lie ahead?

The systems discussed in this chapter are organisational systems that can be described as "complex" in the sense that a large number of independent variables interact within the system in a great number of ways. Kaufmann (1995), in his cardinal work, provides

3 Address, entitled "Back To The Future", to the Chief Officers of the Police Development Programme, Bramshill House, Police Staff College, March 2001.
excellent insights into complexity theory and self organisation in systems. A fine balancing act amongst these variables creates a state of stability that can easily become a state of instability when that balance fails. A state of what is almost suspended animation exists just before the stable, ordered state falls apart into turbulent chaos. If turbulence begins to occur, then chaos results, accompanied inevitably by self-organisation of the system into a new state. This process is unsafe because it may result in the system evolving into an unpredictable state. The danger lies in the randomness of change and the lack of control that the new order brings. If organisations can predict this "tipping point", they can prevent chaos and the unpredictability that self-organisation creates. In addition, organisations can use the understanding they gain about information and knowledge flows to design better strategies, policies and tactics intended to maintain order and stability.

We already have some notable examples of complex systems in policing. For example, the National DNA Database and the Automated Number Plate Recognition System are intelligence systems with large and complex data sets that are constantly changing as new scenarios are developed and new information is obtained. There is massive potential for new connections and combinations to be discovered in these data sets between events, people, locations and times. These connections and combinations can be used to generate new understanding about the environment in which the systems operate, thereby enhancing our ability to control these systems. The complexity that exists within even these modest-sized systems is seemingly infinite, and requires special tools if we are to manage this complexity and harness it productively. An example of such tools is FLINTS, whose design is informed by lessons from complexity theory and which harnesses the mathematics of this theory to discover links between crimes, criminals, locations and times that would otherwise not have been discovered using traditional linear or manual approaches.
This chapter will examine two main areas: First, it will explore why we need to recognise the underlying metaphors of chaos and complexity theory and consequently, how we need to change our approach. Second, wherever complexity exists in our systems there is the potential for us to create connections and linkages between elements of the systems. The chapter will also explore ways in which these two understandings can inform practical intelligence and analytical work.

4.2 What are Chaos and Complexity?

"Chaos" is colloquially used to express a situation of incomprehensible disorder. However, the new scientific theory of chaos redefines the term and attempts to describe apparently unpredictable and random behaviour in dynamic systems, which often turn out to have surprisingly simple underpinnings. In contrast, "complexity" is the term used to describe the behaviour of collections of simple units in a system that can interact to create evolution within the system. Examples of these units can be atoms, neurons, "bits" of digital data (this is why the smallest unit of information in a system usually referred to as a zero or one), cells, molecules, or persons or other members of a population. The key to understanding complexity lies in realizing that the system evolves through the interactions over time among the small units within the system. This behaviour can sometimes be modelled. For the purposes of this thesis, complexity is used to identify patterns, peaks, troughs, trends and "surprises" within the massive systems of data collected by the policing function. These models can then be used to gain insights into the causes, influencing factors, links and weaknesses inherent in the system. These insights can then be used to guide our interaction with the environment in an effort to enhance its stability, prevent instability, and improve harmony and safety.

A number of key characteristics define chaos. It will be useful to examine these within the context of policing. To begin with, it will be helpful to identify these key characteristics, then illustrate some of the ways in which complex, chaotic systems can lead us to create algorithms that are useful for understanding systems and predicting their behaviour and the effects of our interventions. Moreover, this can help us to develop our knowledge about the data we possess, most of which we cannot use or penetrate because the variables are so numerous and wide-ranging, the layers of data are so deep, and our conventional approaches are insufficiently sophisticated to master the complexity involved.
Chaos results from a deterministic, non-random process. It is neither indiscriminate nor haphazard, despite what is suggested by the common connotation of the word. The modern understanding of chaos states that what is seemingly random often results directly from prior causes and is never governed by some notion of free will or truly random action. In a policing context, Command and Control systems provide a good example. These systems manage a wide range of information, including messages received from conventional telephone calls, calls from the 999 emergency call system, police radio traffic, collections of general information reports, and the results of incident logs and crimes. Activity in the system is determined by information input from many sources, some of which are related, but all of which have some impact on the system. If we were able to take a "snapshot" of the whole system at any one point in time, we would see a different state of affairs than if we looked at the system again at another point in time. Placing a number of these snapshots into a sequential chronology demonstrates the action of chaotic "periodicity", in which a pattern emerges from the apparently chaotic state. Over time, the system would exhibit ebbs and flows of patterns by virtue of the causal relations between the bits of information in the system. The patterns appear disorganised and erratic, though sustained, but usually fail to meet the statistical definitions and tests for true randomness.

Chaos also happens in systems governed by feedback. In these systems, past events affect current events and current events affect future events; the results of these chains of causality is that changes in one or more aspects of the system feed back into other aspects, creating the perceived patterns that arise in the future. In policing this can be seen in the way that criminal events occur and are reported, and how environmental conditions such as geography, time, populations and events such as soccer matches affect behaviour. A good example that the author experienced personally is the way in which the offending population in given localities is often restricted to certain members of the population and their family groups and associates. If an apparently prolific offender is incarcerated for a given period of time and that offender is (de facto) an active criminal, then certain types of crime, as well as their pattern, their frequency, and the persons suspected of involvement with the prolific offender's network, may change. Although this observation does not always hold true, there are nonetheless patterns in the persons who
are regularly arrested for crime versus those who are never arrested. In the previous chapter, a number of these patterns were illustrated.

The ability of a suspected offender to engage in crime, plus the opportunity and means to commit a crime, all involve feedback loops that affect the macroscopic view of crime within the population as a whole. Gaining an understanding of these feedback loops is the key to using chaos and complexity theory to support the investigation and prevention of crime.

A useful example involves the term “noise”, which can be used to depict erratic behaviour in a system. Noise occurs as a purely random sequence of data, and because it is random, it carries no meaningful information. In contrast, chaos only exists within nonlinear systems, in which the system variables combine in more complex ways than by simple addition—but nonetheless combine in ways that can be understood and modelled.

Chaos can result in simple systems as well as complex systems. There is also no need for a high number of variables, since as few as three interacting variables can generate chaotic behaviour. In addition, chaotic behaviour is self-generated (within the system itself), and does not require variables external to the system to create a chaotic state. The given conditions or parameters of the system itself are all that is needed.

A common misconception noted by Williams (1997, p. 209) is that chaotic states result from inaccuracies in data, such as sampling or measurement errors. Although it's true that such inaccuracies can lead models astray, the important point here is that as long as control parameters remain within an appropriate range, complex interactions among these parameters can still lead to chaos. The ranges of these variables have limits or boundaries that typically restrict the results of their interactions to certain finite regions (called "attractors") in the phase space that describes the system. These attractors can be thought of as a means to describe the long-term behaviour of the system. As we shall see later, there are three main attractors that explain the range of states observed in chaotic systems: steady states, periodic states, and chaotic states. Steady states represent a state of equilibrium, in which the external view of the system suggests stability at a fixed point (which is why these are also called "fixed-point attractors"). In contrast, periodic states have two or more clear states that alternate within an externally visible cycle and have a
limited range of values; this latter aspect is why these situations are also known as "limit cycle attractors". Lastly, chaotic states fit neither of these patterns, and thus have what is known as "strange" attractors. In all three cases, the important thing is to remember that the behaviour of the system exists within a finite limit or region of phase space that is restricted and defined by the attractor. This behaviour is also highly responsive to (sensitive to) changes in the initial conditions of the variables and thus, to their initial point in phase space. Lorenz (1963, p.130) first discovered the presence of chaotic behaviour whilst working on weather systems. He altered an initial condition only very marginally, yet that alteration resulted in disproportionately chaotic behaviour in the system. Chaos can be explained in simple terms see Lorenz (1993). However, it can also be used to explain difficult problems: See also Lorenz (1976, p.495), (1987), (1991. 241), in applying these principles to non-deterministic climatic change. The nature of the subject is the relationship between simple states and complex states.

Chaotic states often appear to be disorderly or incoherent, yet on closer examination, many different structures or types of order begin to emerge. This is one reason why it took more than 10 years for the scientific community to accept the findings published by Lorenz. Chaotic states do not often appear to contain any order or flow of order between states until they are examined closely, sequentially and within their phase space.

Attempting to predict the long-term behaviour patterns of chaotic systems can be fruitless because these systems are so sensitive to tiny differences in their initial conditions. If those initial conditions change, we experience considerable difficulty auditing and measuring their

---

4 Lorenz, a meteorologist, was the first to note the presence of chaotic behaviour in systems. In 1961, he decided to examine one particular sequence of modelling data at great length. Instead of starting the whole sequence on his computer from the beginning, he decided to start some way towards the middle of the whole sequence. He decided that the best way to achieve this shortcut was to copy the numbers at which the sequence should start directly from a former printout of the simulation results. Expecting nothing unusual to happen after the sequence began, Lorenz instead found that his new weather model differed dramatically from his original model. In order to explain this, he examined the shortcut he had taken and found that he had typed in the number .506 instead of .506127. This small change in the initial condition of the simulation amounted to only one part in five thousand, yet it changed the results of the model beyond all recognition.
variables to any reasonable level of accuracy. However, short-term predictions can still be relatively accurate. In addition, as chaotic behaviour emerges the system undergoes progressive changes that irretrievably lose the details of the initial conditions. Because of this phenomenon, it is often impossible to establish a chaotic system's initial state or prior history. The mathematical explanation for this is that the equation is "noninvertible"—we cannot determine the system's prior history, which can be irretrievably lost.

4.3 What is a Complex System?
Throughout this chapter, the term "system" will be used. This term is intended to describe the entity of "change" over time under the pressure of interacting, complex variables. For the purposes of this thesis, examples include computerised and human intelligence-collection systems, Command and Control systems, briefing systems, policy-generation systems, and so forth. Other examples would be the human body, the Health Service, a school, an epidemic, an economy, and so on.

Complexity theory is concerned with the investigation of the properties and behaviour of the dynamics of nonlinear systems. Linear systems are systems in which the outputs equal the inputs or the whole equals the sum of the parts; moreover, cause and effect are considered to be observable, and a pre-eminent position is held by reductionism, by means of which large problems can be broken down into smaller problems that are considered manageable and that can be reassembled to reproduce the original, larger system. More importantly, small changes in the initial conditions of a linear system produce similarly small changes in the final conditions. By contrast, nonlinear systems are those in which the inputs and outputs are not proportional to each other or the whole does not equal the sum of the parts; moreover, cause and effect are not evident simply from reductionist observation. The key feature of a nonlinear system is the unpredictability brought on by highly complex interactions among the system's variables and the "magnifying" effect that produces changes in output that are disproportional to changes in the inputs. Despite the seeming unpredictability of such a system, a property of "self-organisation" is evident. That is, even though the system exhibits symptoms of unpredictability, it also possesses inherent characteristics that lead to the development of organised states.
Linearity is attractive because it offers an easy path to structural stability and equilibrium, features that would be naturally attractive and desirable to a liberal society because control can be maintained and apparent safety ensured. However, linear systems can also be limiting, narrow and delicate because the structural strength they possess can translate into inflexibility that renders the system adaptive only with great difficulty in response to significant changes in its environment. Bureaucracy is often a feature of an archetypical linearised social system.

The significance of nonlinear systems is that unlike linear systems, they can generate instability and dynamic change. They can thus be seen as mechanisms that respond to social and environmental pressures. Where innovation, change and responsiveness are important, nonlinear systems can provide powerful strategic approaches and metaphors.

The first reference in the sciences to complexity as an emerging field of scientific enquiry can be traced back farther than the explosion of interest in the subject in the latter quarter of the 20th century. Poincaré (1905, p. 147) noted that:

"If we study the history of science we see produced two phenomena which are, so to speak, each the inverse of the other. Sometimes it is simplicity which is hidden under what is apparently complex; sometimes, on the contrary, it is simplicity which is apparent, and which conceals extremely complex realities.”

Although complexity was recognised, Poincaré pointed out that science had been conspicuous for its devotion to linear models of thinking, and that even when complexity was recognised it was often ignored. Working with mathematical models that sometimes exhibited traces of nonlinear behaviour, scientists generally chose to ignore this complexity rather than confront it.

As Schum noted (2001a, p.183), we often attempt to simplify what is in fact recognised as complex, and do not always have the time to deliberate on our evidence to a degree that would reveal complex associations. He claims that this occurs at such a fundamental level that we disregard subtleties in our evidence even when we have knowledge of its existence. In other circumstances, we do not recognise its presence at all and therefore
have no hope of drawing conclusions from it. In order to deal with the threats we face, we must be able to identify them. Ignoring, disregarding or failing to identify indicators of these threats (including complexity) is dangerous, for it is often not what we know that can hurt us, but rather what we do not know—or what we choose to ignore given our inability to deal with the details or our ignorance of its significance.

Complexity is strongly related to chaos theory, which studies the relationship between chaos and order. A complex system is one that is continually changing over time, even if that change is not easily visible from outside. What makes a system complex or dynamic is the process of change, which occurs by feeding back into the system the results of outputs caused by previous inputs. This result of this feedback is known as "iteration" or "recursion". The system continually iterates (repeats) the processes that generate or modify information, and the resulting information consequently changes over time. From order or stability, the system can fall into chaos and from chaos into a newly organised order.

Learning about this process has much to offer policing in both a strategic and a tactical sense. Systems such as policing fluctuate between chaos and order, and it is exactly this kind of fluctuation that the science of complexity tries to harness. If we can understand the phenomenon within a policing context, we can use it. Understanding complexity is thus promising for policing for a number of reasons:

First, complexity science explores the delicate relationship between simplicity, order and seeming or actual randomness. Policing has to confront this problem every day, yet it has until now been constrained by conventional views of the world in which the traditional linear model-building procedures of science have been used. Policing practice has thus been linear rather than complex.

Second, understanding complexity helps us to come to terms with a universe that was once seen as a simple, deterministic place in which all our answers lay in the simple physical laws of nature. Complexity tells us that although physical laws are still relevant, our environment can still fall into disorder and unpredictability when an understanding of those
physical laws would lead us to least expect it and despite linear predictions that it would not.

Third, complexity theory offers the opportunity to harness our understanding of complex phenomena and use them as tools. Extending the use of DNA analysis is an excellent example of how complexity has been harnessed as a practical application tool.

Fourth, complexity theory allows us to combine imaginative thought and innovative strategic thinking to harness mathematics and powerful computing technology to model our world and predict when chaos and its inherent dangers may appear.

Probably the best way to define complexity for policing purposes is that it is the study of dynamic change over time. Complexity arises when change begins to appear and the system evolves from what was a stable, orderly state to what will become an unstable, disorderly state. Here we might think about crowd behaviour or the emergence of crime waves or drug networks in communities.

During the past 350 years or so, we have seen the dominance of reductionist (Newtonian) views of the world and of the systems in which we live and work. Complex systems are broken down into ever-smaller parts, until everything is reduced to simple parts or rules, often using simplistic statistical models, in an attempt to find the individual building blocks that make up the "whole". What this way of thinking leaves for us is a difficult problem: How do we use the information we get about those smaller parts to explain the whole?

4.4 Tradition and the New World: Linearity and Complexity

There are two useful ways in which science attempts to describe systems: linear systems and complex systems. The first involves system types with fixed variables that we can thus term "fixed linear systems". The classic metaphor here is the Newtonian one, in which variables are set in a fixed universe or environment. Linear mathematics rules in these systems because interaction A will reliably result in consequence B, interaction with B will result in consequence C, and so on (Figure 4).
Figure 4 Illustration of a Linear System. Interaction “A” will result in Consequence “B” Interaction with “B” will Result in Consequence “C”, and so Forth.

There is no “fuzziness” about the system; its underlying laws can be proven and modelled in a linear way. In addition, there are no feedback loops to affect the system.

In contrast, the second way involves systems with no fixed variables that we can call nonlinear or complex systems. In Figure 4.1, we see that we cannot simply move from A to X in a linear path. We must instead pass through at least one of the elements that lie between them. We have thus encountered a situation in which a large range of variables affect the solution to the problem. In addition, if we then seek to move from X to the next step (Y), we encounter yet another set of intermediate variables. In real-world systems, we may encounter hundreds or even thousands of variables in attempting to solve a problem. Moreover, there are feedback loops between variables that may return us to previous states rather than allowing predictable progress from A to X to Y.
4.5 Linear or Complex Systems

Probably the most important thing to note about linear and complex systems is that each has different properties in terms of its predictive ability. Linear systems have variables that are simple and directly related. Mathematically, a linear relationship can be expressed as a simple equation in which the variables involved appear only to the power (exponent) of 1. In Figure 4.2, there are no squares, cubes, fourth powers, etc. These types of systems involve simple, deterministic current states that can be used to predict the future with considerable accuracy. *The inputs are related directly to the outputs.* At any point along the horizontal axis, we are able to predict the value along the vertical axis as well as the coordinates of points before and after that point. If you know what the input value is, you can accurately predict the output value, as well as the previous and subsequent input values.
In contrast, in a complex (nonlinear) system we are dealing with more complex mathematical states in which the powers (exponents) involved are other than 1 (Figure 4.3). Moreover, interactions with other variables may alter the behaviour of even a simple-seeming nonlinear equation; the equation, including all those non-1 exponents, is simple enough, but the values of each variable in the equation may be changed by those other variables, throwing off the predictions. These equations are thus nonlinear, and the current state of the system at any given time does not relate predictably to the previous or subsequent states; thus, our knowledge of the conditions at any one point along the horizontal axis will not let us reliably predict the state of the system at any other points along that axis. Using the equations underlying such graphs usually requires computational assistance, and the predictions we make are probabilistic rather than deterministic. It will be seen that what seems to be chaos does in fact contain patterns that can be described statistically. It’s that statistical underpinning that creates attractors and gives us even the slightest hope of being able to predict the behaviour of such systems.
An interesting feature of complex systems is that only a small fluctuation in an initial state of the system or network can result in massive fluctuations further into the system and over time; this occurs both because the exponential nature of the underlying model amplifies small differences and because the input values are affected by other variables. An example would be the activities of a group of criminals committing crimes; although the influences of each group member on the others may be predictable, the responses to these influences are not, other than probabilistically.

4.6 Has Complexity Replaced the Old Order?
The traditional Newtonian approach is still an important and useful tool. It has an important role because some systems can be approximated (at least in the short term) as linear systems, and given a set of constant values, we can use these systems to transfer our knowledge of the past and present into predictions for the future. This is often called a “linear” approach because on a graph, the line extends from past data into predictions about the future in a linear and predictable way (e.g., Figure 4.2). If we know the past of these systems, we know the future.

Inputs with constant values result in outputs that are directly related to these inputs. This allows linear systems to be used as predictors. The difficulty lies in determining whether
the values can be relied upon to remain truly constant. Values taken over different times and spatial dimensions may generate different resulting values. Nonlinear relations also allow prediction if we can adequately characterize the relations. In Figure 4.4, we can see how the identification of such relations allows prediction to be undertaken — the key is knowing what the relations are within the information and plotting them reliably.

**Figure 4.4 In Some Nonlinear Systems, it is Possible to Approximately Predict the Future Behaviour of the System.**

The problem now facing policing as well as other disciplines is the very notion of an emergence of knowledge about our complex, nonlinear environment and world. We are used to dealing with linearity, which has continued role to play in detecting and predicting futures. The difficulty we now face is in dealing with the consequences of being able to predict unpredictability itself—linear systems sometimes offer us that ability.

If we look closely at a bifurcation diagram, as in Figure 4.5, we can see areas within the system where clear patterns emerge. The bifurcation diagram illustrated in Figure 4.5 portrays the way in which large amounts of (it does not necessarily have to be large but large amounts demonstrate highly variable results quickly) information being input into a system, can behave when there are many variables interacting in non-linear ways. The system has the capacity to produce information in the form of outputs that are unexpected. This can represent new knowledge in the form of non-obvious knowledge. A bifurcation is a doubling of the period, such as a change from an N-point attractor to a 2N-point attractor, that occurs when the control parameters are changed. The bifurcation diagram is simply a
visualisation of the succession of period-doubling that is produced as $r$ increases. Successive iterations create a period-doubling bifurcation in which successive values of $x$ are plotted over a number of iterations, thereby producing the distinctive diagram.

**Figure 4.5 Bifurcation Diagram.**

Observe the white space marked by the red arrows in Figure 4.5. These spaces represent attractors. If we closely examine the section of the diagram around $r=3.83$, we can see a three-point attractor. Careful scrutiny reveals that between 3.57 and 4 there is a rich interplay of chaos and order that produces these patterns. The diagram is deterministic because the initial conditions are set, but even a small change in $r$ can make the stable system turn chaotic, and vice versa. If we know the relations between the initial conditions, then we can use the system to make some predictions, but always keeping in mind that small fluctuations or bouts of chaotic behaviour are highly likely to affect the validity of the predictions we make.

### 4.7 Why Analyse for Chaos?

Analysing systems to detect the presence of chaos can help point us towards an understanding of whether apparently random-looking changes and oscillations are in reality an orderly system in disguise, working around sets of attractors that will prove useful to us.
Discovering what rules are involved in determining this behaviour can help us to develop heightened levels of understanding of causes. This understanding can, in turn, be used to develop short-term predictions.

Time limits, cycle limits can help to identify attractors of particular interest all of which can become useful and possibly reliable predictors for distinguishing between unreliable long-term predictions and reliable shorter-term predictions. These limits or attractors can be used to enhance the capacity of the system to model states useful to the user. The underlying weakness inherent in chaotic systems (unpredictability, high variations in states for example) can become useful in revealing the details of the real-world states and physical laws that govern the states under analysis.

Advances in computer power have enabled us to investigate interesting and difficult problems in ways that were previously beyond our grasp. In Chapter 5, the "MAVERICK" system, designed by the author to exploit the power of modern computers to manage and correlate highly complex sets of data, illustrates how profound this analysis can be. The system manages nonlinear relationships in collections of evidence in order to extract knowledge about events of interest to investigators and intelligence analysts.

Layers of information can hide linkages between factors that are too obscure and too difficult to discover using conventional approaches. These remote and indirect linkages reveal useful chains of information that can inform our investigation of a crime, identification of offenders and prediction of future threats. They also suggest useful strategies to prevent some of the threats inherent in the system from becoming a reality.

As a means of describing the world and the environment in which we live and work, complexity theory is one of the most exciting areas of science and one that can and should be employed in policing. In terms of importance, it ranks with Darwin's theory of evolution because it helps us to discover the "order" that lies deep within most complex systems, ranging from the mechanisms driving large corporate organisations, to explanations about

5 Police organisations are staffed similar to large corporate organisations.
the workings of living cells\(^6\), to the spread of epidemics\(^7\). Complexity explains why this order exists, and provides valuable tools to determine when a stable and orderly system (such as a society) is about to fall into unpredictable chaos. It provides a system of thinking that can help us prevent chaos and instability from overwhelming what was previously an orderly, stable system. Learning about the parts or the elements of the system provides insights into the relationships and linkages that define the system as a whole.

Charles Darwin, (see Gould 1992, p.2),\(^8\) who many consider to be one of the fathers of modern science, said that our complex world can only be understood by a process of mixing information or data with our own theories or explanations of the world. Understanding is not merely about the collection of information, whether it be scientific data or other data: it is the combination of data with our complex view of the world (our theories) that presents useful tools for those engaged in any pursuit that requires the production of explanations from investigation:

"About thirty years ago there was much talk that geologists ought only to observe and not theorise; and I well remember someone saying that at this rate a man might as well go into a gravel pit and count the pebbles and describe the colours. How odd it is that anyone should not see that all observation must be for or against some view if it is to be of any service."

This is perhaps one of the most important lessons in the scientific revolution of the last 200 years. It tells us that data alone (we could replace the word "data" with "intelligence information" or "evidence") means nothing; it is the complex world in which we live where true meaning and explanations of events are to be found. Data is only the evidence upon which we can measure the reliability of our explanations. If scientific observations of the world are to be useful to us in any way, they must be tested against some theory or explanation. This is the opposite of how many people see science; a common view is that if

\(^6\) The use of cellular material to identify donors at the scene of a crime is now common practice in modern policing.

\(^7\) In terms of the high numbers of variables, their interactions, and their effects, there are similarities between the spread of epidemics and the evolution of criminal networks.

\(^8\) Charles Darwin: Letter to Henry Fawcett 18 September 1861. Quoted by Gould, S.J.
we have the data, we somehow automatically receive an explanation packaged with it. This is not only wrong it also presents organisations like the police service with a problem. People begin to rely on the data without resorting to the imaginative and creative process of explanation to form a theory or hypothesis. The world is too complex to be explained solely by a set of decimal places.

For our purposes, the importance of complexity as a scientific theory is best summed up by its ability to provide an understanding of key elements in systems or networks. An understanding that the whole is different from the sum of the parts is fundamentally important, as discussed and was shown in Chapter 1 in the discussion of decomposition and synthesis of propositions. Like many other large, busy organisations, policing agencies often concentrate on the "parts" rather than gaining an understanding of the "whole". Poising ourselves on the edge between chaos and order provides us with a valuable position from which to monitor our greatest threat—the instability inherent in that position and the ability of the system to self-organise into new and possibly undesirable states when we lose control.

The architecture of our current world has been built up over many millions of years, from the way that chemical molecules formed into cells, to the way that cells interacted to form organisms and ecosystems, and thence to the way that animals evolved within those ecosystems to form communities and nations. Humanity is just one aspect of that complexity, and policing merely one aspect of human activity. If we need to produce an example to illustrate how complexity relates to our every day world of policing, I can think of none better than DNA (discussed in Chapter 1) and the impending impact of the Human Genome Project.

4.8 Predicting Chaos and Self-organisation

As we have seen, minor instability can create a massive outpouring of chaos in chaotic (nonlinear) systems. The system may move from states of stability and predictability to states of crisis and chaos (Figure 4.6). It is important to be able to predict when this transition is happening or about to happen (the point of "criticality") because remedial

---

9 Miller (2001) discusses "havoc."
action and policy can then be undertaken. Determining levels of acceptable stability is a matter for the professional judgement of the policy-maker, based on high-quality information. If the crisis point is to be avoided and the system prevented from tipping into chaos, with the inevitable unpredictability associated with the subsequent self-organisation, what action (if any) needs to be taken?

Figure 4.6 Depiction of Criticality, the Point at Which Stability can Degenerate into Chaos.

Political scientists have coined the phrase “crisis instability” to describe the extreme sensitivity of world social and political systems to seemingly minor perturbations (Saperstein 1994, P. 149). In the sciences of chaos and complexity, these surges in system activity from stable to chaotic states can be seen in bifurcation diagrams. In the terms of the present thesis, the danger in bifurcation is that one bifurcation will usually result in a second, third, fourth, and further bifurcations until we experience chaos (Figure 4.7).

10 Both static and dynamic mathematical models have been used to predict outcomes of policy options in international affairs. Non-predictability in a deterministic dynamic model is usually referred to as ‘chaos’ and is used in this chapter as a paradigm of shifting states: namely, stability and instability.
Figure 4.7 A Bifurcation Leading to Additional Bifurcations.

Figure 4.7 demonstrates the process of bifurcation. The system suddenly surges from a stable state into what may appear to be random divergence. These bifurcation diagrams are a visual summary of the succession of period-doubling produced as $r$ increases. Figure 4.8 shows a bifurcation diagram of the logistic map ($r$) along the x-axis. For each value of $r$, the system is first allowed to settle down (stabilize), then successive values of $x$ are plotted for a few hundred iterations. Patterns appear as the process proceeds. The clear white areas marked with red arrows indicate steady states. At $r = 3.83$, we clearly see a three-point attractor, and between $r = 3.57$ and $r = 4$ we see deep areas of chaotic activity interspersed with areas in which a stable state exists. Identifying these regions provides indicators of the movement from stable states to chaotic states.

Figure 4.8 A Bifurcation Diagram Showing the Results of Successive Iterations.
One of the difficulties in analysing a complex system is that at first sight it often appears to be the product of randomness. It will be difficult to distinguish the outputs from random behaviour that is insensitive to initial conditions. Metaphorical use of the language of complexity is adopted by some researchers to describe the conditions and states in systems. They use the mathematical terms in a metaphorical way because they are fascinated by the way the language accounts for and explains complex states, and particularly those on the edge of chaos and order. For example, "bifurcation", defined formally as a "period doubling", has come to be used to refer to qualitative change. The importance here is that metaphors from complexity enrich our understanding, and can help to extend nonlinear thinking into new areas; as will be proposed in this chapter, policing could be one of those areas. It is important to be clear about the difference between technical and metaphorical language while at the same time reminding ourselves that the world cannot be explained by purely mathematical models. In this sense, the use of complexity metaphors to capture the richness of the states that we encounter and must
describe can be very useful. Indeed, the description of the FLINTS system is made easier by reference to the language and metaphors of complexity than it would be by seeking a deterministic description from philosophy, logic or epistemology.

Physical science is well versed in dealing with high levels of instability and turbulence created by small adjustments or variations. In fluid dynamics, scientists are very careful to monitor the effects of small adjustments in flow; "turbulence" results from chaotic flow. The same lessons can be applied to the flow of information in police systems. Acceptable, stable conditions can be sent into uncontrollable turbulence if certain conditions are not maintained; furthermore, it may only take a small adjustment or change of condition to bring this about. The ability to predict when chaotic airflow will appear over an aircraft wing requires careful measurement, analysis and monitoring. Instability noted in the laboratory will help designers to avoid discovering when chaos "kicks in" by the loss of test pilots and passengers.

4.10 Combining the Complex Real World with the Linear Digital World for Predictive and Discovery Purposes

A useful strategy in designing databases is to recognise that we are entering a process with two symbiotic components: the real world, and the virtual world. Together, these components link "real world complexity" with the man-made "virtual world" created by encoding data from the real complex world and rules for operating on this data in a database. In this manner, real-world data can be categorised, managed and combined algorithmically. This process allows complex relationships between what was once thought to be unconnected data to be connected and the relationships displayed. Once processed within this "virtual real world", the data can be decoded and re-expressed in the real world to simplify the task of understanding the complex combinations we discover. The methodology described in this thesis enables FLINTS to operate in precisely this way.
4.11 Thinking in Silos

A common feature in current policing is what Sir Edward Crew has described as thinking in "silos". For example, crime is dealt with by Detectives and Crime Policy, Community Affairs by Community Officers, Public Safety by Community Officers, Intelligence by Intelligence Analysts, and so on. In addition, operating above this is some notion or assertion that all policing needs is to have an intelligence-led model and that everything else will fall into place. What is missing is a rigorous and clear understanding of what that intelligence model should look like and why that model should exist. Furthermore, the fundamental principles upon which it operates and measures to assess effectiveness must both be understood.

The research conducted during this thesis has involved two visits to the United States to study intelligence management. The first involved travel to Washington (D.C.) and San Francisco (California) and the second to Washington and New York. During research visits with the American Federal Bureau of Investigation (FBI) and the San Francisco Police Department, it became clear that the problem of silos also manifests itself in law enforcement in the United States. Organisational structures were found to be hierarchical.

---

11 The term "thinking in silos" has been borrowed from an idea expounded by Sir Edward Crew to describe a common tendency and failure in strategic thinking. Crew has described how strategic thinkers should consider peripheral and secondary issues as well as those which appear to be immediately obvious because they exist within the narrow "silo" we inhabit.

12 Research visits: Two visits to the United States to study intelligence management. The first trip, in April 2000, involved travel to Washington (D.C.) and San Francisco (California) and the second, in December 2001, involved travel to Washington and New York. Visits were conducted with Federal Bureau of Investigation (FBI) and the San Francisco Police Department in April 2000, referred to as "stove-piping". I was privileged to receive and grateful for the support and assistance provided by the U.S. State Department (Washington, D.C.) and the Embassy of the United States of America, London especially invitations the author received to visit the U.S. and present the methodology and FLINTS. Following the terrorist crimes committed in United States on 11 September 2001, great determination is now being exercised to improve intelligence operations. Part of this effort now focuses on the growing interest in the lessons that can be gained from chaos and complexity metaphors in the holistic as well as the atomistic management and analysis of information. See Economist (2004, p.53).
and great emphasis was placed on tackling organised crime gangs, who were viewed as similar hierarchies. Power and strength to control the environment was paramount in both structures. Little recognition existed of the need for holistic, imaginative approaches to managing information in a substance-blind manner across the whole organisation. For example, the FBI do not routinely share intelligence data with the police departments about crime and events known to them even when this information would aid the work of local law enforcement. Sharing information tends to take place on the basis of the perceived seriousness of the crime rather than the value of the information itself in a general sense.

The source and context in which the information was discovered overrides the value of the information to fill gaps in the intelligence machinery of the organisation and other organisations. If the crime is considered serious, then the information may be shared, but if not, then it may be treated as redundant or proprietary information and not be shared. This makes the assumption that information about minor crimes may not have any bearing on more serious crimes, and vice versa. For example, knowledge that a particular car theft was committed by a suspect known to the FBI might be considered too minor to pass on. The assumption is made that because it is “minor”, it cannot have any bearing on any other crime, serious or not, in any police system. The problem manifests itself when, for example, the information about the car theft may be the missing link in a series of other crimes or a link to some other crime. This is made worse by the way teams of officers are organised. The police department organises itself on the basis of crime type; that is, one team or department may be organised to investigate drug crimes, one to investigate thefts from automobiles, one to investigate street robbery, another to investigate murders, and so forth. The focus of each team is on their own crime classification, not that of others. There is some evidence of competition between these departments for organisational status and praise as well as for budget share, so there may even be a reward for not sharing information even when that information could aid in the detection of crimes being investigated by other departments. Imagine the existence of a criminal who derives a "living" from the illegal trafficking of drugs. Further imagine, that in order to raise funds to support this enterprise, he raises money by committing minor street robberies for cash and jewellery, items that are not easily traced. In addition, he engages in a “specialty crime” of stealing briefcases from cars to obtain credit cards. All this activity is deliberately committed across geographic or organisational boundaries to evade detection. If a department responsible for car thefts arrested this criminal in the process of a crime, their
focus of attention would not routinely be directed towards asking questions about his overall criminal activities. He may even appear in court on a charge of theft that would not reflect his true enterprise. Holistic approaches in intelligence collection, management, analysis and dissemination are crucial to effective law enforcement because information sharing would reveal the entirety of the criminal's crimes. A similar problem exists within the intelligence community where federal organisations have been structured on the basis of areas of operation. This became obvious during research visits and meetings with federal intelligence agencies in Washington DC. Again, an assumption operates that information collected in one domain will have no bearing in another.

The Defence Intelligence Agency (DIA) is responsible for the collection of intelligence affecting military capabilities and responses. Taking the relationship of these three organisations alone, what would be the consequences of (say) a terrorist resident inside the United States or a terrorist taking up legitimate residency in the United States with the intention of building an apparently legitimate profile and identity while awaiting foreign instruction to commit acts of mass terror? One agency may possess information significant to the responsibilities of another without realising its importance to that other agency. Without the ability to realise the importance of this information, the agency concerned is left “hostage to fortune” when in reality, they could, with the appropriate structure and policy in place, have an opportunity to “snatch victory from the jaws of defeat”. The term “thinking in silos” is now familiar to the American intelligence community as a result of this kind of inter-organisation barrier, though until now it has been referred to as “stove-piping”.

Each of these “silos” impacts and interacts on the other, so treating them in isolation limits our ability to respond effectively and comprehensively to crimes that may span multiple silos. The intelligence model, which logically should be the glue that holds the policing model together, is a poorly understood tool in our toolbox. This area is where the silo exists in its most pernicious form—information and knowledge is endemic to all human interactions, and cannot be left to a stand-alone system in which isolated silos are allowed to exist.
One of the greatest examples I have seen of the "intelligence silo" is the scenario in which the police officer responsible for a geographical area seeks intelligence about a problem from an intelligence officer only to be confronted with the question of why they want access to the relevant data. This question ("what is your need to know?") illustrates a reductionist and isolationist view. Whilst this may sometimes be perfectly proper for security reasons, it does nothing for the officer attempting to come to terms with the complex and diverse array of associations between different elements that affect the maintenance of stability and order in their area of responsibility.

4.12 The Complex Police Environment

Police organisations have a wide range of responsibilities, including public safety, the maintenance of order, law enforcement, the reduction of crime, and the solving and detection of crime, to name but a few. In addition, the police undertake many semi-formal responsibilities that no other organisation is equipped to deal with. When other public services cannot cope, or when a problem is encountered outside their jurisdiction, it is the police that the public and the government turn to. The resulting workload is immense. As an example, in the year 2000/2001, the West Midlands Police dealt with 364,881 crimes and 869,462 incidents, received 4.75 million telephone calls,\(^\text{13}\) and attended more than 730,000 emergency 999 calls, all of which resulted in officers creating more than 100,000 intelligence logs.\(^\text{14}\) These numbers indicate a very high level of formal and informal contacts with the public, but the total number is unknown because the 7573 officers and 3273 support staff engage in an almost infinite number of interactions with the public (many of which are not recorded) 24 hours per day, 365 days per year.

This adds up to an enormously complex business. Policy-makers must organise resources, strategic directions, and policies to manage the two. The level of activity and interactions between the members of the police service and the public, the number of events and locations, and the pressures of dealing with the workload in the time available are immeasurable. The complexity involved can be likened to the interaction of atomic bodies

---

\(^{13}\) This does not include direct-dial calls. Members of the public can call these directly if they know the number. Source: West Midlands Police Information Technology Department.

\(^{14}\) An "intelligence log" is a submission of information about issues of interest to operational policing.
in physics. As with atomic structures, each interaction affects and changes the system, even if only by a small degree, and we know from the preceding discussion of complexity that such small fluctuations or perturbations can have dramatic consequences.

The potential for complex combinations can be illustrated by a simple example. If we assume that only 10 variables were operating within this complex system, there would be 1013 different ways of combining and assembling them into patterns. If there were 25 variables (for example, simple categories like people, events, locations), there would be 33,554,406 ways of combining and assembling them into interesting combinations.\footnote{In general, the number of possible combinations of two or more evidence items, when we have n items, is: $2n - (n+1)$. This amounts to an exponential explosion of information.} If there were just 50 variables involved, the number would be immense—more than 1.126 x 10\textsuperscript{15}. Now think about the number of calls, incidents, crimes, and arrests that the police deal with over time. They clearly work within a highly complex system of interactions that requires more than a linear approach.

Even if we wanted to, we could not possibly explore all possible interactions. For example, if we attempted to do so in the case of just 25 variables, and each combination took just 1 minute to deal with, the exploration would take up 69,905 person-days (268 person-years). Not only would this take an immense amount of time, but it would also prove to be enormously unproductive. Exploring more than 33.5 million actions in order to find one of interest would be a poor use of time, as it would amount to searching every possibility in the hope of finding something purely by chance.

How often are police officers asked to answer the question “have you looked into everything here?” One response would be to say “no, but I will report back in 268 years!” What we should instead be doing is looking at relevant information and likely causal events. Fluctuations in criminal activity, public order, and public safety can highlight how our environment is changing and therefore how we should respond to maintain stability.

For example, a particularly important skill is the ability to identify sets of prolific linked offenders, because these may represent the greatest threat in the form of repeated rather
than isolated crimes (Leary and Pease 2003). Another is the ability to identify patterns of linked criminal acts or precursor activity to the commission of criminal acts. Another is the ability to physically identify (by means of unique references) suspects and offenders from amidst what may appear to be non-specific and divergent data sets. When these data sets are combined or juxtaposed in various ways, they may reveal key indicators of identity (Leary 2004). This approach is described in the examples of FLINTS at work in Chapter 3.

Let us consider the potential of this approach. Imagine a comparison of the six million fingerprint records of former and current known offenders in the United Kingdom collection with the latent fingerprint marks of unidentified persons found at crime scenes. Then imagine a comparison of the one million DNA profiles of known offenders in the National DNA Database in the United Kingdom with the unidentified DNA profiles collected at scenes of crime and that have not yet had their donor identified. Now add the information contained within the National Police Computer system, which has indices that detail the names, addresses, and unique reference numbers for persons and crimes, as well as National Insurance numbers, convictions, intelligence information about wanted persons, and descriptions of vehicles by number plate references, including the names of the owners, their addresses, and taxation details.

If we can provide a means to combine the data in these individual systems (i.e., avoid the "silo" approach, in which each system remains isolated) along with a means to model changes appearing in these systems over time, we can analyse the changes and draw conclusions about models and limit cycles within them. What would begin to emerge is the portrait of a dynamic system with diverse variables. Investigations could then draw upon the iterative recursive nature of the interactions within the processes that generate the data in these systems over time. Many of the links that could be developed would be nonlinear and entirely dependent for their identification and discovery upon a hierarchy of initial conditions. Of course, to do so would require a methodological approach and system

16 A potential suspect or offender is a person who can be said to have had the opportunity to commit the crime.

17 A person who can be said to have had the opportunity to commit the crime.
such as described in this thesis that is capable of managing the complexity of such interactions and identifying the relevant data and patterns.

4.13 Policing and Complexity

Why should policing be concerned with complexity? A simple answer is that understanding complexity can provide us with a deeper level of understanding of the environment in which policing operates. As the statistics in the previous section make clear, enormous numbers of variables shape this environment, and their interactions are impossible to understand without understanding complexity. Casti (1994, p. 269) describes two scientists talking about complexity and reports their conversation. The first states that "complexity is what you don't understand"; the second scientist responds that "you don't understand complexity." The exchange serves to highlight two very important issues surrounding complexity. First, complexity can help us to understand behaviour or states within a system that are beyond our current understanding; second, complexity depends upon how you look for it. Casti explains (p. 269) that:

"In short, meaning [complexity] is bound up with the whole process of communication and doesn't reside in just one or another aspect of it. As a result, the complexity of a political structure, a national economy or an immune system cannot be regarded as simply a property of that system taken in isolation. Rather, whatever complexity such systems have is a joint property of the system and its interaction with another system, most often an observer and/or controller."

It is fairly easy, therefore, to see how an intelligence analyst, an investigator or a strategic decision-maker in policing interacts with the system to draw on relevant information, thereby enabling a conclusion to be drawn or leading the person to set about asking another question and eventually sending the results back into the system. This iterative two-way process in which input leads to output and feedback can be seen in operation when the results of strategies are operationalised. Changes can be seen in aspects of the environment such as the incidence of crime, availability of illicit substances, or frequency of visible policing activity in a neighbourhood.
4.14 How Should Police Respond to Complexity?

Training our policy-makers and managers about the historical lessons demonstrated by good leaders is certainly of benefit, but we would be better served if these people were introduced to scientific issues connected with problem solving, mathematics, statistics, physics, and indeed complexity theory. Von Clausewitz, Nelson and the early Greek military leaders certainly understood various aspects of complexity and grasped the importance of

Strategic studies in military and law enforcement colleges share a tradition of interest in the study of successful leaders of the past. Although this study is important in terms of the provision of role models, it does not of itself provide the generic skills and competencies necessary in a world in which complex issues involving political, economic, social, technological and religious matters combine to characterise and shape the problems we face. A good example of this was found in Washington (D.C.) during a meeting with Mr. Richard Wright of the National Defence University. In a December 2001 meeting, this topic was explored with the author. A course entitled "Profiles in Leadership" is provided by the National Defence University to examine the principles of political, military and corporate leadership. The purpose of the course is to help students be better leaders, and more broadly, to prepare the next generation of civilian leadership in the national security community. The course examines what are claimed to be "timeless" notions of leadership and how they are reflected in current-day problems. Topics include effective small-group leadership, establishing a leadership style, bureaucratic survival strategies, organizational decision-making, motivating change, and organizing teams for success. It was agreed that courses of this nature are a common feature of military and law enforcement training, but that they could be greatly enhanced by including material about effective hands-on management, analysis of intelligence material, and methods for practical decision-making using evidence whose credibility, relevance and probative value is questionable. It was agreed that many of these skills are assumed to exist rather than taught to practitioners. Interestingly, since the terrorist incidents of 11 September 2001, a new course has been included called "America’s War on Terrorism". This is described as a “review of the new national security paradigm” and begins with an overview of the post-Cold War security environment to establish a theoretical framework for understanding the global terrorist threat. Another section examines the national response to the attacks of September 11, again by examining the “leadership dimension”. Other aspects of the course look at the international perspective and the domestic response, with an emphasis on homeland defense. Students then look at the near-term challenges faced by the United States and the anti-terror alliance in meeting the terrorist threat. Again, it was agreed that understanding the importance of managing intelligence material at all levels of organization would greatly enhance the student’s ability to make defensible decisions and draw defensible conclusions from diverse arrays of material using rational and systematic methods.
information and knowledge of the systems they were becoming elements in. However, studying their approaches alone may not be the best approach to take in the context of a world in which information travels at the speed of light (much of it is “open source” and available to anyone via the internet) and global communications circumvent geographic barriers. Moreover, diverse variables are at play in this world, some of which are ignored because they are so minute that they are considered to be insignificant—this despite the fact that, as we have seen in the discussion of chaos theory, minute changes can have massive consequences. Understanding the impact of the interconnectedness of the modern world, and thus the strong tendency to nonlinearity and chaos, can clearly provide insights into better ways to generate strategic policy designed to overcome and divert threats.

A common feature of current criminal activity in the United Kingdom is the use of stolen cellular telephones to plan and execute criminal acts, some of which are committed across geographic boundaries. Although these devices provide the means for criminals to communicate quickly and apparently covertly, they also provide the potential for sensing and collecting digital traces that can be assembled into networks of calls between the users of the phones. These networks, some of which can grow rapidly and evolve in complex ways, can provide very useful insights into the relations between the users in terms of the calls made, the locations at which they were made, the times they were made, and the durations of the calls. These networks can be combined with other information that can help to identify some of the users and thereby gain insights into their possible co-conspirators. It can be crucial to identify the key elements in these networks so that in appropriate cases, covert monitoring can be undertaken. This monitoring in turn provides even deeper insights into the criminal networks. Tasking surveillance teams, planning an arrest operation, or tasking a counter-insurgence operation by a covert “friendly” agent can all be undertaken with greater precision and effect if they are armed with the right information. The outcome of this approach can be arrests or warrants executed at the most important or appropriate time, such as when evidence of the illegal activities can be recovered real time in the possession of the suspects.

19 Recently, there have been large increases in the incidence of thefts of cellular telephones. These occur in street robbery offences, thefts from vehicles and thefts from buildings. Many of these devices are later used in crime and many are “re-chipped” or programmed to permit covert use.
This approach can have additional benefits; witnesses who are fearful of providing testimony may not be required to give evidence because that evidence becomes effectively redundant. The protection of informants and agents whose evidence is similarly rendered potentially redundant would be another example. Disputes about the relevance, credibility and probative force of the evidence adduced can also be greatly reduced.

Flexible decision-making requires choices, but to exercise choices one needs knowledge. Prediction is the exploration of knowledge from a current system into the future, thus the ability to make useful predictions can provide the necessary knowledge. Undertaking that transfer of knowledge involves understanding the system in which you are working.

The designers of policy need to understand and master the system for which they are forming policy. Putting in place a strategic and flexible policy facilitates the making of predictions about what may happen next, what to deal with and what to avoid. This allows thought processes such as the following: "If we take action X, then Y will happen, but if we do not take action X, then Z will happen." The problem with overly firm policies is that they are like tablets of stone: they are strong under the right conditions, but may shatter catastrophically if those conditions change.

What we are learning now is that the professional policing environment adds up quite literally to a complex system in its own right, with near-infinite variables causing changes and potential conflicts. Competing social problems, organised and skilled criminal networks, and even disorganised antisocial behaviour are all examples of these variables at work, shaping and forming our society and the policing environment.

Why then should those involved in law enforcement be interested in the study of complexity in policing? Though most people are familiar with the role of investigation in law enforcement, few in my experience are familiar with the original foundations upon which policing was established, namely the prevention\textsuperscript{20} rather than the detection of crime.

\textsuperscript{20} Although the modern perception of law enforcement concerns the detection of crime, political expediency in the 19th century demanded that the new police force should concentrate on the prevention of crime as well as the diversion of offenders away from crime. Critchley (1978) points
Although prevention has proven to be an acutely difficult task for law enforcement since the inception of modern policing some 160 years ago, much progress could be achieved by accepting that policing must involve two major strands of policy: first, that police deployment and activity should be organised in ways likely to reduce the incidence of crime, and second, that systems should be implemented to organise the collection. The two strands of policy can act in parallel because the latter informs the former, while the former, properly organised, will eventually inform the latter.

Operating in this way can do much to optimise use of the available policing time and activity because it is often not what we know that will do us most damage, but rather what we do not know. Time is a scarce resource, but it is also a key component in operational activity. Because it is in such short supply, it can cause those engaged in managing the information upon which activity is to be based to disregard some of the details inherent in the information itself. Some of the detail may even be recognised as important, but is ignored because time is in short supply. On other occasions, the detail may not be recognised at all. One of the things that can be done to overcome this problem is to design systems that can enhance our ability to access the details of information we already possess but that cannot be readily recognised or accessed because the information is hidden in complex layers of data or perhaps in a disparate collection of systems. FLINTS is a system designed to assist in overcoming these obstacles because it can help us discover hidden information that, although not previously considered relevant, becomes relevant as time goes by. Reducing this delay can increase the availability of information in the system as a whole and thereby optimise its potential use. Better strategies can be designed that more accurately reflect the threats we potentially face, and therefore, strategies can be designed and implemented to prevent those hypotheses from becoming a reality.\(^\text{21}\) This

\[^{21}\text{The issue of persuading those responsible for intelligence policy and the training of intelligence agents about the importance of observing details in information systems was the subject of a meeting between the author and Professor Schum in Washington. [Specifically the discussion focused on his original works on (Schum 2001b) Evidence Marshalling and Argument Construction, The Case of General Alpha, commissioned by Defence Intelligence Agency of the United States; (Schum 2001c), The Case of Wigmore v Al-Qaeda and Evidence Marshalling and Argument}

\[265\]
approach sometimes involves indirect reasoning as well direct reasoning. For an extended discussion see (Schum, 1991, p. 99) In the following example (Figure 4.9a), the chain of reasoning is direct because each item of evidence or hypothesis leads directly to the identification or formulation of the next. The steps are direct and simple inference chains that lead to a hypothesis (Wigmore's "probandum"). In Figure 4.9b, however, the reasoning is not direct and involves oblique or indirect steps.

**Figure 4.9a A Simple, Linear Inference Chain.** *(P = probandum)*

![Figure 4.9a](image)

**Figure 4.9b A Nonlinear Inference Chain.** *(P = probandum)*

![Figure 4.9b](image)

These chains can become very complex, but can still be easily constructed and visualised by FLINTS. Many alternative layers of information can be combined and analysed, then used as new steps in new chains of reasoning over the passage of time.

The use of computers to assist us in this process is not a mere convenience—it is an imperative. Even undertaking what may be considered to be simple tasks involving only a small number of steps can quickly become so complex that it lies beyond the capacity of human memory. There are simply too many variables. As the number of items increases over time, the potential exists for exponential growth in the number of potentially relevant chains of inference. Accessing, navigating and keeping track of these chains of inference using conventional methods soon exceeds the capacity of the human mind.

[Construction, Restricted Access Documents]. Referring to his publications, Schum posed the question about the need for such marshalling methods and techniques. The response was that marshalling systems such as FLINTS provide the ability to mix and match, generate and eliminate hypotheses to such an extent that analysts can set about contemplating which of those threats, given the right conditions, may become a reality. Identifying these threats early presents the possibility of implementing strategies to prevent that reality from coming to pass.
4.15 What Are the Implications For Police Work?

Let us return to complexity for a moment. If the rules that control the system or network are linear, the range of outcomes is directly proportional to the inputs. By establishing what the inputs are, it may then be possible to predict the outcomes and present the police policy-maker with an ideal tool. However, as in most scenarios where highly variable groups of people and descriptions and categories and records of events are concerned, the system is likely to display nonlinear features. A decision to arrest someone or to investigate a network of crime or criminals is an input in itself, and will have some degree of effect on the subsequent structure of the network.

A practical example here would be a police intelligence system. These systems contain highly variable categories of information and highly contentious levels of quality in the accuracy of information; some information will thus always be subject to questions about its credibility. This is not the result of a lack professionalism; rather, it is an inevitable consequence of the type of environment in which the police operate. Witnesses and those supplying information are susceptible to the vagaries of their senses, and their ethical standpoint or motives may sometimes be other than what they state to the police. Even physical and forensic evidence must have its quality checked; evidence never arrives with its credentials stamped on it. Instead, the credentials of evidence have to be assessed, measured and declared by a human expert.

Imagine that the intelligence system has identified that currently a network of confidence fraudsters has been preying on vulnerable elderly persons in a particular geographical area. Let us also assume that we have what we assess to be very good descriptions of 10 suspects from witnesses who saw 10 of the crimes take place. In addition, we have obtained two DNA profiles from fingerprints left at two of the scenes. We believe from our experience of dealing with these types of crimes that this method has been connected with travelling family groups who centre their operations around a leader or a "key player" within their extended family. The key player travels the area to identify vulnerable elderly victims.
The family groups are widely dispersed, with most persons related in some way to other members of the group. Identifying the "key player" will inevitably raise smaller potential networks of related persons to treat as suspects. However, the current state of our intelligence suggests two likely "key players". Unfortunately, we do not possess DNA profiles from either to use as elimination samples. The potential involvement of these two suspects suggests which family group members to treat as suspects in the extended network, as shown in Figure 4.10.

**Figure 4.10 Hypothetical Network of Key Players and Their Associates.**

![Network Diagram](image)

The ability to select the right "key player" in the right network will be crucial in identifying the offender from the range of "possible" suspects. Imagine that we receive information from a questionable but not entirely unreliable source as to the identity of the "key player". Although this is just one small detail of information within a mass of other information about other criminal suspects, our discussion of chaos theory suggests that it may have massive effects upon the system's ability to predict likely suspects. In this case, new information about the likely player directs our attention to an entirely different extended family network.

One retort here could be as follows: "What is the point of employing or engaging complex systems and techniques if the outcomes are unreliable?" The answer is simple: if we are able to identify when unpredictability arises, we can avoid its consequences (an inability to
control and master the system or network). The ability to predict the apparently unpredictable state is a very useful tool: it reveals what we know and what we don’t know. Put another way, identifying unpredictability reveals when we are in danger of losing the potential to gain knowledge.

Another use for complex systems is that they are very good at extending our knowledge from the known to the unknown; we move from a state in which we know what the system holds and can predict, on the basis of this knowledge, to a state in which we can attempt to fill in the gaps in our knowledge and discover what we don’t know but need to know.

Unfortunately, no linear system can be sufficiently comprehensive that it can deal with and predict all the events we are likely to need to know about in the future—this is because the world is a complex and chaotic place, not a linear one. However, given static and deterministic values, linear systems can still play an important role. Neither complex nor linear systems provide the full answer on its own, and neither should be treated as exclusive. *We need both.*

The fall of the Berlin Wall is a good example of the need to engage in predicting the unpredictability of a situation. Although the perfect solution may initially have been seen as being achieved (i.e., the break-up of the communist domination of eastern Europe), the resulting chaos created a political dilemma of great complexity.

### 4.16 Linked Strategies to Harness Complexity

The author developed linked and interrelated strategies designed to underpin the need for integrated thinking in response to diversity and complexity. These strategies were accepted and implemented by the West Midlands Police and by the Home Office.  

---

22 The FLINTS system provided three key strands that supported the strategic development of the force. First, the neo-Wigmorean methodology and FLINTS reflected a recognition of the need to concentrate on a better understanding of the role of evidence in forensic (meaning "wider than simply scientific") investigation and intelligence. Second, it reflected a substance-blind approach to the treatment of information. Third, it reflected a recognition of the need to attain broad organisational acceptance of the approach and provide the connectivity necessary to support both holistic and atomistic information management. FLINTS now presents every member of staff, in
include Community Affairs, Crime, Intelligence, Forensic Science, and Homicide Investigation.

The traditional approach to managing resources in policing has been the single-case method. This is again a reductionist approach, and takes no account of the modern ability to manage large volumes of complex data and of problems at any one time. In this approach, a problem is encountered or a crime is reported and the response is to dispatch an officer to deal with the problem. This classic “response policing” gives little thought to the underlying elements and causes of problems. As a result, it fails to take advantage of our knowledge that many of the problems we face have interrelated features and causes. One problem may be connected to another, and any crime may be the result of some apparently unconnected event, scenario, circumstance, or opportunity created by some other social pressure.

It is inefficient and uneconomic to investigate every event in isolation in this way. If we learn about one problem, we can learn about many of the elements connected to it. We can then learn about connections to other problems. We should be interested in identifying the connectors between and causes of events, not merely the presence or the occurrence of such an event. Furthermore, we should be interested in sets of events that may be linked together because elements in one set of events may fill gaps in other sets. As noted previously in this thesis, it may be more important to investigate a seemingly minor crime that appears to be part of a series than a single isolated, seemingly more serious crime.

One may say this all sounds very abstract and ask whether it is relevant to real-world problems in policing. Take one small police system as an example of the practical impact of applying this recognition of complexity: the police fingerprinting system. In the West Midlands Region, the Fingerprint collection runs to more than half a million sets. When a latent Finger mark is recovered from the scene of a burglary and no information is available every department, with access to masses of information, but in rational, systematic ways so that it can be acted upon and used. The use of security levels ensures that abuse and inappropriate use of the system are both prevented and (should they happen) detected. Security levels and covert recording and monitoring of patterns of use exist.
about who may have left that mark at the scene, we are left with a problem about selection of suspects to compare against that mark. Where does the Fingerprint expert start? Who should the mark be checked against? In short, who might be the burglar?

On its own, the Fingerprint system may have 1 set of prints out of the half million that will match the marks found at the scene. Even with modern digital fingerprint systems, the Finger mark at the scene may be of questionable quality. Given the sheer number of potential suspects in the collection, we would benefit from some means to narrow down the suspect population. If the Fingerprint system were to be linked and integrated with the forensic DNA system, any hits against persons for burglary using a similar method based on DNA evidence could be compared with the Fingerprint case, and would provide good leads for further investigation. Furthermore, forensic Footwear, Tool mark, Handwriting, and other cases could also be compared. All these sources of data may provide valuable insights into who may have committed the crime if they are integrated into the overall intelligence system. More importantly, a system that narrows down the list of people who should be investigated by comparing multiple sources of evidence should greatly increase the efficiency of the investigation. But to do so requires embracing complexity, not ignoring it.

In the West Midlands Region, this strategy is now common practice; DNA hits are used to inform Fingerprint searches, and Footwear matches are used as to suggest who may be a suspect in undetected burglaries. From this experience, it was learnt that the creation of a complex system created by linking a series of smaller systems presented the opportunity for elements in one system to fill gaps in another. The West Midlands Region now routinely finds that forensic handwriting matches on cheque books is providing evidence of conspiracies in automobile crimes. In simple terms, we have learned that the elements of one case may inform another case at another location that was originally thought to be unconnected. Varied, diverse linkages and connections between events, people, and materials that were thought to be unconnected can now be detected. Approaching problems on the basis of reducing complexity into a manageable simplicity provides many new metaphors for engendering a greater understanding and more flexible (adaptable) policy-making.
4.17 The Implications for Policing: Reducing Uncertainty in Systems

Willmer (1970, p. 17) demonstrated that the value of an item of information is determined by the difference between the level of uncertainty before and after the information is received, and that this uncertainty can be effectively calculated. Police systems, like most systems in large corporate organisations, have two characteristics that generate uncertainty: high variability in data types and data whose credibility is often questionable.

---

23 A seminal work on the development and critique role of probabilistic reasoning was Eggleston (1978 2nd edn.).

24 Willmer demonstrated that if this approach were to be applied to a database of crimes and people who may have committed those crimes (a population), various equations would apply. Consider a set of crimes (\(a_i\)) and a set of people (\(b_j\)) who could have committed those crimes, where:

\[
\begin{align*}
  a_i & = \text{the } i\text{th recorded crime, where } i = 1, 2 \ldots N(t) \\
  b_j & = \text{the } j\text{th person in the population, where } j = 1, 2 \ldots M(t) \\
  N(t) & = \text{total number of people at time } t. \\
  M(t) & =
\end{align*}
\]

Further, let the probability at time \(t\) that person \(b_j\) is associated with crime \(a_i\), based upon the information available, be \(p_{ij}(t)\).

Hence, we know that a useful measure of the uncertainty which exists in the system is given by the entropy which is defined as

\[
H(t) = -K \sum_{i=1}^{N(t)} \sum_{j=1}^{M(t)} p_{ij}(t) \log p_{ij}(t)
\]

where \(K\) is a constant and is dependent upon the choice of units of measure used.

Suppose that in the next interval of time, further information is received concerning the number of recorded crimes, the number of people in the population, and the probabilities with which they are associated. Thus, the entropy (uncertainty) level at time \((t+1)\) is given by:

\[
H(t+1) = -K \sum_{i=1}^{N(t+1)} \sum_{j=1}^{M(t+1)} p_{ij}(t+1) \log p_{ij}(t+1)
\]

This means that if we wish to define the value of this information in terms of the effect it has on the uncertainty of the system, a measure of its value is given by:

\[
\Delta H = H(t) - H(t+1)
\]
In order to use data for discovery purposes in a police system, one must combine the data into different configurations and assess the results. Different sorts of data algorithms will generate different scenarios. The cocktail of data that exists produces a classic complex system because there are near-infinite potential combinations and connections between amalgamations of data, and both the data and the connections change over time in response to recursive (iterative) activity caused by the outputs of the system acting as new inputs. As this leads to a complex, nonlinear (chaotic) system, the sciences of chaos and complexity have obvious relevance to managing this data.

By assembling credible, reliable information about issues and scenarios of recurring interest to users, the FLINTS system tries to overcome the problem of reducing uncertainty in order to enhance the overall value of the data it contains.

Functional developments that could help us to make better use of fertile areas for research and development using awareness of non-obvious relationships within forensic databases are those amalgamations of data from different sources into sets that, when taken together, permit conclusions to be drawn and meaningful interpretations to be made about scenarios of recurring interest to users.

If the elements of these amalgamations are not credible, then the conclusions drawn from them may not be reliable. This creates "system noise" in that we have a high degree of uncertainty connected with any conclusions that we draw. If we rely upon the system for decision-making, we will have to exercise care in dealing with the potential for uncertainty. The strategy employed by the FLINTS system is to minimise the level of uncertainty associated with the system by reducing entropy, as defined by Willmer. This is done by using certain classes of information that has been graded before it is used.

The diagram in Figure 4.11 provides an example of the way in which uncertainty can be reduced over time in a system if the system is stocked with high-quality relational data whose credibility and relevance have been predetermined. Here, we can see that at point 1 in time we have a high degree of uncertainty in our database. If we begin to stock that database with data that we know is credible, reliable and relevant to our common objectives, we can reduce uncertainty. For example, if a police intelligence system is
stocked with data from diverse sources whose relevance, credibility and value are questionable, we will inevitably create a system with a high level of uncertainty.

**Figure 4.11 Reducing Uncertainty in Systems by Stocking a Database with Data that We Know is Credible, Reliable and Relevant to Common Objectives.**

Figure 4.11 was presented by the author at the First World Conference on Criminal Investigation and Evidence, The Hague in 1995. This was central in developing the ideas underpinning the methodology developed in this thesis (Leary, 1995b, p. 17). This represents the combination of different sources of evidence to reduce uncertainty and increase knowledge about factors affecting crime. This facilitates the investigation of series of crimes as well as single isolated cases.

![Entropy - reducing uncertainty](image)

Uncertainty

1. DNA
2. F/Ps
3. Footwear
4. Time

However if, as in the illustration, we begin to stock the database with information that we know is useful in drawing conclusions about issues of general interest to us, we begin to reduce uncertainty in the system. DNA hits, Fingerprint hits and other forensic matches linking people to crimes and crimes to other crimes are data sets that have the key characteristics that are important to us; they are credible, reliable and relevant to our general problems. If we then collect masses of this type of data, we create a system that can generate complex evidence we believe to be credible, reliable and relevant. Using the FLINTS system, we can then simplify these connections in a way useful to us.
But how does this happen, and how do we discover these complex combinations? Unmatched DNA stains reported to police forces by the National DNA Database is an example (Figure 4.12). What develops over time is a picture of crimes being committed by persons who leave forensic material behind but who have not yet been identified by police systems. One reason for this is that police systems are usually linear (focused on single cases) and do not yet take advantage of the opportunities provided by complex systems and approaches.

**Figure 4.12 Unmatched DNA Stains Reported to Police Forces by the National DNA Database. (OCU = Operational Command Unit.)**

This chart illustrates the range of unmatched DNA stains being found at scenes of crime in the West Midlands Region during a 12-month period. The data is arranged by Operational Command Unit (OCU) areas. Each bar on the chart represents the number of DNA profiles
collected from scenes within that area over time that have not been matched against a person within the National DNA Database. The crimes therefore remain unsolved.

The data in its raw linear state tells us very little other than the obvious: the quantity of unmatched crime stains experienced by each OCU over time. In this form, it would be of little predictive use, yet each individual match (hit) in each OCU represents a person committing a crime. All that is missing is the identity of that person. The current state presented by this data expresses a level of unpredictability and even instability in the "police system". Based solely on the linear nature of the available data, we cannot control this system and are thus at the mercy of an unpredictable state. Left unchecked, the trends expressed in the chart may become chaotic (i.e., the crimes may continue unpredictably).

To make the data more useful and regain control of the environment, we need to increase our knowledge base, and to achieve that increase, we must therefore have access to more details. This is where we begin to harness the power of complexity: those details can then be combined with other data to give us a better understanding of the underlying causes and help us decide what action we need to take to regain control of the system.

For example, it would be advantageous to establish, using data we already have from the unmatched DNA stains, whether any of the stains emanate from the same source and are therefore linked. If they do, we may discover that a single individual or even a networked group of individuals is responsible for a chain of crimes. If we combine that supposition with data about the geography, we may gain additional knowledge about elements of the spatial activity of the offenders. Spatial patterns can be determined from the frequencies of offending and from the distances between the residential locations of offenders and their victims. That is, there is often a relationship between the frequency of offending in a given geographical area and the criminals who live within that area. It is possible to select likely suspects based on spatial data of this kind, which could be combined with a list of unmatched crime stains. This combination will provide valuable insights and potentially powerful suggestions (new hypotheses) about those persons responsible for single and linked offences. We could also plot the unmatched stains over time and space to provide predictive data about where and when further crimes may be committed. An example of plotting unmatched stains on a map is illustrated in Figure 4.13, where the yellow dots
represent unmatched stains and the red dots represent the locations of residence of a repeat offender.

**Figure 4.13 FLINTS Screenshot Illustrating a Combination of Matched DNA Stains and Geography with the Last Known Residence of the Suspected Offender.**

In this illustration, created by FLINTS, we have combined data about matched DNA stains between an individual and the geographic distribution of crime locations and frequencies. The combination and visualisation of this data may provide us with interesting new insights into who may be committing these crimes, and where. For example, in Figure 4.14, which extends the regional illustration from Figure 4.13 to the national scale, we see that a suspect has been linked to a large number of thefts of vehicles in Liverpool, the West Midlands Region, Warwickshire and London.

**Figure 4.14 Nationwide Geographical View of Crimes Linked to a Suspect Produced by FLINTS.**
Each of these crimes also relates to a factory burglary in which computer equipment was stolen. Careful consideration of the logistics and manner in which this individual may have travelled between these crimes and carried away the large amount of property stolen may give rise to a suspicion that the motorway network between Liverpool, Birmingham and London was used. Vehicles thefts may thus have a direct relationship to this aspect of how the burglary crimes were executed.

Combining this hypothesis with data about unsolved crimes of a similar nature in similar areas, particularly where unmatched forensic evidence exists, will provide us with further valuable insights into other crimes that this individual may have committed. The forensic evidence at any of those scenes can potentially provide us with evidence to either eliminate or implicate the suspect and provide us with new knowledge about the type of crimes that individual may be committing. Moreover, any of the associated evidence may provide a crucial clue that compellingly implicates the suspect.

Now consider criminal associates of the suspect. What we ought to be concerned about is whether the suspect operates as part of a network of criminals. If he does, then those associates could also be considered against outstanding forensic evidence at the scenes of crime. By looking at the suspect’s history of offending with others, we may discover the necessary data.

Finally, as we progress with this exploration of the data, we should use any new information that we gain as part of the trail of data to provide feedback to the system. This
feedback will provide new potential combinations and interesting links as it interacts with data already in the system, gradually reducing uncertainty and supporting steadily more reliable hypotheses. This result is symptomatic of the self-organising characteristics of a complex system: evolution over time by exposure to and interaction with other elements of the system. The exposure and interaction involved need not be large. Even for small items of data, the interactions with other data in the system can drastically affect the outcomes.

4.18 Is Feedback a Threat?
Feedback is a common feature in the natural world, and because policing is delivered in that context we should anticipate a need to deal with that feedback. Feedback is a characteristic of any system in which the outputs can affect subsequent inputs (Figure 4.15). Feedback is a characteristic of recursive or iterative systems: What you have or do today influences what you can have or see tomorrow. A police intelligence system is a good example of this because information is collected and sometimes acted upon, and the results of these actions are fed back into the system. This is classic feedback looping, and it can affect the state of the system and thus, of new outputs, often producing very counterintuitive results.

Figure 4.15 Complex System in which the Outputs are Fed Back (a Feedback Loop) as Inputs.

One of the features of the revolution in science over the last 200 years is the way in which scientists have ignored feedback problems in an attempt to produce simpler, workable models. They have generally understood that complexities were present, but chose to ignore them because they were too difficult to solve with existing tools. Instead, they engaged in applying the answers and tools they knew to the task of breaking large
problems up into smaller problems. The difficulty, of course, came when the solutions to the smaller problems were reassembled and placed back together with the larger problems. When simple systems are used without heeding their complex characteristics, nonlinear feedback may arise that causes unforeseen results or even the appearance of chaos.

A good example of this is the current argument about whether genetically modified crops should be produced en masse. Though we know that we can modify genetic structures to produce certain physical traits (outputs) in vegetables, we do not yet understand what results will occur if those physical traits, in the form of genes, are reintroduced into the environment and mix with other crops to produce unsuspected feedback effects. We may lose control of that feedback because we simply cannot model the likely results; the combined variables and feedback potential create high degrees of uncertainty, and as yet, we lack the necessary information to reduce that uncertainty. Similar arguments apply to the debate over whether genetic therapy should be prescribed. In the language of the present thesis, we would be introducing an algorithm (in the form of a gene) into the population, where it will interact with other algorithms in a complex and possibly chaotic way. Similarly, policy, whether social, commercial or policing, can be seen as an algorithm introduced to produce particular results, with often unpredictable results.

Feedback loops are not always counterproductive. Indeed, properly harnessed complexity can provide us with valuable tools. For example, scientists in biochemistry laboratories use feedback loops to produce DNA profiles from very small amounts of DNA recovered from crime scenes, even though these traces are themselves too small to use. The system is called the "polymerase chain reaction" (PCR),\(^{25}\) and involves copying very small samples of DNA millions of times. The process is similar to the mechanism by which DNA duplicates itself naturally. The PCR technique has three steps: First, each double-stranded segment is separated into two strands by heating. Second, these single-stranded segments are hybridised with primers, short DNA lengths 20 to 30 nucleotides long that bind to complementary sections of DNA (the target sequence to be amplified). Third, in the presence of the enzyme DNA polymerase and the four nucleotide building blocks (A, C, T, G), the primers serve as the starting point for the replication of the target sequence. A copy of the complement of each of the separated strands is made, so that there are two double-stranded DNA segments. This sequence is repeated (hence the feedback

\(^{25}\) The polymerase chain reaction technique is a laboratory process for copying a short segment of DNA millions of times. The process is similar to the mechanism by which DNA duplicates itself naturally. The PCR technique has three steps: First, each double-stranded segment is separated into two strands by heating. Second, these single-stranded segments are hybridised with primers, short DNA lengths 20 to 30 nucleotides long that bind to complementary sections of DNA (the target sequence to be amplified). Third, in the presence of the enzyme DNA polymerase and the four nucleotide building blocks (A, C, T, G), the primers serve as the starting point for the replication of the target sequence. A copy of the complement of each of the separated strands is made, so that there are two double-stranded DNA segments. This sequence is repeated (hence the feedback
DNA molecules to such an extent that they the quantity present is sufficient to be analysed and measured. This process is relatively simple, and can be carried out in 24 hours to provide the police with valuable information about the suspect for a crime. PCR is discussed in Chapter 1 and is used to accomplish this.

The West Midlands Police has a de-centralised management structure designed to respond flexibly to fluctuations in the complex environment in which it operates. Given the extent of the variables that affect policy and the inherent feedback complications that result, there is the possibility of wide-ranging behaviour and performance. The force is divided into 22 geographical operational units. This decentralised structure recognizes the need to deal with complexity by decentralizing decision-making and authority. Though this approach may appear to be reductionist, it is an attempt to simplify the overall system's complexity to manageable levels; the overall network is still made up of separate independent units whose efforts combine in a network of linked activities. Information systems, corporate policy and high-level organisational strategic decision-making are all dealt with at the centre, but deployment and problem management is handled by the decentralised units.

Resilience in response to fluctuations in the quantity and type of demand is a matter for the head of each unit and is a crucial factor in maintaining the organisation's ability to resist and withstand surprises and shocks. Diverse environments need diverse responses. The formula adopted is distinctly nonlinear because flexible, interrelated strategies guide rather than control key areas of policy. The result is an organisation that evolves and self-organises in a controlled way when faced with new, evolving, complex problems. When pressure and turbulence are experienced at one point within the network, another point can help take up the strain. Complex formal and informal communications networks allow the organisation to respond to challenges with a wide range of resourceful and enterprising practices that have evolved within the diverse management approaches. The system tends

aspect) between 20 and 35 times. The two strands produce four copies, the four produce eight copies, and so forth until a large number of copies of the original DNA have been produced. The PCR process is usually limited to a small regions of DNA not more than 1000 nucleotides in length.

26 Explained in detail by Sir Edward Crew at Bramshill House to the Chief Officers Development Programme.
to be more resilient and stable than a simpler, more centralised system. It can absorb environmental fluctuations in either demand or poor performance by any one unit to a greater degree than a system that can only respond in a linear way based on fixed systems and responses. Simple systems often have fixed, linear communications networks, with fixed links and dependencies. The system is designed to control rather than to evolve, and therefore reacts in a very controlled and limited manner to any problems presented to it. It thus has limited ability to absorb a serious fluctuation in any one part of the network.

FLINTS uses feedback loops to keep the system up to date and to expand knowledge about criminal networks that are developing and falling apart over time. For example, if a DNA match linking a crime to a criminal is acted upon as a case lead, this may result in new information coming to light that is relevant to future police action. If a criminal admits to a further 20 crimes and implicates other criminals, that information can be fed back into the system to provide an enhanced level of detail. The criminal then serves as an "attractor" (as defined in chaos theory) for the newly discovered evidence, for other suspects, and for links between them (Figure 4.16a/b – 4.17a/b).

Figure 4.16a Using Attractors to Link People, Crimes, Events, Locations and Times.
In this example, any of the nodes can provide the starting point for the generation of many new hypotheses (Figures 17b and 17c). This demonstrates how FLINTS can harness complexity so as to serve as a generator and tester of hypotheses.
Figure 4.17a Using Attractors

Figure 4.17b Using Attractors
4.19 The Driving Forces Behind Complexity in Policing

There are three driving forces behind our capability to understand the emerging science of complexity:

- First, we now have powerful computing systems that enable researchers, analysts and investigators (the term "investigator" is used here in its widest sense) to quickly perform millions of calculations so as to model the environment in different ways.
- Second, the growth in computing power has enlivened an interest in other fields where there is a need to deal with lots of information: weather prediction, the spread of epidemics, cell biology, population statistics, air traffic control, and policing itself.
- Third, these interests and computing power have been combined with a developing view of the geometric displays used in understanding chaos theory, including the ability to visualise system dynamics. Certain mathematical operations have now been shown to be not as precise as we originally thought. For example, we would soon find that it is impossible to precisely measure the geographical extent of the City of Birmingham or Coventry in the West Midlands, though we could make a fairly good approximation. The closer we focus on the border, the more complex and irregular its shape becomes. We begin to recognize how the inherent complexity can change our view about what we originally set out to achieve.

Complexity has only recently been recognised in the form of complex remnants of the results of mathematical equations. It is now beginning to be analysed in many areas of life, most of which are connected in linked systems. Some of the disciplines in which chaos and complexity are being now recognised as powerful tools for understanding previously incomprehensible phenomena include mathematics, physics, meteorology, weather, biology, chemistry, medicine, economics, engineering, the stock market, and sociology. Many of these disciplines, in fact, have impacts on each other. The question arises about why policing and allied disciplines such as criminology, evidence, public policy and the law have not yet adopted this analytic approach. This thesis provides a model of how these fields could do so.

4.20 Complexity, Chaos and Communities

Communities and particularly cities have changed drastically in the last 100 years. Before this time, cities were well-defined entities where the population was fairly static and
predictable in terms of its ethnic mix and inability to travel. Cities have since then become unpredictable environments with diverse social, economic and institutional cultures as well as subcultures made up from multinational, multi-ethnic, and sexual and socioeconomic mixes. Moreover, the ability to travel has vastly expanded, making it far easier for these cultures and subcultures to mix with each other and with those of different cities. The geography itself delivers desolate areas and affluent areas determined by these diverse mixtures and pressures. there are almost endless walkways, subways, shopping malls, and areas where the public feel safe to visit, and other areas where they don't.

Stability is no longer synonymous with a city life in which nothing seems to remain stationary for very long. To see city life through a reductionist Newtonian or linear lens would not reveal very much of value. But the tools for dealing with complexity can provide us with deeper levels of understanding of the spatial order and microcosms within a city, whereas otherwise we would be overwhelmed by complexity and diversity. In policing, we need to be aware of the diverse issues that affect our views of the city and be prepared to have interrelated policies that reflect the need for flexibility as well as the ebbing and flowing of diverse social interactions. An imaginative and well-received course was delivered to every member of staff in the West Midlands Police that explained the role that diversity has in the application of our response to the ever-changing complexity of the urban and policing environment.

Cities are ideal entities for the application of complexity theory. In the West Midlands Region, there is a recognition of the issues attached to neighbourhoods, districts and "sectors" inside cities as well as of the different modes of interaction that will take place in different areas—so much so that the basic geographical unit of deployment is now something called a sector, though sectors are also being broken down into smaller microcosms called "micro-beats" that further reflect the complexity present in our communities. These types of structures are well known in complexity theory, and provide a better way to reflect, view and assess the complexity of modern life. There are masses of data available about the diverse issues that affect city life, including population estimates and densities, Borough political boundaries, and lists of services and systems. These are

1 A Sector is a local police station area. (A Village or Small Town in size).
used by urban planners to design land use, build roads and develop open space. The patterns that emerge when these data are subjected to careful measurement help us to gain valuable insights into the stability and potential for chaos that exists in our cities. We need look no further than the way in which a small traffic accident or a heavy rainfall clogs up the entire road network. A small change in local stability can have massive effects upon overall stability and on our ability to move around.

4.21 The Result of Chaos: Self-organisation

An interesting feature of the effects of a chaotic state is the way in which elements of the system may begin to self-organise over time. As we have already seen, this is caused by feedback loops in which outputs become or influence new inputs. For example, when the traffic system clogs up, thousands of independently motivated motorists try to find quicker routes around the blockages, often learning from each other and thereby creating a new set of problems. Similarly, high-density policing deployed to crack down on drug abuse in one geographical area may prove effective in removing the problem from that locality. But because drug networks self-organise over time, the old problem may simply reform into a new structure elsewhere.

The elements that make up our social systems are interrelated by means of their highly variable characteristics. The more we observe the world, the more we recognise complexity at work in these relations and the more we understand about the implications for us. Policing offers very good examples.

If the police service is to operate effectively in this complex, ever-changing, but increasingly understood world, we need to adopt new ideas and metaphors to describe our responses, strategies and policies. Because information and knowledge are commodities that govern so many of our activities and our new and emerging technologies, we need to assess the impact of these tools to obtain, understand and use that knowledge to inform the environment in which we operate. We should embrace the notion of complexity not so much as a science, but rather as a way of describing what we face and as a set of metaphors or tools to engender understanding of it.
The sciences of complexity, chaos theory, and related theories of dynamical systems offer two lenses with which we can view policing. The first is as a set of tools, and the second as a way of assessing and describing threats (Figure 4.18).

**Figure 4.18 The Tools and Threat Lenses.**

1. The tool lens: descriptions of information and systems. Patterns, fractals, connectors, networks, time, etc.
2. The threat lens: features of threats (e.g., instability, chaos, unpredictability)

Complexity offers us a range of descriptions about our professional environment and the systems we operate in. These systems describe complex associations and patterns that require complex as well as linear approaches to solve them. But complexity is itself a threat; the purpose of the policy-maker in policing must be to maintain stability and control as well as to prevent the emergence of chaos. To do this, we are required to entertain ideas about the future—what it holds, and what options and threats exist. In light of assessments about where we are and where we are headed, we must be prepared to constantly adapt (self-organise) if we are to present realistic chances of preventing chaos and instability.

### 4.22 Systems, Data and Quality

In police work, the policy-maker must be able to prevent high levels of crime and the consequential social costs (which arise from unpredictability and chaos), while at the same time being prepared to take action and reap the benefits of efficient action if high levels of crime begin to appear. Enhancing public confidence, keeping prolific criminals behind bars to head off "network of criminals" problems, and providing a safe and well-ordered society are the key goals. Being in control of "systems" and of policy is of the utmost importance, for there can be no useful prediction without constant monitoring by means of access to high-quality information.
A good example would be how the West Midlands Police have developed the way they record crime. Until recently, the recording of crime information was seen as a statistical procedure; the data was collected for the Home Office for the purpose of measuring how efficient the force was in crime detection. The inevitable was happening: officers would not record allegations that they were not satisfied were proven because they knew it would not reflect well against the force in the year-end tally of crime. Conversely, where crime could easily be solved, it was readily recorded and the records were sometimes manipulated to reflect the highest number of detections that could be defended, regardless of the quality and value of the investigation. An almost purely hypothetical exercise in investigation could be said to be operating solely to serve the purposes of the counting system.

For example, someone reporting that two bottles of milk had been stolen from her doorstep might not obtain a crime record number because the offence would be difficult to solve or the investigating officer might consider it trivial and not worthy of a crime report. Conversely, if a young offender was caught stealing a bottle of milk from a doorstep by a patrolling officer and that suspect decided to admit his guilt for this and an unknown number of similar thefts, then every possible instance of a theft of a bottle of milk would be recorded and attributed to the record of our now honest and confessing thief. The crime figures were thus skewed towards reflecting an efficient force in whose area of responsibility crime levels were modest and detections high. The true picture was not known, and no real judgements could be made about efficiency even if the police force truly was efficient. Faced with this problem, it was not possible to use the crime recording

---

2 Here, "manipulation" means presenting crime data to reflect the best possible position for the police service collecting that information. This has been common in national crime recording policy for a long time, and does nothing to aid the use of crime data as intelligence. The problem manifests itself particularly in the overzealous recording of high levels of detected crime and the low levels of recording of crimes that are difficult to detect due to the type of crime committed, that involve allegations suspected to be false, or for which there is some evidence to substantiate the original allegation, but for which doing so would entail a protracted investigation with little likelihood of success.

3 Detection is a term synonymous with “solved”. The terms is used commonly by the police and Government for statistical purposes.
system for intelligence and predictive purposes because the data was seriously flawed. The West Midlands Police has now recognised that accurate recording of crimes is crucial to maintaining good information systems in which predictive analysis can be undertaken. This approach initially attracted criticism from some quarters because crime levels in some areas suddenly appeared higher than in previous years. However, the benefits of being able to assess the current state of the policing environment and hence predict its future state far outweighed the ability to promote the force's image by the use of a statistical contrivance. Under the former circumstances, policy could not be designed on the basis of the crime information system and future trends were predicted as a "shot in the dark".

To use a metaphor, the enemy (criminals and their networks) was carrying on activity in a real world where they knew opportunities were arising and weaknesses appearing. They were "self-organising" into efficient networks faced by a police service armed with a statistical tool rather than a crime intelligence system. Whilst the police were busying themselves maintaining what they saw as a controlled state, chaos reigned and criminals were organising themselves into networks that would prey on vulnerable areas.

4.23 Maintaining Stability in Complex Scenarios
In the Cold War era before the 1990s, stability was maintained by a matching of capabilities in the East and the West and by a balancing of competing forces or threats. High levels of intelligence and information flow were maintained, and each side responded to the other's positions with about the same level of opposition. Jet fighters would invade the opposition's air space to test and measure the strength and level of response. Countermeasures would lead to retesting of defences in an ongoing cycle (a system). The deployment of one side's forces was determined by reference to information about the deployment of the opposing side's forces. Very small increases and decreases in activity on one side were often mirrored on the other. These very small perturbations made it possible for stability and the status quo to be maintained. The results of chaos (a third world war) were avoided. Prediction and adaptation to change were the goals of the policy-makers. When the Berlin Wall eventually fell, fragmentation and the self-organisation of smaller, less predictable states resulted. The ability to engage the unpredictable was thus seriously diminished.
The police service has much to learn from political science in this sense. Where there is a breakdown in the state of affairs and the status quo changes, history has shown that successful military leaders have generally tried to amass enough strength to overwhelm the opposing side so as to minimise the risks entailed in resorting to battle. Those with the greater strength often prevented the opposing side from entering into conflict because the latter’s chances of success were small and the risks attached to defeat too dangerous to ignore. Leaders tried to avoid situations in which a small event or fluctuation would become the turning point in the conflict (“my kingdom for a horse”). Here, we are again seeing the avoidance of chaos by military leaders who knew well that the risks of conflict were high and who were thus unwilling to enter a situation in which only a small perturbation could cost them the conflict (“for want of a nail a shoe was lost; for want of a shoe, a kingdom was lost”). Control, not chaos, was sought.

One alternative to the amassing of expensive resources that are only used in rare circumstances is the use of resources that are flexible, adequate to the task (e.g., for humans, well-trained), and highly adaptable to change. The answer is to have alternative plans, tasks and resources available for deployment, backed by accurate and timely information about the issues that may create chaos.

Dealing with the problem of bifurcations leading to chaos or to self-organisation is a key problem for the decision- and policy-makers of the modern age. Ensuring that our systems are configured to deal with these problems is of the utmost importance. We must be able to deal with bifurcations by identifying their presence and, when they do appear, by having a system of choices available. Which future do we want to move forward into and which set of plans should we implement if we choose one particular path?

Bifurcations can appear in the state of public order, in social conditions, in public safety and in criminal activity. We need to aid the decision- and policy-maker by providing the ability to access relative probabilistic assessments of the chances of bifurcations occurring and of their results. To do this, we must be alive to the need to understand the environment we are operating in and the system in which plans are contrived.
Complex police systems require flexible and imaginative people who are open to and capable of adapting to new problems as they arise. Some may be obvious, whereas others are hidden by complex detail or concealed by other means. Imagination, innovation and the ability to handle information are extremely important to coping with the future of our complex world. Time and time again we see intelligent manipulation of "the system" by criminal minds. We must apply more intelligence than these opponents and be better placed to maintain control. The key is to accept that the policy-maker can influence shifts in states, often by manipulating small elements at the lower end of the system that will cause greater and more desirable effects at the top. This is an example of how an undesirable aspect of chaotic and complex systems (the ability of small perturbations to cause large consequences) can be turned to our advantage, provided that we have the tools to predict when opportunities arise for such interventions.

We need to be prepared to branch away from the traditional reductionist approach of simple mathematics and probability in assessing problems and system states. Conventional mathematics have difficulty in dealing with the problems that arise in complex systems such as policing. Linear mathematics deal with associations between the highest- and lowest-value assessments in a given scenario, and these are used to assess which solution best fits. In a complex system where there are highly adaptable variables, such as witnesses and communities, linear threat assessments may be insufficient because they fail to account for the system's nonlinear complexity. We may have to be more critical and be aware that on occasions, only small perturbations need to be made to bring about a change. Seeking the most contextually relevant strategy may be the best way forward because, quite simply, there is no "best solution" to be had—events move too fast and "change is the only constant".

The modern era provides a complex backdrop for policing. A problem may arise from almost any configuration of variables, and the large number of possible avenues to follow may make it seem a tall order to engage in predicting where problems will arise and to design solutions as problems emerge. However, we also know that small elements or even levels of interaction or adjustment in a complex system can result in massive changes as outcomes. The image of a butterfly waving its wings in Tokyo and thereby creating a storm in New York is an attempt to portray the theory. Small changes in one element can
combine with changes in other elements to produce large changes in the overall system. Identifying the right informant⁴ in the right criminal network and at the most appropriate time can have massive effects on the flow of intelligence as well as on the ability of counterintelligence to fragment, distort or change that network. The use of sensing devices to collect information covertly⁵ or overtly⁶ may have the same effect.

A more practical example for our purposes would be the ability to identify a network of criminals operating in an adaptive, organised way and preying upon a housing estate. If we can identify the elements in the network, we can set about identifying the best way to bring it under control. The presence of a network of links between these burglars does not automatically mean that we have encountered an instability; whether we view this situation as "unstable" will be determined by our judgement of the likely effect the network will have if it were to remain unchecked.

Analysing the elements of a network with a view to determining its potential impact will provide us with a set of options. The strategy we adopt may be arrest, surveillance, infiltration or simple disruption by communicating to key elements in the network that we "know" about their activities. Choosing "the most appropriate option" will be a matter of analysis and professional judgement of the relative probabilities of achieving a range of hypothetical outcomes. Identifying the connectors (criminals, crimes, locations, associations etc) within the network will provide good targets for activity (Figure 4.19). The nodes in this illustration represent the people, and the arcs represent the inferential links. Removing particular nodes (perhaps by arresting the criminal) will eliminate the links between some

---

⁴ The police service use the term "informant" to refer to a member of the public, often a career criminal, who agrees to provide "inside" information about crimes that have already been executed or that are in the process of being planned. The information is given in return for financial gain or for protection against retribution by the criminal fraternity. In the United States, these individuals are sometimes called "agents" and the process is supported by a federal statute.

⁵ An example would be interception of radio or telephone traffic or the use of hidden visual sensors.

⁶ An example here would be DNA-sensing devices or silicone probes designed to collect and analyse liquids in real time at the scene of a crime. Other examples include reagents for enhancing latent Fingerprints and technical lighting for use with photographic systems designed to detect otherwise invisible stains or marks in blood, old or faint bruises, or teeth and bite marks in flesh.
nodes and thereby change the overall shape of the network. It is the decision about where to act, how to act and the possible consequences of each action that will determine what should be done.

**Figure 4.19. Network of Linked Offenders; the Connections are Based Upon Police Data About Previous Joint Offences.**

This does not mean we have to arrest every element or break every connector in the network to bring about control. Breaking down the network by arresting those persons who are key connectors (those people who act as “glue” holding the system together) is what we should be most interested in achieving. Removing the key elements in the network for the purpose of gaining control is the key to success.

**4.24 The Danger of Self-organising Systems**

The difference between linear and complex systems is that the elements in fixed linear systems may not interact or may only do so within a fixed environment. In a complex system such as policing, with literally thousands of elements in the system, we can find features that appear to be self-organising. Taking action at one location will result in some
change or outcome somewhere else. When pressure is applied or interactions take place, elements self-organise and the system evolves into something else. This can take place outside the control of the policy-maker. Self-organisation begins to take place at the point scientists call the "edge of criticality", which is the point at which a system changes from one configuration (possibly a stable one) into another (possibly a chaotic one). There has been a great deal of scientific interest in understanding the dynamics of "criticality" and the mechanisms that cause systems to change.

As noted by Coveney and Highfield (1995, p. 233), the global proportions of biological evolution provide a massive system for the study of complexity. In the 1970s, Niles Eldredge of the American Museum of Natural History and Stephen Gould of Harvard University used fossil records to propose a view that evolution takes place in a series of discrete steps followed by long periods with no change. They called this phenomenon "punctuated equilibrium" because the steady state (equilibrium) was broken up (punctuated) by chaotic states rather than changing continuously. Although a detailed discussion of this theory is outside the bounds of this thesis, it is important to point out its implications for the study of complex environmental changes because crime takes place within similarly complex environments. It is also important because it implies that evolution cannot be contained within conventional "linear" Darwinism as described by Dawkins (1989, p.290). Mass extinctions and the emergence of new species take place in surges and bursts of activity, followed by stable states, then subsequently by new surges and stable states. Similarly, the appearance of new technologies and new social contexts may lead to such surges, as in the example of a new "species" of crimes involving cell phones (other examples would be new types of fraud, new methods to distribute drugs using networks of agents and sellers), discussed earlier in this chapter.

Bak and Chen (1991) proposed that life exists as part of a dynamic system that is far from stable—so much so that it can and does spontaneously organise itself into much greater states of criticality. The important lesson for the study of complexity and for this thesis is that the ability to self-organise is an intrinsic quality and can take place without the influence of external causes. Furthermore, the "edge of criticality" becomes a vitally

\[7\] Bak,P. and Chen, K. dealing with self-organised criticality.
important place to begin one's search for dynamic change. Using computer simulations, Bak and Chen concluded that during periods of hyperactive evolutionary activity (the "punctuations" in Eldredge and Gould's theory), the mean fitness of a species is low and they undergo relentless mutation (change) in response to selection pressure, leading to better fitness for those that survive. This has interesting consequences for policing because it may provide insights into the way certain groups of criminals or patterns of criminal activity burst into activity then fade away during certain periods of time. It also has implications for the way in which we interact with the initial conditions and limit cycles of the system in an effort to control and contain crime within what we deem to be tolerable levels. This, of course, must be balanced with tolerable levels of state interference with the freedom of the individual. Chapter 5 examines some of the issues raised in attempting to balance these competing demands.

The network depicted in Figure 4.19 may have elements that we can safely interact with without losing control and stability. We may be able to successfully fragment the network, but on the other hand, this fragmentation may lead to a phase of re-organisation outside our control and knowledge. Identifying the "edge of criticality" here will provide us with knowledge about how far we can go and when we can act. For example, having identified (by whatever means) a network of active burglars or drug dealers, we are faced with decisions about how to react. Should we gather intelligence, or arrest key figures so as to disrupt the network? Let us suppose that we decide to do the latter rather than engaging in gathering further evidence and intelligence. Within a complex system or network such as this one, we need to take stock of two things:

1. We need to identify which of the key elements (criminals) we should remove from the network to gain the maximum disruption and fragmentation of the network. Organised football hooligans, terrorist groups, burglary gangs and car thieves are all combinations of people with crime and disorder in mind but who vary over time. (This alone is evidence of the complex nature of the structures supporting the network.)

2. We need to be mindful that when we interact with the system or network, say by arresting key players, there will be an immediate change in the structure of the network.
and thus, a reorganisation. In effect, the system will self-organise into some other structure that we may still have to deal with.

A useful point to note about self-organising systems is that, with the right predictive information about likely ways they will respond once interfered with, we can test our goals by staging an interference. We must begin by asking how removing elements of the network will affect it. Will it re-organise? The self-organising elements here might be handlers of and dealers in drugs, and they might need to establish new communications channels, recruit new "pushers" and obtain access to new sources of the substance if the key importer is removed from the network.

One sure danger arises if we let the network self-organise blindly. Unwittingly, we may be encouraging something like natural selection that selects for a fitter, leaner and more effective system. One interesting area for thought is the role of undercover informants; unchecked and uncontrolled by firm plans, they may engage in manipulating the network so that it works in a different way more suited to their own operation, the details of which are poorly known to the police. Here, control is vital. Natural selection and self-organisation of a network in the wake of police disruption of the system is one thing, but subversive activities by an informant who is a "rogue insider" may create more problems than the disruption solves.

4.25 Complexity and Prolific Offenders: Disrupting Networks

In terms of policing strategies, assuming that removing the most prolific offender will cause a network to break down and disappear is synonymous with treating a complex self-organising network as if it were a linear network. The results are not necessarily that simple. As interactions come into play and as action is taken and information gained, turmoil results and the network changes in structure over time in response to the changes in its constituent parts. New networks will grow, old structures will die, and distortions in activity type will occur, even if only temporarily. There may even be times when there is little or no new self-organisation taking place. In this state, the original disruption appears to have had the intended effect, and the network thus appears to have been a linear one, with little danger created by our choice of intervention. This period of equilibrium is likely to be only temporary. At other times, and despite the lack of any direct intervention, the
network may change drastically, possibly even beyond recognition. Care has to be taken not to confuse a diminishing network with one that has merely paused during its evolution into a new structure.

4.26 What Can We Do With Complex Crime Networks?
Crime networks are simply interrelated groups of people associated and connected by virtue of their activity and by communications links. They may be offending together, planning crimes together or helping thieves to dispose of stolen property after the event. A stark feature always seems to be the presence of some level of synchronised activity. Research is now indicating that these groups are not always hierarchical, as has so often been assumed. They are often chaotic instead, with distinct self-organising properties concealed within that apparent disorder. Take out one of the links and new a one will appear to take its place. Reshape the network by disrupting the elements and a new shape may appear, one that is sometimes very different form the one we set out to disrupt. It is becoming increasingly clear that these networks are more often than not “complex” rather than hierarchical, and this presents us with a different problem to solve. In a hierarchy, there is assumed to be some level of control from the top down, and the structure is designed for predictable, specific purposes. But this hierarchical view of criminal networks (Figure 4.20) is based upon an overly simplistic and linear view of the world. It ignores the interrelatedness of the elements as well as the feedback loops operating within the network. If, as we suspect, hierarchies are not as common a feature of crime networks as we once thought, then we need to rethink our approach. We need to “complexify” our view of the world to help ourselves realise that criminal networks are self-organising systems with no real top and no real bottom.

Figure 4.20. Traditional Hierarchical View of a Crime Network. Research Indicates that These are Rare, and Certainly not as Common as was Once Assumed in Policing.
In Figure 4.20, the connectors ("arcs") flow in a hierarchical way, and there are no arcs between distant elements. This may be a feature of some networks, but networks of criminals more commonly represent a complex network of links such as the one shown in Figure 4.21.

**Figure 4.21 A More Realistic Depiction of a Criminal Network, with Many Linkages Between Distant Positions Within the Hierarchy.**

Figure 4.21 represents a “complex” crime network. This is a common type of network in which links (arcs) between the nodes (people) do not appear in ordered layers, flowing hierarchically from top down and bottom up. Instead, there are horizontal as well as vertical lines, and the connections flow in complex, seemingly unsystematic ways. Elements at the bottom of the network are often directly linked to those at the top. Different approaches will be needed to tackle these more complex networks. For example, when dealing with “informants” it will be crucial to establish whether they are operating from within a hierarchical network or a complex network. Information received from an informant at the bottom of a hierarchical network may be of limited value if the intention is to fragment the whole network because that informant will only have access to limited
chains or pathways of intelligence. Conversely, information received from an informant within a complex network may provide access to widespread and far-reaching pathways of intelligence due to the multidimensional links between elements in the network. Another example of an important application is the deployment of covert surveillance aids. The efficiency of any covert sensing device for evidence and intelligence gathering will again be determined by its ability to “hook into” the connections between elements of the network. Different results will be obtained depending upon where in the network the technical aid is deployed. Time spent analysing the network, the likely results of different deployment strategies and the overall aims of the operation will determine where that sensing device should be located. In the hierarchical network, the decision may be somewhat simple, but in the complex network the opposite is true.

A useful approach is to make policy based upon comparisons of the relative probabilities of the outcomes from different choices in order to maximise the expected gains; these consequences may be disruptions, distortions, or even the release of new information as a result of fracturing particular parts of the structure. For example, the assumption that “there have been 25 robberies in this area in the last 7 days, therefore there will be 25 more identical cases in the next 7 days” may work on occasions, but we must be alive to the limits of such simplistic assumptions. Other factors may affect this assessment: the geography; the actors available as victims, offenders and witnesses; and the opportunity to commit crime all have their part to play, and make for a complex system.

It is useful to be able to identify what fixed elements exist within a network because these are obvious targets for action. If they are fixed, they may serve deterministic roles, and their effect on the behaviour of the network is likely to be similarly fixed. One way of achieving such a state of known “fixed elements” is to introduce a measure of time, of space (geography), or of the fixed elements such as people and known events. Here, time is the focus because it provides a good example of a constant that lets us determine what the temporally fixed elements in the system are (Figure 4.22) within a given time span. Moving outside that time frame will eventually lead to changes in what was formerly fixed.
Figure 4.22. Temporal Classification of Evidence.

<table>
<thead>
<tr>
<th>Prospectant</th>
<th>Concomitant</th>
<th>Retrospectant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before the crime</strong></td>
<td><strong>At the time of the crime</strong></td>
<td><strong>After the crime</strong></td>
</tr>
<tr>
<td>- Motive</td>
<td>- Opportunity</td>
<td>- Physical trace</td>
</tr>
<tr>
<td>- Propensity</td>
<td>- Means</td>
<td>- Psychological traces</td>
</tr>
<tr>
<td>- Character</td>
<td>- Intention</td>
<td>-</td>
</tr>
<tr>
<td>- Habits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Conduct</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Behaviour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Traditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Customs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Victims</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Offenders</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4.22 illustrates the way in which data can be classified into fixed elements over time. FLINTS 1 manages physical retrospectant trace evidence relevant to inferences about opportunity and means for people (victims, offenders, witnesses, populations), places, events and times. New developments in the software have enabled it to manage prospectant and concomitant evidence relevant to inferences about people, places, motives, propensities, characters, habits, conduct, behaviours, traditions, customs and times.8

Some of the benefits of the methodology and FLINTS for the police service are to be found in the software's ability to combine different configurations of prospectant, concomitant and retrospective evidence in drawing inferences about links and connections between people, places, events and times. This allows the police analyst or investigator to access the rich array of connections, patterns and links that lie hidden beneath the layers of complex data. No one person can keep track of the possible combinations and layers of

8 See generally Wigmore (1937) on temporal classification of evidence.
data in addition to the possible connections and linkages that may result from these relationships. However, computer-based systems such as FLINTS can assist in managing and pursuing such relationships.

Figure 4.23 illustrates how this might be done.

**Figure 4.23 Using Outputs as Inputs: the Elements of Self-organisation.**

In Figure 4.22, we can see that time is a means of helping us to understand the temporal classification of evidence. Wigmore (1931, p. 1017) used this method for the evaluation of evidence in single cases, but it can be extended and transferred into the analysis of multiple cases as well, as has been done in the FLINTS software. Simply classifying the evidence in terms of past, present and future is an effective method we can use to assist us in trying to make sense and use of the evidence. Analysts should also be aware of and encouraged to think about the way in which "the present" shifts with each case. By examining evidence about past and present events, we can begin to draw a range of both linear and nonlinear inferences about future events.

For example, if we are faced with a mass of information about a number of events of burglary crimes which we suspect may be linked, we can assemble them into categories. What evidence do we have in our database about the motives or the methods used by
offenders before they committed the crimes involved? Placing these types of evidence into categories in this manner may present us with opportunities to group similar facts together in such a manner that we may be able to draw inferences about similarities and links. What about evidence we might have expected to see given certain patterns of events, but do not see? Does that recognition give rise to the premise that certain items or strands of evidence are missing or does it indicate that the evidence never existed? Did some person have a particular motive to commit the series of crimes, whereas others did not? Similarly, placing evidence about events that took place at the time of the crime can present us with powerful evidence to eliminate certain persons from suspicion and implicate others who cannot be eliminated. The presence of Fingerprints, DNA, Footwear or witness identification of the offender may present us with the means to show that a particular person had the opportunity and means to commit the crime. That may prove crucial in determining whom we can and cannot eliminate from suspicion (Figure 4.24). In addition, it presents us with the means to determine who may be committing certain types or patterns of crime that we see emerging in patterns of events that extend into the future.

**Figure 4.24 The Possibility of Eliminating a Node Based on Inference.**

The network in Figure 4.24 demonstrates links between criminals on the basis of known intelligence collected over a given time span. The links are made up from data about co-accused persons who have been arrested and charged alongside other criminals. By analysing the potential links and the effects of removing those links (Figure 4.25), we can determine how to fragment the network and thereby isolate certain elements from others. This could be achieved by arresting the persons represented by these nodes and the
associated links. In this case (Figure 4.25), removing only three links resulted in a considerable increase in fragmentation of the network.

**Figure 4.25 Analysing the Effects of Removing Nodes / Links.**

Figure 4.26 illustrates a complex network of offenders linked by virtue of their previous co-offending habits and activities. From the pattern, it is clear that these offenders have displayed a propensity for offending together. Obviously, the task of analyzing the effects of removing nodes becomes far more complex in such situations.

**Figure 4.26 A Complex Network of Linked Offenders.**
4.27 A Complex Network of People Based On Histories of Co-offending

Earlier in this chapter, it was said that in nonlinear systems, “the whole is different\(^9\) from the sum of the parts”. In a complex network such as the one depicted in Figure 4.26, we can identify the overall “whole” network and lots of “parts” or subnetworks. If we decide that this network or parts of it are a contributing factor to or a cause of instability within a geographical area, we will be faced with the decision of choosing where our efforts should be concentrated to disrupt the formation of the instability. The decision about which elements to arrest will have important consequences.

The illustration in Figure 4.27 shows the effect of removing only four key elements from the complex network: the network begins to fragment, and certain elements are isolated. This may indeed be the desired result and may assist us in achieving our goals. What we must guard against, however, is the way in which the isolated elements (the nodes in the illustration) may regroup or how the remaining elements will remain connected and continue to interact.

Figure 4.27 Fragmentation, but the Network May Adapt After Nodes have been Removed.

\(^9\) Note that the word “different” is used rather than “greater”. The whole can be either greater or lesser than the sum of the parts.
In order to predict how future actions will affect a system or network, we must gain knowledge of the present state of the system. We must also be aware of the fact that we can never gain total knowledge of the present state, since just as it is impossible to precisely measure the border of a city because of the complexity of that border, so must measurements always fall short of complete accuracy because of the complexity of the system being measured. Thus, it is simply impossible to recover "everything" about a given state of affairs. This applies to a crime network, a financial market or even the results of a scientific experiment. Instead, the goal must be to recover "enough" information.

We must thus deal in approximations, albeit often very accurate approximations. It is important to highlight this point, because if we know that we are dealing with approximations, we can adopt an appropriate mindset in which levels of estimation, judgement, opinion, assessment, and evaluation can be applied rationally and scientifically. Our estimates are by no means random measures, but rather deterministic measures to the extent that this simplification is possible, each having some room for inevitable inaccuracy.

### 4.28 Generating Knowledge from Complex Systems: the Use of Attractors

The numbers of variable combinations involved in police systems is immense. However, as we discussed earlier in this chapter, even highly complex systems often reflect the results of iterative interactions of relatively simple rules. The results of these interactions is that even when the system appears to be entirely random, certain "attractors" can be revealed by analysis. This is as true in social systems (such as criminal networks) as it is in the physical systems studied by science. Indeed, it has been demonstrated in this thesis that by using different configurations of attractors, it is possible to extract useful and complex linked networks of relationships across a vast array of categories of data. The larger our systems become and the more diverse our data sets become, the more difficult our task becomes. Faced with such obstacles, it is imperative that our analytic tools be designed to help us manage and make use of the data. The more imaginative the tools we design to increase our ability to draw useful and interesting conclusions from systems, the more successful we will become in identifying relevant attractors amidst the world's unending complexity.
A useful attribute of any complex system is its ability to combine data sets and thereby provide an almost endless stream of knowledge based on the relationships among the data. In policing, we can use this to help us answer questions and formulate scenarios in the process of trying to maintain stability and predict future threats. The key lies in being able to find the right data, combine it, assemble it in the right places, then finally use it to draw a conclusion. Part of the process involves persuading others that a particular point is proven. There is an unbridgeable gap between what is "true" and what can be "proved" (Casti 1994), particularly when a complex system is involved because of the large number of variables and the presence of alternative explanations that could emanate from the same data. The question arises as to how complexity theory can assist us in formulating good questions, answering those questions, and building interesting scenarios.

The process of asking questions and building and deconstructing interesting scenarios lies at the very heart of the process of investigation. Put another way, the goal is to generate new explanations and knowledge. The generation of that new knowledge is an important component of every function of policing, whether it be detecting social exclusion problems on housing estates, identifying accident "black spots", or determining who may be involved in committing crime. The process is not limited to the practice of criminal investigation, as is often assumed. The dynamic nature of the data and patterns that exist in a complex system mean that the use of these patterns is often not limited to the domain in which the system exists. Complex systems are often so dynamic, so non-specific and so fuzzy that they can be utilised to answer questions in any number of problem areas. This is what makes them of such great use to policing.

In terms of complexity theory, there is a means by which particular states within the system can be described that is both relevant and useful to policing. This involves the "attractors" we have discussed previously. These attractors arise from the properties within a system that make the system exhibit patterns or states to which the system is likely to gravitate. The system will revolve around these states, despite oscillations and fluctuations resulting from complex interactions among the components of the system. Identifying attractors can thus be a very good way of determining uses for systems.
A useful way of describing an "attractor" is that it is a restricted set of conditions within which the system may find itself. Understanding those conditions provides some meaning for the system. Particular people who repeatedly offend, victims who suffer crime regularly, geographical areas where safety is at risk, networks of criminals, times when particular crimes are committed, and places subject to large-scale criminal activity are all examples of sets of attractors. Our only limit in the use of attractors is our ability to be imaginative and creative in identifying them and using them effectively.

To demonstrate the versatility of "attractors" we might wish to consider the following examples of social and cultural attractors within a police intelligence system. These can include community leaders, political boundaries, religious groups, population types, states, Counties, Borough areas, publicans, Neighbourhood Watch committees, Parish Councils, parent-teacher groups, and social groups. These are all examples of things we can use as "attractors" in an effort to identify patterns, connections, links, and scenarios in our system (Figure 4.28).

Figure 4.28. Using and Designing Attractors to Detect Patterns.

In Figure 4.28, we see a database of information that might literally contain many millions of items of data. This may be crime data, criminal population data, Stop and Search data
for suspected criminals, vehicle data, and so on. As stated at the outset, it is impossible in even a moderately sized database to set about exploring every possible relationship and scenario that might be of interest. Instead, we have to employ some form of strategy to make use of and sense of the data in a reasonably timely manner so as to obtain answers that are likely to be relevant to our objectives. Attractors can help guide the search for such a strategy, as discussed in the next section.

4.29 Attractors and the Role of Elimination

Attractors work because they help to distinguish that which is relevant from that which is not. The key here is the elimination of data that are not relevant (i.e., those that are unrelated to the "attractor" of interest) rather than directly implicating data that is directly relevant. As Conan Doyle pointed out so memorably, once you have eliminated the impossible, whatever remains, however improbable, must be correct. There is also a good real-world reason for this: Elimination is the bedrock of good scientific investigation because it operates by eradicating that which is not relevant so that whatever is left is, by default, relevant. (See Popper, K. 1968 and 1981). As Cohen (1977, p. 224) argued, induction and the action of inductive probability grade the weight of relevant evidence. Central to this approach is the ability to construct inductive questions in the hope of discovering something in our system of information that may be useful to our purpose. Conan Doyle’s Sherlock Holmes was greatly adept at asking searching inductive questions of the world, of nature and of particular scenarios, and sometimes of all three at the same time. Hintikka (1983, p. 154) argues that Holmes’s investigative ability was characterised by his ability to ask the "right" strategic questions. This involved an interplay between careful observations and deductions. The best questions are those most likely to produce informative answers and, as the interrogative process progresses, to eliminate that which is not relevant from the plethora of available information. These questions (p. 170) often open up potentially fruitful lines of enquiry to fill gaps in our knowledge with useful and relevant information.

---

10 Ayer (1968, p.15) introduces a fascinating discussion about the way in which Popperian ideas although important, had been largely anticipated by Charles Sanders Peirce.
The FLINTS systems uses attractors to define the patterns of what we seek, and searches every available database in the West Midlands Region to find data that will fall within the attractor. It always, therefore, eliminates very much more data than it links to. The attractor acts as a magnet because data of interest will be attracted to it and stick. The advantage with a complex system is that the "Attractor" can be a quite simple magnet, with only a few elements, but still have the power to sift through many millions of items of data to find the few hundreds or thousands that will form part of the pattern defined by the attractor. This is a powerful technique for identifying only the necessary data amidst a plethora of irrelevant data.

The skilful use of this technique requires analysts to identify the right type of attractor. As noted earlier in this chapter, there are three main types of attractor we can use: fixed-point attractors, acyclic attractors, and "strange" attractors.

4.30 Fixed-point Attractors
These attractors resemble the social and cultural attractors mentioned earlier. They are elements in the system that centre on fixed points such as sets of people, organisations, places, and the times of fixed events. The precise set is often a subjective matter that cannot be described precisely, as it depends on the system and the context in which it is being used. But the key distinguishing feature of this type of attractor is that once defined, the set of elements does not change.

4.31 Cyclic (Fixed-limit) Attractors
This type of attractor is associated with systems in which inputs or outputs repeat themselves in a cyclic fashion. The system will initially pass through transient phases before it enters a repetitive cycle that continues forever. These types of cyclic attractor can be used to describe a system that fluctuates within clearly defined limits, which is why some scientists call them "fixed-limit" attractors. They are typically found in systems where there are limits based on time, geography, numbers, or logic. Because of their fixed limits, they tend to resemble geometric structures. A simple example might be the political process, in which considerable fluctuation occurs in the lead-up to an election, but after which the government settles down into a period of stability interrupted primarily by such phenomena as cabinet shuffles. In terms of policing, we could describe the categories of crime in a
police database (such as burglary, murder, car crime, theft, and fraud) as acyclic attractors. The categories of offender and fixed locations (such as sectors or OCUs) would also be acyclic attractors.

A useful way of distinguishing between a fixed-point attractor and an acyclic attractor is illustrated in Figures 4.29 and 4.30:

**Figure 4.29 A Fixed-point Attractor.**

![Figure 4.29 A Fixed-point Attractor.]

**Figure 4.30 An Acyclic Attractor.**

![Figure 4.30 An Acyclic Attractor.]

**4.32 Strange or Complex Attractors**

The strange attractor is also sometimes called a "complex" or "chaotic" attractor. The reason for this name or term is that the attractor combines the effects of the same attractor observed over a period of time; thus, although each individual observation may appear static, the overall system evolves over time. The attractor can consist of infinite numbers of fixed-point attractors, and can magically turn dull statistical data into a telling
picture in which the system's behaviour over time can be visualised. When strange attractors are used, we gain access to patterns of data over time. Because few things in the real world are static, this is the most common type of attractor we encounter.

An example of this very complex type of attractor might be a very large Command and Control system within a large police force. If it were possible to take a thousand single snapshots of the state of the system at single points in time, then string those snapshots together over a thousand points of time in a row, we would create a moving picture. That picture would be arrived at as a result of the strange attractor's extremely complex pattern, which changes over time as information is continually fed back into the system between each consecutive pair of snapshots. It is the recognition that systems evolve over time that makes this type of attractor so common, and so important to the task of understanding the real-world complexity of policing.

4.33 Practical Use of Attractors

Figure 4.31 presents a spreadsheet that combines data about crimes, people and evidence matches. The fixed points in the system can be accessed and combined to reveal patterns of connectivity (attractors).

**Figure 4.31 Attractors in Use in a Spreadsheet.**

Figures 4.31 to 4.34 were drawn by the author and used as an abstract model to demonstrate the author's neo-Wigmorean methodology. They were also used by the author to instruct the software programmer about what the software should do. They were thus used as a model for the development of the FLINTS software application.
For example, person 1 is linked to crimes 1, 4 and 5 by DNA, Fingerprints and Handwriting evidence, respectively, whereas person 4 is linked to crimes 1 and 4 by Footwear and Tool mark evidence, respectively. There are undoubtedly many other patterns in the system if we look for them. A visualisation of the network of the links in this system would resemble the pattern shown in Figure 4.32.

Figure 4.32 Visualisation of the Patterns Identified in Figure 4.31.

On closer examination, we can now identify other patterns from within the network. For example, persons who have committed more than one crime can be seen in Figure 4.33. Similarly, Figure 4.34 reveals groups or sub-networks of people operating together.

Figure 4.33 Visualisation of Persons Who Have Committed More Than One Crime.
The potential combinations of attractors in a system is large. It should be noted that although these network charts were produced from a system containing only five crimes and five people, the inherent patterns need to be thought about carefully in order to understand the potential information that current systems contain but that have not been "tapped" or "mined".

Imagine the potential information that could be gained from a system in which typically 300,000 crimes per year are recorded, with more than 100,000 arrests annually and some 60,000 scenes of crime visited each year. From those scenes of crime, evidence traces from a wide array of sources, are recovered. In addition, the system is further complicated by the 18,000 forensic matches based on common evidence types such as DNA, Fingerprints, Footwear, Tool marks, Handwriting, Ballistics, and Drugs. This is, in fact, a description of the situation experienced in the West Midlands Region each year. If we consider all other sources of data, such as information in the Command and Control system, Custody system, Stop and Search system$^{11}$ and the Police National Computer, we would have access to an enormously rich source of intelligence information in which linkages and networks between elements in the system as a whole could be discovered—though the results of analysing this information would be likewise enormous. Each of these systems changes over time as

$^{11}$ Section 1 of the Police and Criminal Evidence Act of 1984, confers a power to police officers to stop and search persons. Records must be maintained of the event by the officer. These forms are completed by the officer and contain a wealth of information about the subject of the stop, their name, address, date of birth, physical description and clothing, location of the stop, where they were travelling to, where they had been, who they were with, and details of any motor vehicle and property they were carrying.
new information is input and old information is weeded out, and the system as a whole is in a continuous state of change. New patterns emerge, and old ones fade over time. The system is characterised by spontaneous bursts or surges of chaotic behaviour as the elements within the system interact in response to changes in the system's environment. Because the patterns show these periods of change, followed by the gradual stabilisation into new attractors, they exhibit behaviour typical of strange attractors, and can be analysed using the techniques developed for working with such attractors.

4.34 Asking Good Questions: Using Holistic Aggregation and Atomistic Disaggregation of Information as an Analytical Technique

Making decisions under circumstances of doubt involves assessing the relative value of each item in a collection of information to the problem under consideration. This can become problematic very quickly if it involves searching the masses of items or groups of items of information contained in systems. The most obvious limiting factor is simply the volume of information that needs to be considered. However, there may also be three other important limiting factors: First, the complex ways in which the information is collected and stored can make access difficult; second, the number of inference chains or groups or clusters that need to be assessed can be enormous; and third, the efficiency of the strategy or methodological process employed by the user to undertake the task can affect their success.

As the search progresses over time, the problem itself may change or the arrangement of the system used to store the information might change as we or other users interact with it—perhaps even to such an extent that it is not possible to complete the analytic task in

12 There is an important issue to be dealt with concerning "old information." An old record, such as a conviction for burglary committed fifteen years previously, may represent a "spent" conviction in legal terms, but may remain highly relevant to an investigation being conducted later. Let us imagine that a highly specialised and thus unusual method was used to commit that crime. The detection of that method could act as a predictor in the future for any crimes committed using that same method. The originator of the technique may be considered a likely suspect in that future incident, or one of his network of associations may have learned the technique from him. These people could be criminal associates, business associates or prison inmates who served a term of imprisonment with the suspect and who learned of the technique in prison.
the time available. Alternatively, due to the changing arrangement of the information, it
might not be possible to be confident in the results obtained.

One good strategy is to employ the use of questions that act as attractors to which certain
classes or types of information may be drawn. The FLINTS system was designed with this
specific purpose in mind, and allows the user to assign values to certain classes or types of
information based on the information's relevance to the problem being considered. The
human ability to employ fuzzy reasoning skills at great speed, combined with the
computer's ability to search for and locate information stored in a database at great speed,
are brought together in a single parallel strategy. This provides great power to define what
is important and locate it, while eliminating other information that is redundant until a new
situation is considered that renders that information relevant once more.

Single items of information such as the location or time of an event might be important,
but so might be sets, groups, or clusters of items of information. Here, we might be
interested in lists of prolific offenders or the sequence in which events occur. Another
example might be groups of crimes committed by the same suspect or groups of suspects
in certain localities.

FLINTS illustrates the power of this parallel approach, which combines human reasoning
with fast computing. Once a question has been framed by the user, it can be “fired” at the
database to act as an attractor or set of attractors. Information relevant to the question
might then be identified, and depending upon the question, the result might be either a
large or small collection of information. The user then faces the problem of assessing how
the results of the search affects their task. In short, the user faces the problem of deciding
what aspects of the returned information is important to them. Often, due to the fact that
no database can contain all information relevant to all problems, there may be a number of
gaps in the returned information. Thus, it's common for imperfect and partial collections to
be returned, and these situations have to be considered carefully by the user.

Decisions about the relevance of information in these circumstances necessitates a
consideration of the many ways in which the information could be arranged. Deciding
which arrangement best assists in solving the problem under consideration or (just as
importantly) which arrangement provides the best avenue of enquiry to navigate the complex collections of information in the system depends on the user's ability to speedily assess those arrangements.

A good strategy here is to view the information from both a holistic and an atomistic standpoint. This allows the user to take both a "top down" and a "bottom up" approach to the information in the collection. One useful method to differentiate between information of interest and information that may be redundant, is to adopt a strategy that involves abstract visualisation of the information, the links and the associations presented in answer to the question. This image presents a snapshot of the information and how the links within it fit together. Atomistic analysis can then be undertaken to learn more about small sections of the image (e.g., a specific link or clusters of information). This analysis helps users to assess where weaknesses or areas of doubt exist within the body of evidence. Each link in a collection, cluster or network represents an uncertainty. Knowing where these exist enables the user to undertake further assessments or searches for further information to assist in either supporting or negating the conclusion initially contemplated as a result of answering the question.

Navigating the system by iteratively cycling between holistic and atomistic standpoints provides a very good method for reassessing the information and any groups, clusters or networks it contains. In addition, it is also provides a method for navigating along links using both direct and indirect reasoning. As we have seen, reasoning can involve both simple inferential chains and more complex, indirect inferential chains. In the following series of diagrams we can see the result of this process in action. The first diagram, Figure 4.35, represents the result of a question being formulated and "fired" at the FLINTS system: "Show me any existing links in the entire database between crimes and persons on the basis of either DNA or Fingerprint evidence, and display the results in one single chart."

**Figure 4.35 The Results of a FLINTS Search for Crimes and Persons Linked by DNA or Fingerprint evidence. (The red arrow indicates the network depicted in Figure 4.36).**
The database this image was drawn from used the prototype FLINTS system, which contained 3,305 crimes and 3,100 persons at that time. The visualisation provides a holistic view of the answer to the question. In the bottom right-hand corner, we can see single links between crimes, suspects and evidence, whereas in the top left-hand corner we can see multiple links. If our focus concerned large networks of offenders and crimes, we might initially be attracted to the top left-hand corner. However, we must keep in mind that the database does not present us with a complete snapshot of the real world. It always contains gaps that should represent areas of interest to us. For more details, see Appendix 4, section 3, "Using Complexity Theory to Identify Complex Links in Masses of Evidence. (Using Complex Strange Attractors).

Let us consider one of the single links in the bottom right of the chart between one person and one crime on the basis of a single evidence type such as DNA. Initially, this may seem uninteresting. In contrast, one of the multiple links in the top left portion of the chart may seem to provide us with an explanation for a series of crimes about which we have been seeking a culprit. We may then assume that the suspect involved is also responsible for all other similar crimes in the area. Great care must be taken at this point because of the gaps that exist in the system. The suspect we identified based on the single links may in reality be the prolific offender, but we simply have missed the evidence to substantiate that
conclusion. It might exist in the real world, and we have simply been unfortunate or inefficient in collecting the evidence.

The addition of only a small number of items of information might transform our view of this chart. For example, one DNA link between one of the single-link suspects at the bottom right might result in linking that suspect to a whole series of crimes and thus move them and their network towards the top left of the chart. In this sense, the system and this chart can prompt us to search for and collect other evidence that might have this result.

We must engage in contemplating what we had not previously considered, then, with the aid of that succession of ideas, generate and contemplate new impressions. It is the association of ideas as well as sources of known information that moves the investigation forward.

We can engage in and contemplate what Peirce (1958, p. 249) called the law of association of ideas:

"In the absence of external impressions of interest, thoughts begin to dance through the mind, each leading one another by the hand, like a train of Bacchants on a Grecian vase, as Hegel says. After a while the clear train of thought breaks, and for a time ideas are scattered, soon, however, to take places again in another train... many things are worth trial, which do not seem at any time probably true."

In the remainder of this series of charts, we can see the result of navigating the system to allow atomistic views of various locations within the chart. It is the user's responsibility to decide which areas are of the most interest, then focus the system on that area of the chart to present the information in greater detail. Again, we can contemplate scenarios and associations that might lead us to new and interesting conclusions and even further contemplations. An interesting reluctance is encountered when this idea is presented to senior managers in policing: they are uncomfortable with the notion of staff "surfing" the

13 This is an old idea from 18th psychology that remains relevant to this discussion.
system with no apparent objective in mind. It has been suggested by senior police managers that analysts should focus only on set objectives, and not become swayed by other interesting avenues of enquiry. What is needed is a realisation that both directed (set objective) and undirected (surfing) explorations are important. Initial objectives, such as the identification of a group of firearm or drug dealers, may initially be thought to be the worst problem faced by a particular policing area. However, if during the analysis a user encountered information indicating that a series of sex offences never previously thought to be linked might in fact be associated with a prolific offender, we must face the problem of these competing new objectives. Though some might fear losing control of the analytical function, it should be realised that learning what we do not already know involves considering what we have never previously considered. By carefully examining Figure 4.36 and contrasting it with Figure 4.35, we can easily identify the new chart in the top left-hand corner of the latter figure. (Marked with red arrow in Figure 4.35).

\(^{14}\) This is an illuminating problem. When planning training for staff in the use of FLINTS, the author introduced the notion that FLINTS could be used abductively by analysts to discover new problems never previously contemplated. By merely "wandering" or "surfing" the networks of links between people, crimes, locations and times, they would discover new and interesting associations. They can fairly easily detect crime in this way by identifying a suspect not previously thought to have been involved. The manager's fears manifested themselves in the claim that analysts could not clearly account for the time they had spent in this activity. Furthermore, they felt they would lose control of the intelligence process if this exploration were to be allowed. In the ensuing discussions, it became apparent that managers had difficulty understanding the importance of the different forms of reasoning involved (deduction, induction and abduction). The role of discovery and abduction in particular was problematic to them. Performance measures placed on managers and staff were cited as reasons for maintaining a focus on the original objectives.
Figure 4.36 An Enlarge View of a Network Extracted from the Chart in Figure 4.35.

Figures 4.37 and 4.38 represent other areas of Figure 4.35, but in still greater detail. Because we have now focussed at a smaller level of detail, it is no longer possible to identify these enlarged areas in Figure 4.35.

Figure 4.37 Further Detailed & Enlarged View of an Area from Figure 4.35.
Note the position of the suspect Simon Paul in Figure 4.37 and also shown in Figure 4.38. Navigating from the holistic high-level view of all the information in the system (Figure 4.35) down to progressively greater levels of detail (Figures 4.37 and 4.38) provides an ideal method of dealing with large amounts of information without losing the ability to learn from smaller subsets of this information as we progress through an investigation.

Figure 4.38. Further Detailed & Enlarged View of Another Area from Figure 4.35.

4.35 Prediction in Complex Police Systems
Establishing present states—that is, taking control of the systems we possess to find out what we currently know—allows us to find pathways and routes into the future and to make predictions about what we do not know but perhaps ought to know. The networks in Figures 4.24, 4.25 and 4.26 illustrate a determined present state; we know that those links exist because we have the evidence for them. Each person (element) in the network had, on previous occasions, been arrested along with other persons in the network. Having established that fact, we can set about predicting a future state of the network if we take particular types of action. In Figures 25 and 26 we see the resulting fragmentation of the network by the removal of certain elements.

Figures 4.24, 4.25 and 4.26 demonstrate some fairly simple examples of disrupting or fragmenting systems or networks of crime. Even these simple networks conceal complex
patterns. The combinatorial predictive potential within those networks is large. In Networks (Figure 4.24) there are 14 nodes that generate 16,369 possible combinations of two or more nodes. FLINTS helps the user to navigate these networks, and make decisions about the most appropriate action to take.

These networks (Figures 4.24, 4.25 and 4.27) demonstrate how complex networks of people within a system can evolve in terms of relationships, over time. By analysing the links and determining which elements should be removed first, we can fairly quickly break down the network into its components.

Figure 4.25 is the result of removing three nodes from Figure 4.24, and represents a predictive assessment of the likely outcome of removing those elements. What we must also ask here is what is the likely extent and level of the self-organisation will take place after we take that action. We might not want to force certain elements closer together by removing intermediate elements; furthermore, we might want to maintain a certain status quo whilst we engage in counterintelligence and insurgence activities.

If this situation represented a shoplifting ring, then our action might be less risky than if we were dealing with a drug cartel across national boundaries. In any event, we know now that we have the ability to engage in predicting what the results of our activity might be. We can thus engage in informed choice—an important luxury for the decision-maker.

What we have engaged in here is modelling the current state of a network in order to find out the likely structure that would result if we interact with it. Present knowledge is transferred into future knowledge by assessing a range of possible outcomes (a range of uncertainties). Remember, we need to assess the uncertainty of the self-organisation that will occur after we act.

An interesting issue for discussion at a later time might be the impact that government performance indicators have on deployment policy and on decisions staff in these kinds of scenarios. If simplistic measures are used, such as the number of arrests or the number of investigations within given geographic areas over given time scales, this might force decision-makers to adopt arrest and investigations options rather than to solve overall
problems. The study of complex systems reveals that simply accepting the most obvious solution (arresting those who may appear to be the most prolific offenders in the system) might not always be the best course of action. This action may not be the same thing as adopting strategies to remove from the network the key element or elements most responsible for holding the structure together. Policing needs to understand that, as Poincaré (1905, p. 147) noted, what may appear on the surface to be simple might conceal a highly complex set of conditions and states beneath.

4.36 Conclusion
The need to seek out and identify critically important states within our systems is a key factor in attempts to protect our future against instability. Our thinking must not be constrained by a willingness to accept a single strategic victory. Only a range of strategies will deliver the flexibility that the complexity of the modern world demands, and generating these strategies requires a whole new set of metaphors and thinking. Police approaches, like those in many other disciplines and professions, have suffered from "silo" thinking. In police terms, this involves classifying one situation as a crime problem, another as a traffic problem, and yet another as a community affairs issue. This rigid approach serves only to restrict our capability to react to complexity and thwart chaos whenever it threatens.

Seeking to avoid unpredictable outcomes and maintain control are the necessary goals. Simple linear or quantitative methods for assessing the current state of affairs are useful, but have significant limitations when dealing with the complex, nonlinear nature of the real world. If we can reduce our assessment to a simple measure and predict the future on the basis of a direct relationship with the past, so much the better. But the overriding message repeatedly experienced by police organisations is that the environment we operate in is rife with complexity and complex systems. Simplicity and linearity are not underlying constants that we can rely upon, and we can no longer accept the world as a fixed "given". There may be phases that are fixed, but complexity is quickly being identified as the overriding metaphor for our world. In such a complex environment, we need the flexible strategies provided by an understanding of complexity and chaos theory, combined with an ability to identify current states as a necessary first step in attempting to predict future states.
The FLINTS software aids police decision-making by being better able to cope with the complexity of the environment in which decisions are made. Because it has been designed to capture and monitor dynamic changes within the system over time, FLINTS is itself a dynamic, complex system—the first such system to be used to aid policing in this way. The system engages in both linear and nonlinear discovery, and employs both approaches in parallel, thereby allowing users to speedily ascertain what is directly observable from the information. Then, just as importantly, they can observe what is *indirectly* observable amidst this information.

Rather than ignoring the nonlinear behaviours that remain after linear approaches have been attempted (that is, the complexity and nonlinearity typical of complex, chaotic systems), FLINTS acknowledges and harnesses these behaviours. Why is this important? Because what takes us by surprise is often the result of meeting face to face with something we had not contemplated: that which we did not already know. It is not unreasonable to suggest that we should engage with the material of surprises—*information and knowledge we do not possess or, if we do possess it, whose importance we have not yet contemplated*.

Nonlinear models produce surprises because the complex layers and associations of information within them conceal many of the hidden links, and small changes via these links may lead to large consequences. By accessing and tapping into these areas in which we can find surprises, we gain new knowledge and the ability to deal with surprises such as those that led to the discovery of chaos theory. Because linear systems do not present such surprises, they are limited in the amount of new information or knowledge they can reveal. An important feature of the FLINTS system is its ability to reveal that which we do not know, yet ought to know.
CHAPTER FIVE

Barriers, Pitfalls and Moving Beyond FLINTS

Introduction

This thesis has explored how the development of a neo-Wigmorean approach to evidential reasoning could aid the management, analysis and use of evidence in pre-trial police investigations. This exploration included a discussion of the development of the foundations of the methodology and a case study of the application of this general theory in the form of FLINTS. The point was made early in Chapter 1 that one of the dangers of this approach is that FLINTS may come to be seen as simply a machine that replaces human reasoning skills. On the contrary, as is true of Wigmore’s method, FLINTS is an example of the benefits that can be gained from systemising an art in the form of an orderly approach to the management and analysis of a mixed mass of evidence. But FLINTS is also a tool to aid thinking; it is an embodiment of a way of thought, not just a computer program. Integral to the process of good thinking is good reasoning. That, in turn, aids discovery, the gaining of knowledge and the filling of gaps in our evidence.

Having explored the benefits and demonstrated some of the opportunities presented by the adoption of the ideas embodied in this thesis, it is now necessary to consider some of the barriers to implementation and pitfalls that may be encountered. This Chapter considers two problematic areas encountered during the development of this thesis. The first is the need to work within a framework of legality and the second is the importance of training and continued professional development for those engaged in using such an approach. A third area examined in this Chapter is the future: it discusses the future beyond FLINTS in terms of the evidence and intelligence management systems of the future. The Chapter introduces the latest developments undertaken by the author in the form of a new methodology and a case study that takes evidential reasoning beyond what is possible with FLINTS. Information technology and the proliferation of global communications systems

---

1 The first edition of this thesis contained a more extensive review of material covering the legal framework, barriers and pitfalls encountered when adopting advanced approaches to the management and analysis of evidence and information contained in systems. On the advice of the Examiners and PhD Supervisor, it is agreed that this subject is worthy of a PhD thesis in its own right. On their advice, the material has been shortened.
are enabling both individuals and organisations to collect and transfer great masses of information. However, as Leary (2004, p.7) stated, making sense of this information and putting it to good use is becoming a pressing problem. Although this new approach is, strictly speaking, beyond the scope of this thesis, and goes beyond and is distinct from FLINTS, the new approach is discussed in this Chapter to demonstrate how the development of a neo-Wigmorean approach can overcome two difficult problems in evidence management: first, managing large collections of evidence in highly complex cases that may be linked; second, providing the investigator with a means to manage and shift their "standpoint" in making sense of a mixed mass of evidence. The methodology has been implemented within software called MAVERICK, which demonstrates what can be achieved in the future.

The first barrier to be discussed is the "framework of legality" that needs to be considered when adopting the ideas embodied in this thesis.

5.1 Framework of Legality

As our ability to access, combine and use evidence increases, the need to operate within a general framework of legality gathers greater importance. This term is used to mean the body of laws and regulations that constrain and govern the use of data.

New approaches in using information so that non-obvious relationships within our collections of information can be exploited have to be balanced with the need to work within this framework. Users of methodologies and systems such as those advocated in this thesis must be ready to assess the risks of possible misuse of information for unlawful purposes and, potentially, the erosion of protections of civil liberties. This includes the risk of inadvertently misusing information for lawful purposes.

The amount of physical, forensic and contact trace evidence now managed in FLINTS presents a problem in terms of keeping records and audit trails up to date. Ensuring that records are accurate and that information is legitimately retained and removed from the databases when they can no longer be validly preserved are of great ethical, moral and legal concern. The reality is that there will always be some delay in removing such data from our systems. For example, there is an inevitable delay between courts informing the
police of the results of cases and that a decision not to proceed has been taken and action taken to remove the data from the system. During this delay, there is a possibility that matches will be gained that raise suspicions about the presence of the suspect at the scene of a crime at the relevant time, but on the basis of illegally held data that may not be admissible in proceedings.

Such an unlawfully held sample of evidence may give rise to a match between a crime and a suspect and, when used in FLINTS, can provide links between series and strings of offences and suspects. Once a match of this nature is made in FLINTS, it is difficult for the analyst to ignore it.

The importance of working within a framework of legality and the dangers of breaches of that framework, which could bring the management of evidence and intelligence into disrepute, is not limited to operational work. It has to be introduced into an overall strategy for training too. The point has been made in this thesis that traditional police training and practice have been overly concerned with the law of evidence and too little concerned with the logic of enquiry and the principles of proof. The concept upon which FLINTS was built promotes a wider appreciation of the role of evidence and proof in police investigation, but this does not mean that the law of evidence is unimportant. See Zander, (2003) for a survey of recent debates and reforms.

It is beyond the scope of this thesis to deal in detail with the laws that affect police investigation and intelligence analysis as a whole. The issue is raised here to introduce and highlight the existence of legal problems that need to be reconsidered. The problems include compliance with various bodies of law including Police and Criminal Evidence Act of 1984, the Criminal Procedure and Investigation Act of 1996, the Data Protection Act of 1998, the European Convention on Human Rights and the Human Rights Act of 1998 and the Freedom of Information Act of 2000. Furthermore, the exclusionary rules of evidence cast a long shadow over practical investigations.2 The implications for evidential reasoning when supported by methodologies such as those described in this thesis requires careful consideration in the future.

2 For an illuminating discussion of the way in which discretionary exclusion of evidence has developed in English law, see Pattenden (1997). See also Dennis, I. (2002).
The "framework of legality" introduced and outlined in this chapter has clear implications for systems used in the management, analysis and presentation of evidence and intelligence. The need to ensure that the policy governing the use of such systems is compliant with legislation is paramount to maintaining public and political confidence in systems. Clear reasons for maintaining certain classes of information, an enforced audit policy and a rigorous check on standards by given timescales all require careful consideration.

5.2 Training
The case has been made for the use of better methods and techniques for the management and use of evidence and intelligence in police investigation. It was made clear at the outset of the thesis that the author had developed a dissatisfaction with police training and practice in the investigation of crime and the management of evidence. Adhami & Browne (1996) developed protocols for investigative practice but failed to achieve anything in terms of reasoned approaches. As the thesis developed, the author decided that training in the use of the methods and techniques described in the thesis should concentrate on two areas: First, training should be informed by an understanding of the problems of teaching investigators and analysts the skills of logic and proof; second, there is a need to consider the problems of integrating a logic of enquiry, principles of proof and legal aspects of evidence procedure in training material. These issues will now be addressed as specific topics.

5.3 Problems of Teaching Logic to Investigators and Analysts
There are two problems that need to be considered and overcome: first, the intellectual capacity of the student (or their perception of their own capacity), and second, resistance to and fear of new procedures.

5.4 Intellectual Capacity

3 Material available concentrated on protocols and lists of actions to be taken rather than developing investigative and reasoning skills. See for example Adhami & Browne (1996).
4 These concepts were new to police training and required careful handling for reasons that will become clear as the chapter develops.
Finding the right intellectual approach so that the material can be absorbed and does not appear to be too complex for the ability of the student is important. If the educational material appears too complex, students may resist the material and fail to take advantage of its potential for developing their skills, even if they might well be capable of understanding the material.

Following the events of 11 September 2001 in New York, an intense interest has been generated in North America and Canada about the need for better systems of intelligence and better intelligence training. One piece of work undertaken by Schum\(^5\) has been the development of training material to help analysts make assessments and predictive evaluations of intelligence gathered from diverse sources. Whilst the intellectual depth of the material produced by Schum is ahead of its time and the concepts\(^6\) used are thoroughly justified, Schum's material appears too challenging to many intelligence analysts.

The examples provided by Schum are complex and require concentrated effort. One effect is that analysts will simply find it too difficult to grasp. Experienced staff can handle the material, but inexperienced staff may have difficulty doing so. The dilemma is this: If the training is too simple, it will lack depth and will lose impact; on the other hand, if it is too complex, the training will cause trainees to fear that the work is too difficult and that they are not "up to it".

Simple training examples are needed. These examples should be capable of being taught to students in reasonable timescales while still providing a good understanding of the concepts. This will overcome the fear of the complexity of logic and allow the trainees to develop the necessary skills. Schum uses a number of techniques, including Wigmorean analysis, to teach the skills of intelligence analysis.

\(^5\) The author is deeply indebted to Professor Schum for access to his training and lectures in Washington DC.

\(^6\) Experienced teachers of evidence, intelligence and logic might not have difficulty with this material. However, intelligence analysts come from a different background and have generally not had the opportunity and benefit of studying problems involving deep logical, inferential and proof-laden scenarios. If they had, the material would be ideal.
Anderson, using a slightly different approach, has integrated Wigmorean analysis with orthodox courses on the law of evidence. The work appears less formal than that of Schum, although rigour is not sacrificed to simplicity. Anderson uses materials organized around the process of argumentation to develop the students' skills in managing a mixed mass of evidence. Witnessing Anderson picking apart an argument constructed by a student soon engenders a realisation that the process of construction and deconstruction of evidential arguments has much to offer those who must train the users of systems such as FLINTS. His approach is clinical, yet easily understood because the material is often presented in the form of stories. Students seem to grasp stories as a medium that they can understand and work with. Wigmorean Charts still present the trainee with some difficulty, especially in aligning and optimising the key list that accompanies the chart. However, it is the process of constructing the argument, challenging one's standpoint and seeking different perspectives on the evidence that provides valuable insights into better ways of teaching the material.

Training has begun, but more progress is needed. Getting the right balance between depth of material and the level of intellectual capacity needed to manage the conceptual operations and put them into action is the key to better training. Getting staff to understand what logic is, what reasoning is, and how evidence and proof fit together is important, but the training must be provided at a level they understand and can use. Trainees need to be eased into the work by means of simple problems and workable solutions so that they can progressively learn to handle more difficult problems.

Training has thus far been based on getting staff to develop a fairly simple but clear appreciation of some of the more important conceptual issues underpinning evidence, logic and proof, then teaching them to apply their understanding in the operation of FLINTS using real data and real cases.

---

7 Professor of Law, School of Law, University of Miami.
8 The author is deeply indebted to Professor Anderson for his attending training sessions in the United Kingdom for investigators and analysts in 1999, 2000 and 2001. These were important sessions for the development of training material.
9 Anderson, T.J. & Twining, W, (1991). This work is supported by a teacher's manual by the same authors (1991a). This provides valuable instruction on the use of the original work Analysis of Evidence.
Before gaining access to the system, staff are given a "tutor led" tour of the operational functions. They are introduced to the extent to which information can be analysed and shown ways in which they can go about using the information to generate and test hypotheses. Trainees are then given an exercise using real data to practice with.

At the end of the practice session, trainees present their work to a panel and justify their conclusions and recommendations. The slides were designed and presented by the author, then put into context using simple case examples. Discussions follow the slide presentation, and the case studies are used to get staff used to handling the conceptual material and the evidence at their disposal.

Two particular areas of difficulty are often encountered by students and need to be overcome:

The first difficulty staff encounter is coming to terms with different forms of reasoning using evidence and inference. Given the problems encountered by Wigmore and more recently by Anderson and Twining in teaching Wigmorean analysis, this was no surprise to the author. In the FLINTS training courses, simple examples have to be given of different forms of reasoning, and these are "picked apart" in class by means of discussion and examples.

The author's experience has been that once staff understand the basics of different forms of logic and can demonstrate them with simple examples, they soon learn to justify and explain why particular hypotheses were generated and how they have tested them, and can subsequently make more balanced comments about how far they can justify their conclusions.

One area that repeatedly produces discussion and awakens interest is the notion of missing evidence. Not only does this generate interest in evidence as a discipline, it also appears to raise awareness of the dynamic nature of evidence. This plays a great part in encouraging trainees to think about evidence not only in terms of that which supports a hypothesis, but
that which might not support the hypothesis. The act of giving them the tools to evaluate

evidence and consider relevance, credibility and weight has been well-received.

Discussions of missing evidence might demonstrate that there are serious gaps in the
investigator's or analyst's conclusions, or that the hypothesis generated is fallacious
because evidence that must exist to justify it is missing, prompt deep insights and generally
seem to overcome resistance to learning the course material on logic. One encounter with
an intelligence analyst during the early training sessions in 2000 produced a question that
the author now tries to encourage as a matter of routine during training. The analyst
asked: "Do you mean that the absence of evidence is evidence itself?" An enlightening
discussion followed in which trainees were openly surprised that it was possible to
demonstrate that under the right circumstances, missing evidence might support a
hypothesis just as strongly as physical evidence might do so in other circumstances. The
issue was then raised that proof of some hypothesis is always dependant not only on what
evidence was adduced, but also on what evidence was not adduced.

This difference is not recognised in police training material and in the traditional approach
to evidence taken by trainers in police investigation thus far. The implications of this
manifest themselves in training sessions and discussions. At its worst, the argument goes
something like this: hypothesis A is raised and information items 1 and 2 and 3 are
discovered. Items 2 and 3 are seen to support the hypothesis, and thus become considered
as relevant evidence. Item 1 is not considered to support the hypothesis and is duly
ignored. This occurs despite the fact that all three items of evidence have some material
bearing on the possibility of the hypothesis being true or false.

What training material in policing needs to do is to explain that items 1 and 2 and 3 have
been discovered because they have some bearing on the case. Furthermore, students must
understand that item 1 may be sifted or screened out not because it has no bearing on the
case as a whole or in part, but rather because it does not support their favoured
explanation. Teaching "relevance" to investigators and analysts has provided some
important steps forward in this area. An example of the positive steps that have been made
is the way in which investigators and analysts can now refer to evidence in terms of that which supports and that which negates the hypothesis under investigation.\textsuperscript{10}

5.5 Resistance and Fear
Resistance and fear appear in a number of ways. Three main situations in which trainees may resist training arise when they fear undermining of their professional status, when managers fear a loss of control or autonomy, and when trainees fear that the approach is too technical. This Chapter has already discussed the latter of these three fears. The discussion will now focus on the remaining two.

5.6 Undermining Professional Status
Some investigators and analysts have exhibited fears that because the conceptual foundations underpinning the FLINTS system are new, they will threaten the current professional standing of investigators and analysts. Because the system automatically provides links between crimes, people, locations and times in ways and in such quantities that previously could only be hoped for, some staff fear that they will be replaced by a computer.

It needs to be explained in training and reflected in departmental policy that the automated links generated by systems such as FLINTS are simply hypotheses that act as "prompts" for investigators and analysts to use, test, support, undermine, or enhance. Instead of searching for issues of interest, the system helps the analyst to identify the most obvious links and allow them to choose where they will pursue the analysis. The technology thus speeds up the process of investigation by allowing investigators to cover more ground and cover it to a greater depth than has formerly been possible. The result is that the investigator's power increases, thereby enhancing (not undermining) their professional status.

5.7 Undermining Management Autonomy and Authority

\textsuperscript{10} Interestingly, it became quite fashionable for investigators to describe their collections of evidence in this way during management meetings and case conferences. It encouraged a more "rounded" approach to the management of evidence as well as demonstrating that the training was having some useful effect.
Some managers appear to fear the system because it undermines their autonomy to set policy about which problems should receive operational attention. For example, a manager might set a policy to address burglary and car crime and design a policing strategy around those problem types. After analysis is undertaken using FLINTS, it may be found that the real problem is the widespread illicit trade in drugs that is taking place. The original policy to combat burglary and car crime was based on simple linear numerical and geographical indicators, but often these indicators are hierarchical performance measures and fail to recognise the rich complexity of the data. Because FLINTS can reveal flaws in the original policy, managers fear that they will appear foolish and that their investigators will pursue different lines of inquiry. Managers must be taught that FLINTS can help them retain more control, not less, by helping them quickly adapt their policy to improve its effectiveness.

The analysis provided in FLINTS can allow for a more extensive understanding to be gained of different layers of information and networks. For example, knowledge about the people involved in criminal networks involving trade in illicit drugs and operating across wide geographical areas can emerge from analysis. However, closer analysis can reveal linked offences such as burglary and car crime undertaken to fund low-level users of these drugs and their habitual drug taking. In this manner, the investigative process may both support the initial policy (targeting vehicle theft crimes) and produce additional benefits by broadening the net to cover additional policy areas. FLINTS allows the analyst to model and test the networks involved at different levels and by reference to different combinations and types of evidence. For example, crime data for drug abuse, burglary data, and arrest patterns of particular groups, as well as stops, searches and seizures under the *Police and Criminal Evidence Act*, can provide "fertile" areas for identifying strategies to tackle, monitor and fragment criminal networks.

Some managers see the system as not only challenging former policy but also of providing evidence for the conclusions being drawn by the analyst. This can include the evidence required to arrest suspects, evidence of high-frequency problems and evidence upon which realistic and achievable solutions can be designed. Deep analysis of strategic problems can thus fall into conflict with performance measures established on the basis of less-thorough analyses. Training needs to identify this misperception and correct it in terms of its
fundamental characteristics. It is not that deep analysis threatens strategic policy, but rather that less-thorough analysis might not produce the right level of understanding of the problem we are trying to identify.

Some managers feel this improved understanding undermines their professional and managerial authority and thereby threatens their position. What the training has so far tried to do and should continue to demonstrate is how the system can promote and enhance managerial autonomy and authority. Armed with the right analysis and intelligence, managers can target the "right" problem and test their policy. This will help to reduce those factors influencing the prevalence of the problem itself.

In the first FLINTS training course, the problem raised by management fears manifested itself in an interesting way. Having undertaken a detailed analysis of a problem involving a network of identified offenders, a team of investigators and analysts briefed a panel of senior managers playing the role of the management team in command of a local policing area. Recommendations were made about what the policing strategy should be for tackling crime. The conversation went as follows:

**Analyst:** "......that is a synopsis of our analysis and recommendations. Can I answer any questions for you?"

**Manager:** "That is a fine analysis of a problem but it is not the problem I decided to tackle. What about the problem I wanted tackled."

**Analyst:** "With respect, we have analysed deeply the information we have and considered and identified what we believe the real problem is."

---

11 The author was asked to deliver a paper on the implications of this problem to the Home Office and Association of Chief Police Officers Research and Development Conference, 11-12 June 2002, Hinckley, Leicestershire. The event was attended by senior Home Office officials. The conference was entitled “Improving and Measuring Police Performance”. The author was also asked to present a paper and facilitate a discussion called “The Role of the National Intelligence Model and FLINTS in Improving Police performance”. The implications for the use of FLINTS extend beyond evidence and intelligence marshalling. The conceptual foundations serve to underpin a better approach for policing.

12 The author was an observer at the briefing of the senior managers by the team of analysts. The manager soon realised that his decisions about policy had not been founded on good intelligence, a matter he eventually conceded to the group with good manners and good humour.
Manager: “Why should I change?”

Analyst: “You are not in possession of the amount and quality of information we are and therefore we recommend you change the strategy. If, you don’t, we will be tackling the wrong problem.”

As can be seen from the dialogue, there was a mismatch between management goals (protecting their investment in the existing policy) and the goals of investigators (changing that policy when it became apparent that it was not the most efficient approach). One interesting development has been the way in which some managers now use the system to overcome this problem. Forward-thinking managers sought urgent access to the system and had FLINTS installed on their computers. They began to "browse" the system to assist them in identifying priorities and deploying staff. Some also used it to generate questions for their analysts to answer. The depth of understanding about local and neighbouring problems was thus seen as being enhanced. Helping managers to understand this revised approach (enlisting FLINTS rather than fearing it) can persuade them that tools such as FLINTS actually support their authority rather than undermining it.

In one real case, whose details are too sensitive to provide in this thesis, several questions were constructed for a security operation to answer. These questions were formulated by reference to proven and potential networks of people that FLINTS was able to identify. The manager used the system to speed up the investigation process and test his own hypothesis and so as to ascertain supporting or undermining evidence about those persons he believed were instrumental in forming a "cell".\(^{13}\) Comments were later made by the team of people answering those questions that they felt the direction they were given was precise and based on good intelligence, and that it allowed them to infiltrate a communications network between suspected "cell" members. Without the initial list of questions, these individuals might not have been identified or monitored, and a dangerous situation could have gone unnoticed. This example demonstrated a good use of the system by a manager to establish their authority and thus, has been used in training sessions ever since.

\(^{13}\) A "cell" is a group of people who come together as a team of specialists to perpetrate organised terrorist acts. The cell is organised in a non-hierarchical manner to frustrate infiltration and detection by security personnel. FLINTS is an ideal tool for identifying potential cells and then offering modelling techniques to test ways in which the overall network can be fragmented, infiltrated or monitored to best effect.
The author produced standard operating protocols (Leary 1999) for use by investigators, intelligence analysts and forensic crime scene investigators. This approach was used by the office of Her Majesty’s Inspector of Constabulary in developing inspection protocols for police services, and much of the contents were incorporated into police policy documents.

5.8 Developing a neo-Wigmorean Approach and Moving Beyond FLINTS

Chapters 1, 2 and 3 contain a description of the origins of the methodology and FLINTS. These Chapters presented a working case study of a neo-Wigmorean approach to the management and analysis of evidence in police investigation describing and explaining the many advantages of the approach. Since the development of FLINTS, the author, in an attempt to improve on the approach and demonstrate what the future may hold, has developed a new methodology and approach. Although outside the confines of the thesis, it has been reduced to a software program that the author has named "MAVERICK." The program is intended to help investigators and intelligence analysts do a better job of managing vast amounts of information and evidence in highly complex cases. It serves to demonstrate the potential of the approach taken generally in this thesis and what the future may hold. The author published a conceptual methodology based on the use of a forensic ontology to identify whether organisations were complying with regulations governing certain classes of activity. One example was financial regulations, see Leary et al (2003). An ontology is a formal, explicit description of a domain, aiming at capturing the semantic context in which data is held. They are usually composed of the following metadata types: Concepts; conceptual Relations; axioms (properties and attributes of concepts); individuals; topics and documentation. This provides a conceptual basis for collecting and relating data so that semantic meaning can be extracted as the data base expands in size.

One of the drawbacks with FLINTS is that it is a system built to undertake fixed tasks using a fixed software model. That is, the system has a set of fixed functions designed to let investigators and intelligence analysts ask questions of evidence collected in a databank in a limited number of ways. Whilst this approach represents a valuable step forward from the way that evidence and intelligence is managed elsewhere in law enforcement, other methodologies could be developed to aid investigation even further. For example, another
drawback of FLINTS is that it manages data according to the model laid down and explained in Chapter 3. MAVERICK, however, is designed to be a more flexible tool that can be configured to model evidence and intelligence in many different ways, depending upon the context of the problem at hand. This means that the tool can be configured based upon the standpoint and context of the user of the system, the problems faced and the information available.

MAVERICK is designed to allow the investigator and analyst to model scenarios that reflect the problem domain under consideration. Different types of scenario demand different models therefore MAVERICK has been designed to be capable of reflecting the different contextual problems perceived by the user. The system includes both normative and heuristic approaches for interpreting the experimental analysis of causal relations in collections of evidence. This allows generalisations, as well as existing and contemplated theories and hypotheses, to be considered by combining human reasoning skills with the computer’s power to conduct sequential (linear) and non-linear data correlations. Assessments, predictions and tests about inferential relations can be undertaken beyond those normally contemplated by humans. For example, if the user is engaged in investigating the relationships between members of a criminal network, MAVERICK can be configured to manage, manipulate and order evidence in such a way as to uncover knowledge about links in criminal networks that would otherwise be hidden by layers of indirect relations. If the user was engaged in investigating fraud involving relationships between people, events, documents, claims and warrants made to secure financial gain, then a completely different set of data structuring or modelling rules will be needed. Humans cannot receive, store and keep in mind such data for any great period of time, especially if the data is complex and voluminous.

MAVERICK offers a glimpse towards future developments in this field by the range of tools available to the user to extract knowledge from collected evidence. The author, (Leary et al 2003), is also experimenting with ideas about the use of relational databases to capture semantic relationships in meta-data. Although new, this may prove fruitful for capturing semantic relationships in data beyond the bounds of current approaches.14

14 As this paper demonstrates, databases for semantic knowledge modelling are not new. However, the author has been experimenting with ideas concerning the use of forensic
MAVERICK uses a range of techniques to let the investigator and analyst ask contextual questions useful to the extraction of non-obvious links and knowledge. This means that the system will not only answer questions designed to reveal obvious or direct knowledge; it will also allow the user to ask questions that will reveal knowledge gleaned from indirect relationships. In this way, MAVERICK is designed to put into practice many of the lessons gained from the study of the complex systems discussed in Chapter 4.

MAVERICK can be configured to collect different types of data in different formats and store that data in a relational database. Operating alongside this database is a rules template that can be configured to allow certain relationships in the data to be recognised and modelled. In order to use the system to best effect, domain expertise is needed in the field of investigation in which the system is to operate. For example, if the system is to be used for detecting relationships in fraudulent transactions, then a certain degree of domain knowledge in that field would be required for the investigator to develop the relational and structural rules to manage the data. If, on the other hand, the domain being investigated was organised trafficking of drugs, then a different set of relational and structural rules would be required. Once modelled, the system can be used repeatedly in that domain. Automated and semi-automated functions can be set in place to allow the detection of certain types of scenarios. The system can be tasked with examining vast numbers of items of information as well as many combinations and series of relationships to detect links that are either unknown or too difficult to detect due to the nature and complexity of the data. This is modelling for obvious and non-obvious knowledge in ways that save vast amounts of time and that enable experimental relationships to be raised and tested. Automated prediction of trends in relationships, events, data types, and frequencies can be detected and used to reconfigure the system for new tasks. Automated discovery of previously unknown patterns can be undertaken across many fields of data on timescales well beyond current approaches. Automated extraction of hidden predictive information from databases is a powerful new technology with great potential to help investigators and analysts concentrate on the most important areas of doubt to them.

ontologies for knowledge discovery purposes. Consideration is being given to building this approach into MAVERICK.
MAVERICK uses a visualisation tool\textsuperscript{15} to let investigators and analysts "interact" with evidence by structuring and re-structuring different sets of data depending on the issue in doubt or the question that must be answered. The skill of the investigator or analyst in using the system is based not on their technological skill but on their ability to model the information at the outset, establish the types of questions that need to be answered, then use the visualisation tool to interact with the evidence and ask questions. In addition to straightforward querying techniques based on the obvious question models that are found in most search functions, the following methodologies have been developed to optimise knowledge extraction from evidence collected in MAVERICK:

1. Rule induction method: This is designed to enable the extraction of useful "if-then" rules from the database on either statistical grounds or based on heuristic experience in the domain under investigation.

2. Nearest-neighbour method: A technique that classifies each record in a dataset based on a combination of the classes of the $k$ record(s) most similar to it in a historical dataset (where $k \geq 1$). This is also sometimes called the $k$-nearest-neighbour technique. For examples see Kleinberg (1997).

3. Decision-tree structure method: Structured sets of decisions based on an approach similar to that in Wigmorean Charts. These decisions generate rules for the classification of a dataset. Specific decision-tree methods include classification and regression trees.

4. Network disaggregation method: Based on the nearest-neighbour method, this method involves the identification of clusters of items of evidence linked together on the basis of the model developed using induced rules. Once the models have been structured, different strategies are adopted to test optimum means of disaggregating clusters so as to detect scenarios and links of interest to the user.

\textsuperscript{15} MAVERICK Visualisation Tool. (M.V.Technology).
Work is underway by the author to develop the following methodologies to further enhance evidence modelling in MAVERICK. See other developments for example Arciszewski, T. & De Jong, K.A. (2001):

1. Artificial neural networks: These non-linear predictive models can be trained to "learn" or adapt so as to identify links as the processing of evidence is underway. The process resembles biological neural networks in structure and again reflects lessons learned from Complexity (Chapter 4).

2. Genetic algorithms: Optimising techniques using processes similar to genetic combination, mutation, and natural selection can be applied in the selection, design and use of different algorithms designed to reflect domains and contexts in which the evidence and system is used. This approach is based on the concepts of evolution and non-linearity discussed in Chapter 4.

3. Dynamic Learning Programs: These will mimic human learning processes but unlike real human learning, the program will not be prone to the fallibility of human learning traits. That is, the computer will not forget any element of the data received and processed including the revision processes involved in updating beliefs after new evidence is received.

The following figures demonstrate MAVERICK being used to investigate complex fraud and money laundering. The system was configured to operate in such a way as to reflect the types of relationships and *modus operandi* inherently found in complex fraud. Both macro- and micro-level analysis can be undertaken whereby large and complex sets of data can be modelled and visualised, as can smaller sets of data in smaller networks. The user defines the tasks and the system undertakes the hard sequential analysis required to arrive at a conclusion. The conclusion is then presented to the user for later revision if necessary.

Figure 5.1. shows how MAVERICK was used to model a mixed mass of evidence in a fraud enquiry. The objective was to model the evidence so that fraud investigators and lawyers could identify fraudulent money laundering and insurance claims between people and accounts. Each item of evidence is represented by a node of evidence and each line
represents a link identified by MAVERICK with another node of evidence. Already patterns and trends can be seen.

**Figure 5.1** A mixed mass of evidence modelled in MAVERICK to identify fraud.

Figure 5.2 shows how MAVERICK was used to identify a series of bank accounts fraudulently used to pay for personal injury and third party damage insurance policies. Some of these policies have been paid for by the same person, often using false identities.

**Figure 5.2.** MAVERICK being used to identify bank accounts used to pay for multiple policies. This is indicative of fraudulent activity.
Figure 5.3. is a development of Figure 5.2. It shows how MAVERICK was used to take evidence discovered in Figure 5.2 (one of the bank accounts) and use it as a new analytical question. Here 40 policies of insurance are identified as being paid for by only four bank accounts giving rise to highly suspicious activity. All these policies were later involved in insurance claims.
Figure 5.3. MAVERICK being used to identify multiple insurance policies paid for by only 4 bank accounts.

Figure 5.4. shows how MAVERICK was used to investigate the possibility that the four bank accounts identified in Figure 5.3 were linked. If they were, this would raise the possibility of collusion between account holders or the possibility of identity theft and fraud. Identity theft here means the fraudulent use of personal information by some person unauthorised to use that information. Identity theft is often used in credit card fraud and bank fraud.

Figure 5.4. shows the four bank accounts of interest. Between them, they have been used to pay for the forty policies identified in Figure 5.3.
Figure 5.4. MAVERICK used to identify in separate clusters the four bank accounts used to pay for forty policies.

Figure 5.5. shows how MAVERICK was used to identify trails of evidence linking three out of the four bank accounts. This demonstrates persuasive evidence of the possibility of fraud because the transactions would in normal circumstances be highly unlikely to be linked. Figure 5.5 shows how the accounts at the top of Figure 5.5. possess links between people, addresses and telephone numbers that would not in normal conditions be expected to occur. The presence of such links provides the justification for further investigation and analysis to uncover evidence to justify or negate the presence of fraud. Many of the linking nodes and evidence are shown by red arrows.
Figure 5.5. MAVERICK demonstrating non-obvious links between bank accounts used to pay for multiples of policies.

Figure 5.6 shows how MAVERICK is used to investigate micro connections in the evidence to test the hypothesis further raised in Figure 5.5. Namely, whether the links between the evidence and the bank accounts is likely to be fraudulent or not.

MAVERICK here demonstrates that more than one line of investigation can be undertaken simultaneously. This lets investigators assess combinations of evidence in apparently different scenarios to determine whether there are any links. MAVERICK can undertake as many lines of investigation as the investigator wishes to simultaneously. The difficult lies in the ability of the investigator to keep track of the enquiry and emerging evidence over time.
Figure 5.6. MAVERICK being used to investigate two lines of investigation at the same time.

Figure 5.7. shows MAVERICK being used to undertake micro analysis across clusters of evidence. This type of analysis is well beyond the ability of any human. The investigation would involve keeping in mind extremely large numbers of evidence in highly dynamic networks of links. Figure 5.7. shows one such network being analysed. Links developed between clusters of evidence can be clearly seen and shown by added red arrow.
Figure 5.7 shows MAVERICK being used to undertake micro analysis across clusters of evidence.

Figure 5.7 shows MAVERICK being used to investigate the presence of unexpected links between clusters of people and transactions identified in an automated analysis. These links could not have been detected manually on acceptable timescales, and needed the power of MAVERICK to search through vast quantities of data and identify the underlying patterns. The red arrow shows the link between a cluster of evidence and a cluster of
persons apparently not connected. Other links can be detected between people by further investigation.

**Figure 5.7. A visualisation of unexpected links revealed by MAVERICK.**

Figure 5.8. shows how MAVERICK can be used to link large clusters of evidence by even single items of evidence. These items of evidence are often hidden in the mixed mass of evidence and beyond discovery using conventional methods.
In Figure 5.8 there are five large clusters of evidence marked in blue. Each cluster contains a complex network of data linking people, financial transactions, credit cards, National Insurance documents, addresses, vehicles and so forth. Taken together, these clusters represent a single larger cluster. However, MAVERICK has gone further to identify single items of evidence that link the five clusters together to make one 'super cluster.' The 'super cluster' is made up of the five clusters of data namely Clusters 18.1–18.5.

In Figure 5.8, MAVERICK visualisation shows how two persons called HAFIQ A and ABIR AHM link clusters 18.2, 18.3, 18.4 and 18.5 together. It can be seen that MAVERICK has also identified that these two persons share the same National Insurance Number and that
a vehicle and credit card also link these clusters together. These links were detected solely by means of automated analysis.

The examples above illustrate aspects of a new approach to the management and analysis of a mixed mass of evidence. Two practical examples have been chosen to help illustrate the benefits that can be accrued. The first describes how the author used the approach to assist corporate lawyers manage evidence in a large series of organised fraud cases. The second example involves an investigation to determine whether persons involved in the fraud subject of the first example had engaged in identity theft.

5.9 Management and Analysis of a Mixed Mass of Uncertain Evidence In Organised Fraud

In Autumn 2003, the author was approached by a large corporate law firm in England experiencing problems in managing large numbers of personal injury and damage claims. These involved claims by persons against third parties and insurance companies for personal injury and damages resulting from motor accidents. Several lawyers were dealing with these cases separately and in isolation and advising client insurance companies about their liability for damages under contracts of insurance to cover personal injury and damages. However, similarities had been noted in terms of the persons involved and the events subject of claims. In total there were 443 cases involving 1,067 people. The case files were voluminous and capable of filling a vast filing room. Some claims were suspected to be based on fictitious events and some on the basis of manufactured false identities of the claimants and policy-holders. In all, there were 11,518 items of evidence to be considered from documents. The claims had been under investigation by the lawyers for 18 months and more evidence was being collected daily. Gradually lawyers were becoming subsumed in the quantity and complexity of the evidence and little progress was being made. More and more cases were being reported and more fraud was suspected of being committed. The average claim was valued at £20,000 making a total exposure of over £8.6 million.

The author was asked to assist in advising lawyers about the validity of each claim and support any findings with the production of evidence. MAVERICK was used to analyse the evidence. The software was configured to identify evidence of fraudulent activity that
would in turn justify the repudiation of claims or satisfy under-writers in assessments about whether to pay claims. Evidence of banking transactions, credit card transactions, telephone numbers, addresses, Post Codes, National Insurance Numbers, vehicles and other sources of information was used. Conventional approaches were not producing the necessary evidence to make these judgements and so the author was given the task. It was decided to undertake the work in two phases: Phase 1 was designed to identify at a strategic level whether fraud was prevalent and to make recommendations for further analysis and investigation work; Phase 2, if needed, was designed to identify specific elements of fraud with evidence to substantiate each finding and in each case. Phase 1 identified major inconsistencies in the data and claims. Phase 2, began on 16 January 2004 and was concluded on 31\textsuperscript{st} March 2004. It identified that in over 85\% of the claims there was evidence to substantiate fraud and repudiate claims. Evidence produced to substantiate fraud was found hidden in complex indirect associations between people, claims, policies and events. Without the methodology and MAVERICK, this evidence would not have been discovered. Both civil and criminal proceedings are currently being contemplated by lawyers.

5.10 Uncovering Identity Theft

In the first example, we saw how a mixed mass of evidence was managed and analysed to determine the presence of fraud. A key element of fraud was believed to be the manufacturing or fraudulent use of identities of people.

Figure 5.9 is an illustration of MAVERICK being used to determine whether there was any evidence of fraud based in whole or in part on the use of false identities. A Question was input to MAVERICK to establish evidence of links between the names used by people, National Insurance Numbers, telephone numbers, policies of insurance and addresses. In Figure 5.9 we can see how one person (indicated by the red arrow) was found to have used 2 National Insurance Numbers to obtain an insurance contract. (National Insurance Numbers are unique to the holder). Furthermore, that the same person was resident at an address (indicated with blue arrow) with another person (indicated with black arrow) who also shared one of the National Insurance Numbers (indicated with yellow arrow). Careful examination of Figure 5.9 will reveal additional evidence of persons using more than one National Insurance Number. The National Insurance Numbers are indicated by nodes
bearing the initials NI. At the bottom the circle of nodes can be seen persons who have produced evidence of more than one address to obtain insurance contracts. (Addresses are indicated with a dotted red arrow). One of those persons is in fact linked to three addresses. Further investigation of this network revealed more evidence of identity theft by more persons and is illustrated in Figure 1.10.

**Figure 5.9. Determining Evidence of Identity Theft and Fraud**

![Figure 5.9](image)

**Figure 5.10. Determining Evidence of Identity Theft Using National Insurance Numbers, Names, Addresses and Insurance Claims.**

In Figure 5.10 we can see how a whole series of National Insurance Numbers have been used by a series of persons to establish different identities. (Red arrows indicate a person
using more than one National Insurance Number and the blue arrow indicates a National Insurance number).

Conclusions
The case has been made in this thesis for using and combining a neo-Wigmorean methodology with technologies such as FLINTS and MAVERICK to aid the process of evidential reasoning and proof. In order to get the best possible results investigators must be trained in the use of logic to generate, investigate and test hypotheses. Furthermore, they must work within the framework of legality.

More could be done in training investigators and analysts to enhance their effective use of evidence. The training issues have begun to be addressed and the lessons are now being taught although it is important that the obstacles are not underestimated. We now need to plan for the future to develop training that will meet the needs that a greater appreciation of evidence, inference and proof presents. This is especially so when we employ advancing technologies to aid the processing of information and thought.
CONCLUSION

This thesis is the result of the dissatisfaction of the author with cardinal aspects of traditional approaches to police investigation, practice and training.

Five key weaknesses in traditional approaches were identified: Firstly, a lack of a theoretical foundation for police training and practice in the investigation of crime and evidence management; secondly, how evidence is treated on the basis of its source rather than its inherent capacity for generating questions; thirdly, how the role of inductive elimination is under-used and misunderstood; fourthly, concentration on single, isolated cases rather than on the investigation of multiple cases; fifthly, how the credentials of evidence are often assumed rather than considered, assessed and reasoned within the context of argumentation. Inspiration for the thesis came from three sources: Firstly, insights from John Henry Wigmore in the management and analysis of a mixed mass of evidence; secondly, developments in biochemistry about lessons from natural methods of storing and using information; thirdly, the science of complexity on the complex nature and uses of collections of data. These three disparate sources of inspiration were studied and used to develop a neo-Wigmorean methodology that despite its origins, represents a wholly new contribution.

Wigmore's original methodology was used and updated to take advantage of modern tools and ideas surrounding evidence and proof unavailable to Wigmore. This was in the form of an extended methodology, computer aided management of evidence, forensic science and evidential reasoning. The thesis adapts the approach to the needs of the detective and intelligence analyst rather than the advocate as was the original subject of Wigmore's methodology. The thesis extends the focus of the methodology from single cases to networks of cases using new conceptions about the nature, characteristics and wide use that can be made of evidence, inference and proof in police investigation. The thesis demonstrates how the structure of the human genome embodies data in the form of the base pairs that form DNA, the commands for use of that data (genes), and the relationships between the data and the commands. DNA permits the encapsulation and compression of enormous amounts of information and complexity for continual use as a template and operating system for the genome. These aspects of DNA form the basis for the methodology and subsequent software, which unites data and commands for using that data into a system that converts simple inputs (individual items of evidence) into complex outputs (linked items of evidence) including expressions of hypotheses, arguments and suggested inferences.

The thesis studied aspects of the science of complexity. In particular, how it can be used to reveal that simple rules can lead to complex consequences, and how complex systems can often be broken down into surprisingly simple rules, as is the case with DNA. This same observation is reflected in the procedure for decomposing then reconstructing arguments in the context of evidence-based reasoning in police investigation.

It has been shown how evidence comes in diverse forms and varied combinations and can be found in places, on things and on people in varied ways and combinations. Acknowledging and using complexity and evidential
diversity is central to this thesis as well as the need to ask questions of and about evidence to ensure that it is reliable.

This methodology and FLINTS aids police decision-making by being better able to cope with the complexity of the environment in which decisions are made as well as the evidence upon which those decisions are based. Because the methodology has been designed to capture and monitor dynamic changes within the system over time, FLINTS is itself a dynamic, complex system—the first such system to be used to aid police investigation and intelligence analysis. The system engages in both linear and nonlinear discovery, and employs both approaches in parallel, thereby allowing users to speedily ascertain what is directly observable from the information. Then, just as importantly, they can observe what is indirectly observable amidst this information.

It has been demonstrated that training is important in evidential reasoning. More could be done in training investigators and analysts to enhance their effective use of evidence including an appreciation of the need to work within a framework of legality. The training issues have begun to be addressed and the lessons are now being taught although it is important that the obstacles are not underestimated. There is now a need to plan for the future to develop training that will meet the needs that a greater appreciation of evidence, inference and proof presents. This is especially so when we employ advancing technologies to aid the processing of information and thought.

This thesis is therefore a demonstration of an application of a general methodology supported by new diagnostic and analytical techniques, the methodology being embodied in software called FLINTS. New work has also demonstrated what the future may hold in developing the lessons from FLINTS and MAVERICK.

The thesis has demonstrated that a broadened conception of evidential reasoning supported by new diagnostic and analytical techniques can improve the investigation and discovery process. The thesis demonstrated how developing a greater understanding of the roles and effects of different styles of reasoning can assist the user and that a range of concepts and tools for the combination, comparison, construction and presentation of evidence in imaginative ways is important and advantageous. Taken together these provide examples of a new approach to the science of evidential reasoning.

Richard M Leary
APPENDICES
EVIDENCE MARSHALLING SYSTEM - Subject to Scene & Scene to Scene

Evidence —► Collation & Storage —► Research —► Action

Evidence

Fingerprint Handwriting hits

Fingerprint

Handwriting

Fingerprint

Handwriting

hits

Criminal Information Bureau (CIB)

Firearms

PNC

Status

CRIMES

Printrack

FSS

Printrack

FSS

Fingerprint

Handwriting

hits

FP Hit

DNA hit

Footwear hit

Toolmark

FSS

SICAR - FSS

FSS

Arresting officer

Analysis

Telecom unit

CCA

Status

CRIMES

per SLA

Planned objective interviews

Arresting officer

OCU ops

Consolidate input

Generate

Toolmark

FSS

Slice

PNC

Status

CRIMES

MIT's
PURPOSE

The purpose of the 'FLINTS' system is to manage and marshal together evidence generated by the examination of physical and 'forensic' evidence from sources where a crime has been committed and the identity of the offender is in doubt.

Traditionally, these evidence types have been managed by separate systems which are not cross referenced and do not readily lend themselves to managing large amounts of data and, at the same time, provide efficient facilities for cross comparison and linking.

It is clear that at present the ability to collect evidence far out-strips the ability to use it in a developmental manner.

THE AIM

The system has been designed with the aim of consolidating HITS routinely generated by current processes, collecting and storing those HITS in one database, limited research processes to generate more HITS and an effective actioning process to operational sources for further analysis and actioning if need be.

Officers investigating crime will be able to access the FLINTS Management and Handling Warehouse to ascertain if there is any positive evidence available against any crime or criminal of interest to them.
INFORMATION TECHNOLOGY

The 'information technology' involved and developed is in the form of a powerful relational database with search and matching facilities. It can be used to supplement the work of Intelligence Bureau.

ACTIONING PROTOCOLS

Actioning the HITS from the 'FIB Management & Handling Warehouse' (situated on Key List at 7) to Operational Command Units and Major Investigation Units requires the development of 'Actioning Protocols.' This is particularly so in the case of 'Cross Force and OCU HITS' and where there are several HITS for one individual. Drafts of 'The Protocols' will be reported in due course and suggestions are requested.

ADVANTAGES OF THE SYSTEM

1. The system consolidates and generates 'strong' evidence of association between a particular individual and a particular crime with evidence that can withstand scrutiny. In the absence of evidence to the contrary, the HIT will usually justify the offender being charged or proceeded against.

2. The HITS will also prompt further investigation and analysis of crime and criminal databases to generate more evidence of association with outstanding crimes.

3. The system brings together all current sources of physical and forensic evidence into one process.

4. The system allows HITS from all sources to be handled, managed and audited by one process.

5. The system allows powerful search and comparison facilities between HITS and crime data to prevent duplication of effort and to report where for example one suspect is identified at several crime scenes by different evidence types or, where several evidence types identify the offender to one scene of crime.
CURRENT POSITION

FLINTS has been developed in its prototype stage to manage DNA, Fingerprint, Footwear and Toolmark Matches. In the future it would manage matches from other forensic sources as indicated below.

KEY LIST

This key list describes the functions of each of the boxes in the flow chart.

Sources of Evidential HITS

1. The Fraud Squad generates fingerprint evidence from routine ‘nin-hydrin’ tests on documents. It also produces handwriting evidence from documents which are stockpiled awaiting identification of a suspect for comparison. HITS to nominals are routinely generated. This information is not available as a matter of routine at present to other officers engaged in investigations across the force.

2. The Forensic Science Service examines firearms and reports HITS to the police service. HITS to nominals are not common but do occur. This information is not available as a matter of routine at present to other officers engaged in investigations across the force.

3. Print Track handles fingerprint comparisons for the force and reports HITS to nominals. There is a sizeable number every calendar month. (800 approx) This information is not available as a matter of routine at present to other officers engaged in investigations across the force.

4. The Forensic Science Service is the custodian of the National DNA Database and routinely reports between 200 and 350 HITS per calendar month to the force. These are scene to scene and scene to suspect HITS. This information is not available as a matter of routine at present to other officers engaged in investigations across the force.
5. SICAR is now operational and generating footwear HITS. These are scene to scene and scene to suspect. This information is not available as a matter of routine at present to other officers engaged in investigations across the force.

6. The Forensic Science Service generates Toolmark HITS from scene to scene and suspect to scene sources.

**Collation & Storage**

7. The FLINTS Management and Handling Warehouse of HITS from all original evidence sources.

8. The CRIMES system will be updated against each crime number the type of HIT available against that crime. (I.e. Crime information.) Any officer accessing the database will therefore be aware of forensic evidence available to the investigation.

9. The STATUS system will be updated against each suspect nominal the type of HIT available. Any officer accessing the database will therefore be aware of forensic evidence available to the investigation.

10. The PNC will be updated where HITS facilitate the circulation of a suspect as ‘wanted’ for that crime. The evidence type may or may not be included to meet the demands of PACE.

**Research & Actioning**

11. The Operational Command Units will receive HITS in accordance with the Protocols designed and agreed for the purpose.

12. The Force Intelligence Bureau.

13. The Major Investigation Teams will be tasked in accordance with the Protocols agreed.
14. The arresting officer or investigating officer will be given evidence upon which an arrest can be made and investigation commenced. A HIT should be seen as the beginning of an investigation not the end.

15. Analysts will be tasked by OCU’s where appropriate.

16. CRIMES and STATUS will be accessed by Analysts for CCA and CPA and any other analytical work considered necessary.

17. STATUS...as above, 16.

18. CCA and CPA will be undertaken where appropriate.

19. The British Telecom Unit will be tasked when appropriate.

20. Planned interviews will be undertaken with reference to the evidence available to the investigating officer.

21. Officers investigating crime will be able to access the FLINTS Management and Handling Warehouse to ascertain if there is any positive evidence available against any crime or criminal of interest to them.

Electronic Transfer of Data

Automated transfer of data between databases involved in this process is seen as crucial. For example, where the FIB Warehouse links with PNC, Status and CRIMES. (See Key List at 8, 9 and 10.) It would be extremely labour intensive to have data input into those databases manually.
1. Bugley Bill provable DNA to Bug 2
2. ________
3. INFERENCE Cheque Block (A), (B)
4. Bugley Bill provable INFERENCE Kit, Cheques (A) (B) (C) (D) (E) (F) (G)
5. Ditto (B), (B) (B), (C) (D)
6. Ditto (C), (C)
7. Could be connected Bug 3.

1. ? provable RP to Cheque (A) (4)
2. ? provable (?) HW to (A) 1 - 4 and (B) 1 and (C) 1 - 2.
3. ? by INFERENCE Handling of Body (A) (B)
4. ? Bugley Bill; and ?

1. Crime Associates/Conspirators
APPENDIX TWO
<table>
<thead>
<tr>
<th>Tangible ( + or - )</th>
<th>Objects</th>
<th>Documents</th>
<th>Images</th>
<th>Measurements</th>
<th>Charts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testimonial (Unequivocal)</td>
<td>Direct Observation</td>
<td>Second Hand</td>
<td>Opinion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testimonial (Equivocal)</td>
<td>Complete Equivocation</td>
<td>Probabilistic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Missing Tangibles or Testimony**

**Authoritative Records (Accepted Facts)**

Indictment for murder, returned June 12, 1900. At the trial in the Superior Court, before SHERMAN and STEVENS, JJ., the defendant at the close of the
evidence asked the judges to rule and instruct the jury: first, that there was not sufficient evidence to warrant the jury in finding a verdict of guilty; and,
second, that there was not sufficient evidence to warrant the jury in finding a verdict of guilty in the, first degree. The judges declined to give either of these
rulings. The jury found a verdict of guilty of murder in the first degree; and the defendant alleged exceptions.

JB. O’Donnell, for the defendant. J. C. Hammond, District Attorney, for the Commonwealth.

KNOWLTON, J. - The defendant was found guilty of murder in the first degree, and the only question before us is whether there was any evidence to warrant
the verdict. He and Casimir Jedrusik were working together as farm laborers for one Keith in Granby. On Sunday, December 31, 1899, Jedrusik disappeared,
and was never afterwards seen alive. On April 10, 1900, his headless, mutilated body was found inclosed in a bran sack in an unused well between four
hundred and five hundred feet from Keith’s horse barn. His clothing was found inclosed in another sack in the same well. His skull was afterwards found
buried in the cellar of the horse barn. The sacks were similar to those which Keith had in the horse barn. The stone, which was inclosed in the sack of
clothing, exactly fitted a vacant place in a stone wall about in line between the old well and the north door of the horse barn. On the day of the disappearance
there was no snow on the ground, and the surface of the ground was entirely frozen. In the cellar of the horse barn pigs were kept, and there was soft mud
there. The clothing which was exhibited to the jury had mud upon it which the Commonwealth contended on the evidence was like that in the cellar. Mr.
and Mrs. Keith drove away to church on December 31, leaving the defendant and Jedrusik about the barn. The defendant’s wife was in the house, where she
was employed as a housemaid, and there was evidence tending to show that the only other person who came there during that day was a young woman who
came to visit her. The defendant was outside of the house, about the premises, for some hours after Mr. and Mrs. Keith went to church, and when he came in
he said that Jedrusik had gone to Granby. There were wounds on the head of Jedrusik, which the Commonwealth contended were made by a corn cutter that
was in the horse barn, and was exhibited to the jury. The evidence tended to show that the defendant had ample opportunity to commit the murder, and that no
other person had an opportunity to do it without discovery.

On November 18th the defendant went to Chicopee to the house of a Polish Priest, to have the ceremony of marriage performed between him and a young
woman who had been living as a maid at Keith’s house, and he found that the priest had received a letter in a name which proved to be fictitious, charging him
with having a wife and children in the old country, and with receiving letters from his wife asking for money for the support of herself and her children. The
priest refused to marry him, and sent a trusted person with him to investigate. It turned out that Jedrusik wrote the letter, and that its contents did not appear
to be true. The defendant was then married by the priest, and the evidence tended to show that he was very angry with Jedrusik, and that he made a strong
treat of vengeance against him. There was evidence from several witnesses that at different times between the defendant’s marriage and the Jedrusik’s
disappearance, the defendant manifested deeply hostile feelings towards him, and made threats against him. On the morning of December 31st there was a
new manifestation of this feelings in charges made to Mr. Keith that Jedrusik had stolen a plane and had stolen butter. There was evidence that, between the
time of the disappearance and the discovery of the body, the defendant was seen to take up one of the planks covering the unused well, and also that when he
was told in the daytime that Keith and one Olds had gone out of the house with a lantern, he said he "knew what they were going to do. Mr. Olds wants to buy
the pumps in the old well." There was evidence that nothing had ever been said by Olds about buying the pump. Immediately after being told this the
defendant went into the horse barn, and was seen looking out of a window from which the well could be seen. When others went to the well after the body
was found, he did not go. There was also evidence that about the middle of January he gave away Jedrusik's rubber boots, and said that he did not think
Jedrusik would come back. There were many things in his language and conduct after Jedrusik's disappearance which the commonwealth relied on as tending
to show guilty knowledge, and much of his testimony in explanation of facts was in direct contradiction of other witnesses. Without going more at length into
the evidence, which was voluminous, we are of the opinion that it would have been error in to take the case from the jury. So far as we can judge from the bill
of exceptions the evidence well warranted the verdict. Exceptions over-ruled.
Issue: Did U. Kill J.?
Prosecution’s Case
Evidence

**Proposition ; Did Umilian Kill J ?**

1. Design to kill J.
2. Threats of unstated tenor, made on discovery of J's interference in prevention of marriage.
4. Threats might have meant merely some lesser harm.
5. Threats of revenge at later time.
7. Threats might have meant merely some lesser harm.
8. Revengeful murderous emotion towards J.
9. J. had falsely charged him with intended bigamy Nov. 18, and had tried thereby to prevent his marriage; thus tending to stir up such an emotion.
10. Letter received by priest, stating that U. already had family in old country.
11. Anon. witness to this.
12. J. was author of letter although it was in a fictitious name.
13. Anon. Witnesses to this.
14. Letter communicated by Priest to U., with refusal to perform marriage; refusal later withdrawn.
15. Anon. Witnesses to this.
16. Letter's statements were untrue.
17. Anon. Witnesses to this.
18. U's marriage being finally performed, U. would not have had a strong feeling of revenge.
19. J. remaining in daily contact, wound must have rankled.
19.1 Witness to daily contact.
20. Wife remaining there, jealousy between U. and J. probably continued.
21. U. Uttered threats and other hostile expressions between Nov. 18 and Dec. 31.
22. Anon. Witnesses to this.
23. U, on Dec 31, charged J to K with stealing K's goods.
24. Anon. Witnesses to this.
25. Does not appear these charges were false, hence not malicious.
26. U's *opportunity* in time and place was almost exclusive.
27. On Dec. 31 U. was on premises.
28.1 Anon. Witnesses to this.
29. U's wife and a woman visitor were there.
30. Anon. Witnesses to this.
Passing tramp-villain might have been there.

In time between Dec. 31 and April others had access to J, if alive still.

U. had uneasy consciousness about J.'s disappearance.

U. lied about J's going to Granby.

U. said J. had gone there, though J. was dead.

Anon. Witnesses to this.

J. might really have gone there, not being killed till later.

U. was conscious that the well was a place where damaging things would be discovered.

He watched those who searched there.

Anon. Witnesses to this.

That might have been due to natural curiosity of a farm hand at strange doings.

U. lied about the reason for Olds and K searching the well.

Anon. Witnesses to this.

U. did not go to the well to see the body when found.

Anon. Witnesses to this.

Several other reasons would explain this.

U. knew that J. was dead, though others did not.

He gave away J's boots and said that J. would not come back; this was about the middle of January.

Anon. Witnesses to this.

Like other's, U may merely have believed that J had given up work at the farm.

Data of slayer on J's body were of a person having free and intimate access to horse barn of K.

Wound-marks were those of a corn cutter from barn.

Anon. Witnesses to thereto.

Precise correspondence not stated; might have been a different weapon.

Anon. Witnesses to 55; and see 26.

Sacks holding body and clothes came from horse barn.

Anon. Witnesses to thereto.

Stone in sack fitted wall near well.

Anon. Witnesses to thereto.

Clothing in sack had marks of mud from barn cellar.

Anon. Witnesses to thereto.

Mud not specifically identified.
Design to kill J.

Threats of unstated tenor, made on discovery of J's interference in prevention of marriage.

Anon. Witness thereto.

Threats might have meant merely some lesser harm.

Anon. Witness thereto.

Threats might have meant merely some lesser harm.
Revengeful murderous emotion towards J.
J. had falsely charged him with intended bigamy Nov. 18, and had tried thereby to prevent his marriage; thus tending to stir up such an emotion.
Letter received by priest, stating that U. already had family in old country.
Anon. witness to this.
J. was author of letter although it was in a fictitious name.
Anon. Witnesses to this.
Letter communicated by Priest to U., with refusal to perform marriage; refusal later withdrawn.
Anon. Witnesses to this.
Letter's statements were untrue.
Anon. Witnesses to this.
U's marriage being finally performed, U. would not have had a strong feeling of revenge.
J. remaining in daily contact, wound must have rankled.
Witness to daily contact.
Wife remaining there, jealousy between U. and J. probably continued.
U. Uttered threats and other hostile expressions between Nov. 18 and Dec. 31.
Anon. Witnesses to this.
U., on Dec 31, charged J to K with stealing K's goods.
Anon. Witnesses to this.
Does not appear these charges were false, hence not malicious.
U's *opportunity* in time and place was almost exclusive.

On Dec. 31 U. was on premises.

Anon. Witnesses to this.

U's wife and a woman visitor were there.

Anon. Witnesses to this.

Passing tramp-villain might have been there.

In time between Dec. 31 and April others had access to J, if alive still.
U. had uneasy consciousness about J.'s disappearance.
U. lied about J's going to Granby.
U. said J. had gone there, though J. was dead.
Anon. Witnesses to this.
J. might really have gone there, not being killed till later.
U. was conscious that the well was a place where damaging things would be discovered.
He watched those who searched there.
Anon. Witnesses to this.
That might have been due to natural curiosity of a farm hand at strange doings.
U. lied about the reason for Olds and K searching the well.
Anon. Witnesses to this.
U. did not go to the well to see the body when found.
Anon. Witnesses to this.
Several other reasons would explain this.
U. knew that J. was dead, though others did not.
He gave away J's boots and said that J. would not come back; this was about the middle of January.
Anon. Witnesses to this.
Like other's, U may merely have believed that J had given up work at the farm.
Data of slayer on J’s body were of a person having free and intimate access to horse barn of K.

Wound-marks were those of a corn cutter from barn.

Anon. Witnesses to thereto.

Precise correspondence not stated; might have been a different weapon.

Anon. Witnesses to 55; and see 26.

Sacks holding body and clothes came from horse barn.

Anon. Witnesses to thereto.

Stone in sack fitted wall near well.

Anon. Witnesses to thereto.

Clothing in sack had marks of mud from barn cellar.

Anon. Witnesses to thereto.

Mud not specifically identified.
1. Symbols for Kinds of Evidence. Each human assertion, offered to be credited, is conceived of as a testimonial fact; each fact of any other sort is a circumstantial fact.

Testimonial evidence affirmative (M testifies that defendant had the knife).

Testimonial evidence negatory (M testifies that defendant did not have the knife).

Circumstantial evidence affirmative (knife was picked up near where defendant was; hence, defendant did have it).

Circumstantial evidence negatory (knife was found in deceased's hand; hence, defendant did not have it).

Same four kinds of evidence, when offered by the defendant in a case. (These are the same four kinds of evidence; it is merely convenient to note which party offers them.)

Any fact judicially admitted, or noticed as a matter of general knowledge or inference, without evidence introduced.

Any fact presented to the tribunal's own sense, i.e. a coat shown, or a witness' assertion made in court on the stand. Everything actually evidenced must end in this, except when judicially noticed or judicially admitted.

Explanatory evidence; i.e. for circumstantial evidence, explaining away its effect (knife might have been dropped by a third person); for testimonial evidence, discrediting its trustworthiness (witness was too excited to see who picked up the knife).

Corroborative evidence; i.e. for circumstantial evidence, strengthening the inference, closing up other possible explanations (no third person was near the parties when the knife was found); for testimonial evidence, supporting it by closing up probabilities of testimonial fact (witness stood close by, was not excited, was disinterested spectator).

Same two kinds of evidence, when offered by the defendant in a case.

2. Relation of Individual Pieces of Evidence, shown by position of Symbols

A supposed fact tending to prove the existence of another fact is placed below it.

A supposed explanatory or corroborative fact, tending to lessen or to strengthen the force of fact thus proved, is placed to left or right of it, respectively.

A single straight line (continued at a right angle, if necessary) indicates the supposed relation of one fact to another.

The symbol for a fact observed by the tribunal or judicially admitted or noticed (km) is placed directly below the fact so learned.

3. Probative Effect of an Evidential Fact. When a fact is offered or conceived as evidencing, explaining, or corroborating, it is noted by the appropriate symbol with a connecting line. But thus far it is merely convenient to note which party offers them.

Everything actually evidenced must end in this, except when judicially noticed or judicially admitted.

We do not yet know whether we believe it to be a fact, nor what probative force we are willing to give it, if a fact. As soon as our mind has come to the necessary conclusion on the subject, we symbolize as follows:

1. Provisional credit given to affirmative evidence, testimonial or circumstantial, is shown by adding an arrowhead.

   Provisional credit given to negatory evidence, testimonial or circumstantial, is shown by adding an arrowhead above a small cipher.

   Particularly strong credit given to those kinds of evidence respectively is shown by doubling the arrowhead; this is usually applicable where several testimonies or circumstances concur upon the same fact.

2. A small interrogation mark, placed alongside the connecting line, signifies doubt as to the probative effect of the evidence.

   Similarly, for each kind of symbol, a small interrogation mark within it signifies a mental balance, an uncertainty, the alleged fact may or may not be a fact.

3. A dot within the symbol of any kind of alleged fact signifies that we now believe it to be a fact. Particularly strong belief may be signified by two dots...

   A small cipher within the symbol of any kind of alleged fact signifies that we now disbelieve it to be a fact. Particularly strong disbelief may be signified by two such ciphers...

Thus, for net probative value, several grades of probative effect may be symbolized. When the supposed inference is a negatory one, the same symbols are used with the addition of the cipher as a negatory symbol...

Finally, after weighing it, detract from the force of the desired inference (in case of a witness, if it discredits his assertion), we signify this by an arrowhead pointing to the left, placed half way across the horizontal connecting line.

Doubled the arrow and the mark indicates particular strength in the effect.

Ultimately, when determining the total effect, in our estimation of all explanatory and corroborative facts upon the net probative value of the specific fact explained or corroborated, we place a short horizontal mark or small X, respectively, upon the upright connecting line of the latter fact.

(4) If a single supposed explanatory fact does, in our estimation after weighing it, detract from the force of the desired inference (in case of a witness, if it discredits his assertion), we signify this by an arrowhead pointing to the left, placed half way across the horizontal connecting line.
□ □ : P—D Testimonial Evidence Affirmatory
□ □ : P—D Testimonial Evidence Negatory
□ □ : P—D Circumstantial Evidence Affirmatory
□ □ : P—D Circumstantial Evidence Negatory
□ § □ : Circumstantial Evidence when offered in the form of a general truth used deductively
❯❯ : Explanatory Evidence for explaining away its effect
❯❯ : Explanatory Evidence for discrediting its trustworthiness
❯❯ : Corroborative Evidence for by closing possible explanations
❯❯ : Corroborative Evidence for by closing possibility of error
□ : Any fact judicially noted
∞ : Any fact presented to tribunal’s own senses
Everything actually evidenced must end in this
↑ ↑ : P—D strong inference arrow (tends to show)
↑ ↑ : P—D strong disbelief arrow
↑ ↑ : P—D inference arrow (tends to show)
↑ ↑ : P—D disbelief arrow
↑ ↑ : P—D “Tends to disprove” arrow (opposite of inference)
↑ ↑ : P—D “Tends to strongly disprove” arrow
Explanatory or corroborative fact tending to lessen the force of the fact thus proved
Explanatory or corroborative fact tending to increase the force of the fact thus proved
A supposed fact tending to prove or disprove the existence of another fact is placed below it

The Basic Palette

The square depicts a testimonial assertion that the tribunal will hear asserted by a witness. The infinity symbol, $\infty$, is placed beneath it to indicate that it is an autopic preference.

The circle depicts circumstantial evidence or an inferred proposition.

The open angle indicates an alternative explanation for an inference proposed by the other side. The angle is connected by a line to the circle depicting the inferred proposition which it explains. An explanation may be supported by evidential data or generalization or both.

A vertical triangle indicates an argument that corroborates an inferred proposition that has been challenged by an opponent. A corroborative proposition must be supported by evidential data, judicially noticed facts, or proposed generalizations.

A line with a directed arrow is used to "connect" and thereby indicate the relationship between two or more propositions with the arrow indicating the "direction" of the proposed inference. More than one proposition may be offered to support, explain, or corroborate an inferred proposition, and lines (with right angles as necessary) are used to depict the claimed relations precisely. See specimen chart, page 148, above for an illustration.

The infinity symbol denotes a proposition established by evidential data that the fact finders will perceive with their senses — i.e., a testimonial assertion they will hear or an item of physical evidence they will see, feel, smell, or taste. The symbol is placed immediately below the square or circle depicting the proposition to be so established.

The paragraph symbol is used to depict a factual proposition of which the tribunal will take judicial notice. The symbol is placed immediately below the circle depicting the proposition to be so established. The letter "G" denotes a proposition in the form of a generalization that provides an important step in an argument that should be made specific and that constitutes a proposition that is likely to affect the tribunal even if it is not supported by evidential data or a subject of judicial notice. The symbol is placed immediately below the circle depicting the generalization.

Additional Useful Symbols and Conventions

The letter "A" depicts an admission, a fact that has been formally admitted to be true by the party against whom it will be offered. The symbol is placed immediately below the circle depicting the factual proposition that has been admitted.

The letter "S" depicts a stipulated fact, a fact that has been properly stipulated to be true by all parties. The symbol is placed immediately below the circle depicting the proposition established by the stipulation.

The letter "U" depicts an undisputed fact, a fact that is not subject to genuine dispute. The symbol is placed immediately below the circle depicting the undisputed factual proposition. The symbol is frequently useful as a convention to simplify construction of a chart and to focus attention on disputed facts. Lawyers must bear in mind, however, that undisputed facts must be supported by evidential data unless they have been admitted, made the subject of a binding stipulation, or established by judicial notice.
Where convenient, an additional line may be inserted in any of the symbols depicting a proposition to indicate that the evidential data or proposition will be offered by or elicited from the opposing party's witnesses or exhibits. This convention may be useful for trial preparation where, for example, many propositions necessary to the plaintiff's case will require support from testimonial assertions to be offered through, or elicited on cross-examination from, the defendant's witnesses.

The open square and inverted U depict what Wigmore described as negatory evidence. A small circle may be inserted on a directional arrow to indicate that a factum probans tends to negate a specified factum probandum. In the authors' experience, the additional complexity and potential ambiguity resulting from these symbols ordinarily outweigh their utility in practice. See page 150, above for further explanation.
Where convenient, an additional line may be inserted in any of the symbols depicting a proposition to indicate that the evidential data or proposition will be offered by or elicited from the opposing party's witnesses or exhibits. This convention may be useful for trial preparation where, for example, many propositions necessary to the plaintiff's case will require support from testimonial assertions to be offered through, or elicited on cross-examination from, the defendant's witnesses.

The open square and inverted U depict what Wigmore described as negatory evidence. A small circle may be inserted on a directional arrow to indicate that a factum probans tends to negate a specified factum probandum. In the authors' experience, the additional complexity and potential ambiguity resulting from these symbols ordinarily outweigh their utility in practice. See page 150, above for further explanation.
APPENDIX FIVE
Key list of the evidence:

1. An unknown number of persons entered the commercial premises of the Blackbread Brewery in the early morning hours of 1 May 2003. (Detective Inspector [DI] Leary testimony.)

2. The persons entered the premises of the Blackbread Brewery by means of a hole that they cut in a metal grille. (DI Leary testimony plus a photo showing the hole.)

3. After entering the Blackbread premises, the intruders were confronted by a security guard named Willard R. (Willard R. testimony.)

4. Upon seeing the intruders, the security guard set off an alarm. (Willard R. testimony.)

5. After he set off the alarm, the security guard (Willard R.) was punched in the face by one of the intruders. (Willard R. testimony.)

6. The punch Willard R. received from one of the intruders caused Willard R's nose to bleed. (Willard R. testimony plus a photo of his injury taken shortly after the incident.)

7. The intruders left the Blackbread premises just as a police patrol car arrived. (Willard R. testimony.)

8. The intruders' getaway car left immediately, at the first sound of the alarm, leaving the intruders stranded. (Willard R. testimony.)

9. The intruders dispersed from the Blackbread premises on foot. (Willard R. testimony.)

10. There were four intruders. (Willard R. testimony.)

11. The security guard could not describe the intruders. (Willard R. testimony.)

12. The light was poor at the time of the intrusion. (Willard R. testimony.)

13. The security guard was confused because of the blow he had received. (Willard R. testimony.)

14. The police in the patrol car that had arrived at the Blackbread premises saw the intruders from a considerable distance away. (DI Leary testimony.)

15. In a search of the area surrounding the Blackbread premises, police apprehended Harold S. trying to "hot wire" a car in an ally about 1/4 mile from the Blackbread premises. (DI Leary testimony plus a photo of Harold S. taken just after he was apprehended.)

16. During a police investigation a short time after the intrusion, a tuft of red fibres was found on a jagged end of one of the cut edges of the
BIBLIOGRAPHY


